Teacher Education in Further Education:
The role of mentoring in student teachers' mathematical and pedagogical knowledge development

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Dedication

This thesis is dedicated to my late brother **Abel Guyborn Machino Machokoto**. Abel called me Dr Machino before I even completed my first degree. Sadly, Abel did not live to see this thesis.

Zorora murugare wangu.

Abstract

Mentoring is a cornerstone within Initial Teacher Education in the Further Education and Training sector. Yet there is lack of clarity about its meaning, purpose, and role, and it is under-researched. This qualitative study explores the role of mentoring in the development of mathematical and pedagogical knowledge of mathematics student teachers by investigating student teacher knowledge enacted in teaching; student teacher needs; how mentoring addresses the needs; institutional issues which have the potential to influence mentoring; and challenges and lessons learnt during the COVID-19 lockdowns. Data were collected from mathematics student teachers and mentors using tasks following the format of the MathTASK programme (mathtasks), observations, interviews, mentor reports, and questionnaires. Data were analysed using the Knowledge Quartet (KQ) and thematic analysis. The mathematical and pedagogical knowledge enacted by student teachers in teaching varies, revealing areas of need: gaps in subject knowledge; procedural explanation; sticking to a single method; unclear explanation; limited connections; limited theoretical underpinning of pedagogy; improper use of terminology and errors; and (over)relying on the internet. Institutional issues that have the potential of influencing mentoring practices (mentoring frameworks; mentor training; teaching for examinations; and, contextualising mathematics teaching to vocational courses and real-life examples) are identified. The study, conducted during COVID-19 lockdowns, shows challenges and lessons learned during e-teaching and e-mentoring which revolve around issues of: teamwork; digital technology; professional and personal relationships; mathematics teaching needs physical demonstration; and, recording lessons and meetings. Responding to these findings, a normative model, *The DOT Mentoring Model* (Doing mathematics, Observing (and learning from) experienced teachers, and Teaching mathematics), is proposed as a guiding framework for mentors. The study has contributed to theory by proposing *The DOT Mentoring Model* and modifications to KQ codes (adding a new code, *Use of technology*, and changing *Adherence to textbooks* to *Adherence to internet resources and textbooks*).

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List of Acronyms

AoC	Association of Colleges
AQA	Assessment and Qualifications Alliance (UK)
BIS	Department for Business, Innovation and Skills
BKSB	Basic Key Skills Builder Basic Key Skills Builder
BSRLM	British Society for Research into Learning Mathematics
BTEC	Business and Technology Education Council
CCK	Common Content Knowledge
CETT	Centres for Excellence in Teacher Training
CfEM	Centres for Excellence in Maths
CK	Curriculum Knowledge
CoP	Community of Practice
CPD	Continuous Professional Development
CTLLS	Certificate in Teaching in the Lifelong Learning Sector
DfE	Department for Education
DfES	Department of Education and Skills
DTLLS	Diploma in Teaching in the Lifelong Learning Sector
E-MMT	E-mentoring for mathematics teachers
ESFA	Education and Skills Funding Agency
ESL	English as a Second Language
ETF	Education and Training Foundation
FE	Further Education and Training sector
FEFC	Further Education Funding Council
FENTO	Further Education National Training Organisation
FS	Functional Skills
GCSE	General Certificate of Secondary Education
HEI	Higher Education Institutions
HMI	Her Majesty's Inspectorate
ITE	Initial Teacher Education
KFLM	Knowledge of Features of Learning Mathematics
KMLS	Knowledge of Mathematics Learning Standards
KMT	Knowledge of Mathematics Teaching
KQ	Knowledge Quartet
LLUK	Lifelong Learning UK

MCOP^2	Mathematics Classroom Observation Protocol for Practices
MKT	Mathematical Knowledge for Teaching
MTSK	Mathematics Teacher’s Specialised Knowledge
NVQ	National Vocational Qualification
Ofsted	Office for Standards in Education
OMIP	Online mathematics instructional programmes
PCK	Pedagogical Content Knowledge
PGCE	Postgraduate Certificate in Education
PISA	Programme for International Student Assessment
PUFM	Profound Understanding of Fundamental Mathematics
SCITT	School Centred Initial Teacher Training
SCK	Specialised Content Knowledge
SKE	Subject Knowledge Enhancement
SMK	Subject Matter Knowledge
TAGs	Teacher Assessed Grades
TPCK	Technological Pedagogical Content Knowledge

1 Introduction

1.0 Introduction

Initial Teacher Education (ITE) courses in the Further Education and Training sector (FE) are largely generic in nature and rely on trainees' ability to contextualise their learning for their own specialism with the support of subject mentors (Lucas et al., 2012). In the generic ITE environment in FE, it is the mentor's responsibility to assist in the development of the mathematical and pedagogical knowledge of mathematics student teachers. However, the ITE in FE is not clearly defined to an extent that Lucas et al. (2012, p. 677) describe it as moving "[f]rom fragmentation to chaos". Also, there have been different and often conflicting definition of mentoring. The mentoring policy seems to be ambiguous with different Government bodies; for example, Education and Training Foundation (ETF)[1] and Office for Standards in Education (Ofsted)[2] giving different and conflicting policy directions. Lack of policy clarity on mentoring leads to unclear definition resulting in unclear practice. There seems to be no (or I have yet to come across any) study on the role of mentoring in the development of the mathematical and pedagogical knowledge of mathematics student teachers in FE; surely, this is a cause for concern that needs research which might influence policy and practice.

In this chapter, I introduce my research study by discussing the background to the study and key problems in mentoring in FE. I identify the gap in literature this study attempts to cover. I then present the aim and research questions of the study. This is followed by a brief description of the study and the theoretical framework which guides the study. I move on to briefly discuss what motivates me into studying mentoring in general and mentoring of mathematics student teachers in FE in particular. The significance of the study is highlighted and how the thesis is organised is given.

1.1 Background to the study

Initial Teacher Education (ITE) has traditionally been carried out in universities and the mentor's role was not significant. Kerry and Mayes (2013) observe the following:

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[1] Education and Training Foundation (ETF) is a Government backed body which was established in October 2013 to support FE. It has a strong relationship with the Department for Education (DfE), which funds many of its programmes. (https://www.et-foundation.co.uk)

[2] Ofsted is a government organisation that stands for The Office for Standards in Education, Children's Services and Skills. Ofsted report directly to Parliament and by law, they must inspect schools with the aim of providing information for parents and carers as well as promoting improvement and holding schools to account. (https://www.gov.uk/government/organisations/ofsted/about)

> The rapidity of the rise of the teacher-mentor role in initial teacher education has been largely the result of a political agenda determined to wrest initial teacher education away from higher education institutions (HEIs) and place it in schools [and FE colleges] (p.1).

Since 2013, ITE has significantly shifted to schools as noted by the introduction of School Centred Initial Teacher Training (SCITT) courses which are designed and delivered by groups of schools that have been given government approval to run their own ITE (Long & Danechi, 2023), and the importance of mentoring has equally increased.

ITE in FE in England has been subjected to politically initiated reforms. Lucas et al. (2012) note that, "Over the last 10 years the system for training further education (FE) teachers in England has been the subject of almost continuous government reforms" (p. 677). Besides the barrage of reforms and the importance of mentoring, it seems little attention has been paid to mentoring by policy makers and researchers. Worse still, it seems there is no (or very little) research on the role of mentoring in the development of mathematical and pedagogical knowledge of mathematics student teachers in FE.

1.2 Key problems of mentoring in the Further Education and Training sector (FE)

1.2.1 Lack of clarity of meaning, policy and purpose of mentoring

School and college teacher preparation programmes' field experiences (of which mentoring is key) have often been accused of "[b]eing fragmented, lacking curricular definition, and appearing disconnected from other components of teacher preparation programs" (Graham, 2006, p. 1118). The lack of connection between theory and practice is also observed by Walton and Rusznyak (2020) who have the following to say:

> Initial teacher education must respond to the demand that newly qualified teachers are able to teach inclusively. This response has been the creation of opportunities for learning in coursework and field experiences. Research has identified the impact of these initiatives and also revealed challenges. One such challenge is the lack of a coherent conceptual framework that leads to a connection between coursework and field experiences (p.18).

Mentoring has become established as a central feature of ITE programmes in FE, yet there remains lack of clarity within the sector about what mentoring should mean (Tedder & Lawy, 2009). Hobson et al. (2009) note that, "[t]here is a wealth of evidence that a number of mentoring strategies and tactics tend to be associated with effective mentoring in general, but it is less clear which strategies promote which of the potential outcomes or benefits" (p. 213). Savory and Glasson (2009) highlight the need for a clear definition of mentoring and understanding of roles and responsibilities and adequate training and time for mentoring. Cullimore and Simmons (2010) view one of the impediments to effective mentoring in FE ITE as a lack of clarity in defining the mentor role, too little contact between mentors and student teachers, and limited mentor training. While one might expect things to have changed, mentoring is still unclear. Research Briefing on Initial Teacher Training in England published on 24 April 2023 by the House of Commons Library reads, "Mentoring across England is not as good as it should be. The DfE should commission a sector body to develop some national standards for mentors" (Long & Danechi, 2023, p. 26).

Lawy and Tedder's (2012) study on mentoring in the FE sector highlights the opaqueness of mentoring in the sector when saying it is not clear whether the emphasis of mentoring is upon support for the learning and professional development of the student teacher, or whether the aim is focused upon assessment and the decision to award a qualification and a licence to practice in the sector. Government policy on mentoring is not clear and Government bodies are seen to be conflicting on the purpose of mentoring. Cullimore and Simmons (2010) observe that Ofsted expects that FE mentors should be engaged in processes of making judgements on trainees against teaching standards. The Department for Education's (2018) statutory guidance for schools says, "The head teacher/principal must identify a person to act as the induction tutor [who is the mentor] to provide day to day monitoring and support, **and co-ordination of assessment**" (my emphasis) (p. 16). Education and Training Foundation (2020) advocates for an approach to mentoring and coaching of teachers in FE which is developmental and nurturing in nature, rooted in collaboration and support, and adaptable to the individual needs of the mentee and/or coachee. Government agencies which work closely and expected to offer similar guidance are seen to be conflicting: ETF advocates for formative support while DfE and Ofsted advocate for judgemental mentoring (thereafter called judgementoring: a term coined by Hobson and Malderez (2013)). This shows lack of clear policy, and as a result mentors are engaging in different and often conflicting mentoring roles: supportive and judgementoring.

With unclear definition, opaque policy and unclearly defined purpose, it follows that the role of mentoring in the development of mathematical and pedagogical knowledge of mathematics student teachers is also not clear; it needs to be investigated, and this study does that. Due to lack of a clear definition, policy direction and purpose, mentoring often fails to address student teacher needs.

1.2.2 Mentoring not used to address student teacher needs

Manning and Hobson (2017) note that a wide range of impediments to effective mentoring currently exist, and the most notable impediments include the use of mentoring as a remedial strategy to address the perceived under-performance of teachers. If mentoring focuses solely on identifying and addressing problems, it can become toxic, as it emphasizes perceived weaknesses without acknowledging strengths, which may be demotivating. In contrast, when mentoring is used for comprehensive professional development, it yields positive results (Malderez & Bodczky, 1999).

1.2.3 Different mentoring practices

A literature review covering 60 years of research about school mentors found that student teachers regard the school placement as the most important part of their training, and the mentor as central to their success, but found a variety of different practices and power dynamics (Clarke et al., 2014). Many student teachers claim their mentoring is random and haphazard, and mentors also report that the mentoring they provide is variable (Hudson, 2013). Findings from a survey of University Leads for ITE in FE support previous research in suggesting that while there is some good and very good provision, the standard of mentoring in the sector is highly variable (Robinson & Hobson, 2017). While the quality of mentoring has improved to some extent across FE in the last decade or so, it remains extremely variable (Greatbatch & Tate, 2018; Hobson et al., 2015). Some participants in a study by Robinson and Hobson (2017) suggest that the issue of the quality and consistency of mentoring in ITE in FE has become more acute in recent years as a result of the increasing time pressure that teachers in the sector find themselves under. Mentoring is too important to be left to chance, yet mentoring expertise of teachers varies widely, which may present inequities for developing student teachers' practices (Hudson, 2007). One might expect that there have been some improvements in mentoring, but more recently, Ersin and Atay (2021) observe that, in several practicums[3] contexts, mentors are found to partially fulfil their mentoring functions and that the quality of the mentoring is observed as unsatisfactory.

1.2.4 Power dynamics

Researchers (for example, Bozeman & Feeney, 2007; Kalbfleisch, 2002; Woodd, 1997) define mentoring in terms of only the mentor and the mentee. However, when it comes to student teacher education, mentoring involves three main actors: the student teacher (mentee), the mentor and the teacher education tutor, and this is referred to as the triad (Bullough & Draper, 2004).

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[3] Practicum is when student teachers are in schools practising teaching under the supervision of a mentor. Practicum is called placement in the English education system.

Bullough and Draper (2004) view the mentoring relationship as complex and hierarchical with the tutor and the mentor on top with conflict a potential consequence. The student teacher is located at the middle trying to balance sometimes conflicting demands in order to maintain desired relationships and to obtain positive teaching evaluations and grades. A closer look at the politics of mentoring, particularly within the triadic relationship that is common in teacher education, reveals a much more complicated story than is typically told: a tale of power negotiation and of positioning and being positioned to influence learning (Bullough & Draper, 2004). In a triadic relationship, actors position themselves, position others and are positioned by others, and with each shift in position comes a change (Bullough & Draper, 2004). In the study reported by Bullough and Draper (2004), the mentor uses *Teacher centred rote learning approach* while the tutor prefers *Pupil centred inquiry-based approach*. The mentor positions the tutor as a theory-based person who is impractical and unrealistic, filled with good ideas but not for high school teaching while the tutor positions the mentor as harmful to students and using outdated approaches. The student teacher is caught in between and has to choose the powerful side (regarding assessment grades) to follow.

1.2.5 Institutional commitment to mentoring

There is research evidence that mentoring in FE is often constrained by lack of institutional commitment to mentoring. Cullimore and Simmons (2010) find evidence of mentors having insufficient time to carry out their role, unsympathetic timetabling and, more generally, mentors receiving insufficient support and recognition from college management. The role of mentoring is often underestimated and it is unlikely that mentors are allocated any time for their mentoring duties by their colleges. Mentoring is also impeded by insufficiently effective processes for induction, training and support for mentors, with evidence that some mentors are not trained, and others receive inadequate preparation for the role (Hobson et al., 2015).

1.2.6 Student teacher qualifications on entry into and exit from FE ITE

Mentoring student teachers in FE is not as straight forward as mentoring student teachers in schools. The qualifications and backgrounds of student teachers on entry into ITE are varied and they aim to obtain different teaching qualifications[4] (Greatbatch & Tate, 2018). Mentoring student teachers with different qualifications on entry aspiring to achieve different qualifications on exit but aiming to teach

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[4] The teaching qualifications obtained by FE student teachers are: Award in Education and Training (AET), Certificate in Education and Training (CET), Diploma in Education and Training (DET), Diplomas in Education and Training with a subject specialism in numeracy (not mathematics), literacy, and/or English for Speakers of Other Languages (ESOL), Certificate in Education (Cert Ed), Professional Graduate Certificate in Education (ProfGCE) and Postgraduate Certificate in Education (PGCE) (Education and Training Foundation, 2016).

the same qualification: General Certificate of Secondary Education (GCSE) and Functional Skills (FS), is obviously challenging for mentors as the student teachers' needs vary.

1.2.7 Mentors and education tutors: who is better?

The role of mentoring in the development of student teachers' subject matter (mathematics in this case) and pedagogical knowledge is complex as the student teachers come into ITE with different qualifications and exit with different qualifications as mentioned earlier. A study by Thompson (2016) finds education tutors and peers to be more helpful in subject matter and pedagogical knowledge development of student teachers than mentors, yet student teachers see mentors on daily basis and tutors once a week for lectures, observations and tutorials. The findings are not surprising as Office for Standards in Education (2003) observe that:

> The lack of systematic and effective mentoring arrangements for trainees on the majority of FE teacher training courses is a major weakness. Few colleges provide their trainees with sustained support from experienced practitioners who can assist them in developing good teaching skills. There is an over-reliance on informal forms of support, and the roles of mentors are often not defined in sufficient detail. Where mentoring support is provided, the standard is extremely variable and, in most cases, not well resourced (p. 18).

Thompson's (2016) findings and Office for Standards in Education (2003) observation are not in agreement with a study by Hobson and Malderez (2002) who states that:

> School-based mentors were also perceived to be more effective than other course personnel [especially tutors] in assisting trainees to develop (1) the ability to use a range of teaching methods effectively, and (2) knowledge and understanding of pupil motivation and behaviour (p. 2).

This contradiction highlights the opaqueness of mentoring especially its role in the subject matter (mathematics in this case) and pedagogical knowledge development of student teachers, an issue this study attempts to understand.

1.2.8 Subject specialist mentors

Lucas et al. (2012) observe that the challenges faced by FE teacher educators stem from the wide diversity of student teachers, and the vast range of subjects and occupational areas in which they are preparing student teachers to teach; this leads to the challenge of providing sufficient ‘good quality’ specialist mentors to help student teachers apply generic teaching and planning techniques to a specific occupational and subject area; for example, Art & Design and mathematics. In FE most ITE delivery takes place in generic groups where there is little matching of teacher educators or learning resources to the student teachers’ specialisms. There is also lack of training for teacher educators on how to address subject-specialist pedagogy; therefore, the ITE relies on student teachers’ ability to contextualise their learning to their own specialism with the support of subject mentors (Lucas et al., 2012). The mentor is thus the subject specialist who supports the student teacher in their workplace and who observes and gives feedback on their teaching practice (Eliahoo, 2011), but finding the ‘right’ mentors is challenging.

Mentors who are subject specialists in the same subject area as the student teachers are often reported as being particularly helpful, as they know how to pitch the subject at the appropriate level for different groups of learners and have ready questions and examples which are aspects of professional practice that novice teachers find particularly problematic (Hankey, 2004). While subject specialists are ideal for mentoring, they are not always available in FE, and this forces colleges to use non-specialist teachers as mentors; for example, an Art & Design teacher mentoring a mathematics student teacher. Eliahoo (2009) observes that not all student teachers are allocated mentors and of those allocated, not all match their mentee’s subject specialism, some mentors are not qualified teachers, and some have little or no training and, indeed, no wish to be a mentor.

To add to the complexity of mentoring, the subject specialist teacher education (including mentoring) is not accepted universally as there are adult educationalists[5] amongst others who argue that specific subject knowledge and pedagogies do not comprise discrete and separate disciplinary constructions (Lawy & Tedder, 2011); therefore, subject specialism training is not important. Subject-specialist pedagogy of student teachers has been a contested issue in FE for nearly twenty years, and debates over it derive partly from the sectoral features concerning ITE and also from several factors concerning the nature of subject-specialist pedagogy itself (Hanley & Thompson, 2021). Policy initiatives relating to FE ITE have insisted on the development of subject specialist pedagogy (Office for Standards in Education, 2003) but powerful social, political and economic considerations, together with practical concerns, have combined in recent decades in a way that has propelled generic teacher training (Fisher & Webb, 2006), and mentoring is caught up in the subject specialist/generic conflict.

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[5] Adult educationalists are also referred to as adult education specialists.

1.2.9 Mentoring during COVID-19

Some of the problems of mentoring were brought about by the COVID-19 pandemic. When the education institutions had to go online, the call for digital technological knowledge drastically increased; teachers (student teachers and mentors included) had to learn fast. Obviously, mentoring was also affected with regard to how mentors assisted student teachers in the use of digital technology. Ersin and Atay (2021) report a study where student teachers said they did not receive adequate digital technological support as "[m]entors were themselves also trying to adapt to this process, the pandemic conditions" (p. 209). More importantly, mentors did not know how to assist the student teachers during COVID-19, while the student teachers looked up to their mentors for help. On a positive note, the education community (and beyond) has something to learn from this experience which could be useful during the post COVID-19 era.

Having highlighted the key problems in mentoring which can be seen to be originating from Government policy inconsistence and filter down to institutional commitment and power dynamics and down to mentoring the student teacher, I move on to identify the gap in literature this study attempts to cover.

1.3 The gap

There has always been lack of interest in FE research by policy makers and researchers in education. Elliott (1996), after seeing the shortage of research in FE, attempts to find out "[w]hy is research in further education largely undervalued by policymakers and practitioners alike?" (p. 1). Among many findings, the most significant one is that many key FE activities are externally controlled. Unlike Higher Education Institutions (HEIs), FE colleges do not have control of their own course validation and assessment arrangements. They are in a dependent relationship with awarding bodies like the Business and Technology Education Council (BTEC), GCSE & Advanced Level (A level) examination boards, and the National Council for Vocational Qualifications (NCVQ). FE colleges' research and development budget goes on maintaining quality assurance systems (Elliott, 1996). While it is important to understand the reasons for the shortage in research in FE; the gap needs to be filled and this study attempts to do that.

Powell (2020) observes that "[r]esearch on student teachers' practice of learning to teach has focused on pre-service teachers preparing to teach in early years, primary, and secondary education settings" (p. 8). There is less research activities in FE, and a relatively small amount of research on mentoring in FE exists. Research on mentoring FE mathematics student teachers is scarcer. There is a gap in literature on the role of mentoring in the development of mathematical and pedagogical knowledge of FE mathematics student teachers which this study attempts to cover.

Most research on mentoring in mathematics (for example; Hyde & Edwards, 2014; Jaworski & Watson, 2014; Mtetwa & Thompson, 2000; Sanders, 2014) concentrate on mathematics student and qualified teachers in secondary schools. On the other hand, researchers on mentoring in FE (for example; Hobson et al, 2015; Manning & Hobson, 2017) concentrate on generic mentoring. This leaves mentoring mathematics student teachers in FE under-researched (Figure 1. 1).

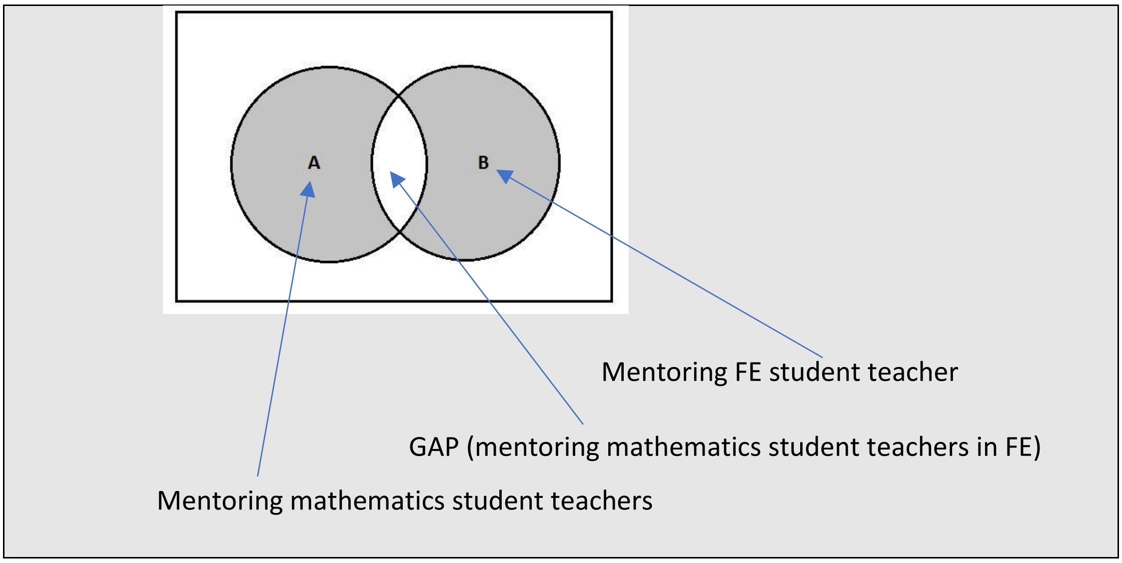

Figure 1. 1 Diagrammatical representation of the GAP

On a positive note, *Mentoring teacher trainees of mathematics for ESL (English as a second language) learners in post-compulsory education: Reflections and challenges* by Norley (2017) is a welcome development. While Norley's (2017) study is credited for venturing into this under-researched field, it focuses on mathematical language development of English as a Second Language (ESL) learners and does not address the issue of mathematical and pedagogical knowledge development of mathematics student teachers and the role of mentoring in that development, and this leaves a gap this study attempts to cover.

The problems and lack of research on the role mentoring play in the development of student teachers is not unique to particular education contexts, subjects or level – school or FE college. For example, in Malaysia, Li et al. (2021) observe that school mentor teachers do not perform their roles constantly when mentoring pre-service teachers in teaching practicum. Despite the plentiful literature on teaching, research on the role played by mentors is still sparse (Li et al., 2021). The study by Li et al.

(2021) is discussed in detail in the *Conceptual framework* chapter (see Section 2.3.5.5). Also, in South Africa, Ndebele and Legg-Jack (2022) report a study of school student teachers which concludes that little has been done on pre-service teacher development via mentoring, and a knowledge gap exists. The study by Ndebele and Legg-Jack (2022) is discussed in detail in the *Conceptual framework* chapter (see Section 2.3.5.6). After identifying the gap this study attempts to cover, I give the aims and the research questions (RQs) of the study of the study.

1.4 The aim of the study

The aim of this study is to develop an empirically grounded normative model on how mentoring could assist the development of mathematical and pedagogical knowledge of further education (FE) mathematics student teachers. This model could inform and enhance future mentoring practices.

1.5 Research questions (RQs)

To achieve the aim of the study, I attempt to address the following RQs:

- **RQ 1**: What mathematical and pedagogical knowledge is enacted by further education mathematics student teachers in teaching, and what are the student teacher needs?
- **RQ 2**: How does mentoring address the student teacher needs, and what institutional issues influence mentoring practices?
- **RQ 3:** What are the challenges and lessons learnt during e-mentoring further education mathematics student teachers during COVID-19 lockdowns?

1.6 The study in a nutshell

In this study, which is qualitative established on (and deploying) an interpretative research methodology, I attempt to address the problems discussed earlier and cover the gap; that is answering the RQs, by investigating the following five areas which emanate from key problems of mentoring in FE discussed earlier:

- the mathematical and pedagogical knowledge enacted by mathematics student teachers when teaching
- student teacher needs
- how mentoring addresses the student teacher needs
- institutional issues which are seen to have the potential of influencing mentoring

- challenges faced and lessons learnt during e-mentoring mathematics student teachers during the Covid-19 lockdowns.

To investigate these five areas data were collected in two phases. During *Phase 1,* data were collected using: mathtasks[6] responded to by the student teachers, observing lessons taught by the student teachers, observing mentor meeting, interviewing student teachers, interviewing mentors, and collecting documents which are reports on the performance of the student teachers compiled by their mentors. Data were analysed using the Knowledge Quartet (KQ) (Rowland et al., 2009) theoretical framework and the thematic analysis which is a method for identifying, analysing and reporting patterns (themes) within data (Braun & Clarke, 2006). During *Phase 2*, data were collected using anonymised questionnaire completed by mentors and interviewing the mentors, and analysed using thematic analysis.

After addressing the five areas; that is answering the RQs, I aim to propose a mentoring model.

1.7 Theoretical framework

Teacher knowledge is conceptualised in different ways by different researchers, but the Knowledge Quartet (KQ) (Figure 1.2) (Rowland et al., 2009) which can be defined as a framework for the analysis of mathematics teaching, with a focus on teacher knowledge, is the theoretical framework used to ground this study.

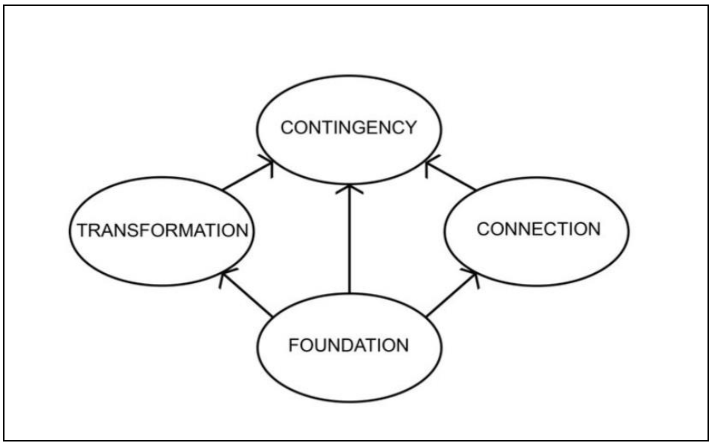

Figure 1. 2 The Knowledge Quartet (http://www.knowledgequartet.org/)

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[6] Mathtasks are classroom situation-specific incidents which are hypothetical but grounded on learning and teaching issues that previous research and experience have highlighted as seminal and are likely to occur in actual practice (Biza et al., 2007). Mathtasks are discussed in detail in Chapter 3.

The KQ is used as the lens through which the mathematical and pedagogical knowledge of further education mathematics student teachers is made visible. While it is difficult to judge one's *Subject Matter Knowledge (SMK*) and *Pedagogical Content Knowledge (PCK)* for effective mathematics teaching, with the KQ dimensions: *Foundation, Transformation, Connection* and *Contingency*, "[m]athematical content knowledge for teaching will be most clearly seen in the action of teaching" (Rowland et al., 2009. p. 25). It is important to mention that the KQ has rarely been (probably not yet) used in mentoring contexts in FE. The KQ is discussed in detail in the next chapter: *The conceptual framework* (see Section 2.2.2.8).

1.8 Motivation into studying mentoring

My interest in mentoring started when I was a secondary school mathematics student teacher. During school placement, I was attached to a mentor whose role was not explained. The mentor was always observing me teaching, writing down 'notes.' We had meetings whenever she felt like; sometimes once a week and sometimes once a month. The meetings were mostly about the lessons observed where we discussed (or I was told about) my strength, areas of development and how to improve. After qualifying, I taught in secondary schools then switched to FE where my interest in mentoring increased as some of my colleagues who are training to teach seem not to understand the roles of their mentors. Due to these and other factors, I started reading about mentoring. My reading raised more questions than answers, and this motivated me into researching about the role mentoring plays in the mathematical and pedagogical knowledge development of mathematics student teachers in FE.

1.9 Significance of the study

There is a possibility the results of this study might attract policy makers' attention and bring about some policy changes that might have the potential of improving the mentoring of FE student teachers in general and those learning to teach mathematics in particular. The study is seen as having the potential to improve not only mentoring but also the teaching of mathematics in FE. The results of this study are also likely going to trigger more interest into researching about mentoring FE student teachers in different subjects and vocational courses. The study adds new knowledge to the already existing body of knowledge on mentoring while covering the gap of lack of literature on the role of mentoring in the mathematical and pedagogical knowledge development of mathematics student teachers in FE. Additionally, this study uses the Knowledge Quartet (KQ) framework within the FE context, which is rare (or has not been done before). This unique application provides valuable insights into its relevance and effectiveness, potentially encouraging further use of the KQ in FE settings.

1.10 The organisation of the thesis

This thesis is organised into six chapters. In this chapter: **Chapter 1**, I introduce this research study. In **Chapter 2**, I discuss the *Conceptual framework* of the study under four sections: *The Further Education and Training sector (FE); Mathematical and pedagogical knowledge for teaching; Mentoring;* and *E-mentoring.* Before concluding the chapter, I give a brief description and the diagrammatical representation of the *Conceptual framework* of the study. In **Chapter 3**, I discuss the methodological approach and presented the research design and research questions of the study. I move on to discuss the participants, data collection and analysis. I then discuss how I attempt to evaluate the trustworthiness of the study. I move on to discuss ethical issues I considered when conducting the study. As this study was conducted during the COVID-19 lockdowns, I briefly explain the impact of COVID-19 when conducting this study. **Chapter 4** is organised into two sections: A and B. The main focus of Section A is the initial analysis of the data collected during *Phase 1* of the study where the data is presented in form of episodes categorised into the Knowledge Quartet (KQ) dimensions: *Foundation, Transformation, Connection* and *Contingency.* In Section B, I give a detailed analysis of the episodes. In **Chapter 5**, I present and analyse data collected by inviting mentors to complete an anonymous questionnaire and respond to interviews which is *Phase 2* of the study. I explore further themes already reported in Chapter 4; therefore, there might be some revisitation and expansion of already reported themes. This mean in Chapter 5, I report analysis of data collected during *Phase 1* and *Phase 2*. **Chapter 6** offers the aim and summary of the research process, the research questions, summary of the findings and answering research questions. I then give the study's substantive, theoretical and methodological contribution, implications and recommendations to policy makers and practitioners, challenges and limitations, and future research. I conclude the chapter (in fact, the study) with my personal reflections during the research journey.

2 The Conceptual Framework

2.0 Introduction

A conceptual framework provides a theoretical clarification of what the researcher intends to investigate and enables readers to be clear of what the research seeks to achieve, and how that will be achieved as well as to describe a set of relationships within the research process (Leshem & Trafford, 2007). In this study, I adapt Ravitch and Riggan's (2012) view of conceptual framework; they define it as a way of linking three elements of the research process which are personal interests, theoretical framework, and topical research. Personal interests include my curiosities, biases, ideological commitments, epistemological assumptions, and professional interests which influence the process of carrying out the study (Ravitch & Riggan, 2012). Theoretical frameworks represent a combination or aggregation of formal theories in such a way as to illuminate some aspect of the conceptual framework (Ravitch & Riggan, 2012) which are the mathematical and pedagogical knowledge for teaching conceptualisations in this study. Topical research refers to work that has focused on the subject of interest (Ravitch & Riggan, 2012); that is mentoring in this study. Topical research describes the 'what' of the study while theoretical framework clarifies the 'why' and 'how' of a study (Ravitch & Riggan, 2012). It is important to note that literature review is considered a form of topical research because it synthesizes existing knowledge on a specific topic, providing a comprehensive overview of the current state of research in that area (Torraco, 2016). Conceptual framework includes theoretical framework and literature review. While personal interests, theoretical framework and topical research are major components of a conceptual framework, Ravitch and Riggan (2012) advise that, "We would never expect to see one [conceptual framework] organised into these parts [personal interests, theoretical framework and topical research]" (p.14).

In this chapter, I discuss the conceptual framework of the study under four sections. In the first section, I discuss the context in which this study is situated which is the Further Education and Skills (FE) sector focusing on: reforms in Initial Teacher Education (ITE), ITE after reforms, teaching mathematics in FE, and mathematics students in FE. In the second section, I discuss mathematical and pedagogical knowledge teachers should or are expected to have by tracing 'key' theoretical frameworks since 1985 and justifying my selection of the Knowledge Quartet (KQ) (Rowland et al., 2003) as the framework I use to ground this study; therefore, the KQ is discussed in more detail compared to other frameworks. The third section is devoted to mentoring. I briefly discuss the origin and evolution of mentoring and give definitions of mentoring. I then discuss the two perspectives of mentoring: *Developmental* and *Judgemental,* and theories of mentoring: *Learning by reflecting* and *Learning through apprenticeship*. I conclude the section by discussing general, mathematics specific and FE mathematics student teachers specific models of mentoring. In the fourth section, I discuss the background of the COVID 19 triggered electronic mentoring (thereafter e-mentoring). I define e-mentoring, discuss the difference between e-mentoring and face-to-face mentoring, e-mentoring during the pandemic and e-mentoring mathematics student teachers. I conclude the chapter with a brief description and the diagrammatic representation of the study's conceptual framework.

2.1 The Further Education and Training sector (FE)

The FE sector in England (sometimes referred to as the post-16 sector, Lifelong Learning Sector, or Post-Compulsory Education and Training sector) is extremely diverse; it includes FE colleges, sixth form colleges, adult and community learning providers, prisons, work-based learning providers, and private training companies (Lingfield, 2012a). It provides education, training, and apprenticeships for approximately three million people over the age of 16 (Hanley & Thompson, 2021). Historically, FE was synonymous to vocational education and training, providing communities with courses that tended to be practical and non-academic. Many FE lecturers came from industries, such as Engineering & Construction and Hair & Beauty, and were vital in providing the subject knowledge needed by colleges to enable them to offer a wide provision of courses (Burnell, 2016). The sector has undergone some radical changes in recent years, but due to space limitations, in this chapter I am mainly focusing on teacher education as it is where mentoring, which is the focus of this study, is situated.

2.1.1 Reforms in Initial Teacher Education (ITE) in the Further Education and Training sector (FE)

ITE in FE has not evolved in a vacuum; training programmes have been adjusted to accommodate government policy objectives. There have been changes of direction and many reforms were implemented when the New Labour Government began a barrage of reforms in 2001 that overhauled (and often confused) the FE teacher education system; ITE in FE in England has been described as going "[f]rom fragmentation to chaos" (Lucas et al., 2012, p. 677), as conflicting waves of reform have reflected differing philosophies of Labour and Conservative led governments.

It has long been compulsory for teachers in schools to be qualified in the skills of teaching as well as in their subject specialisms, but up to 2001 this has not been the case for FE teachers in England (Lucas et al., 2012). It was not a requirement for FE teachers to have teaching qualifications. Following the election of 1997, the New Labour Government announced its intention of introducing a requirement for all new FE teachers to have a teaching qualification based on national standards (Lucas et al., 2012). Between 1997 and 1999 the Department for Education and Skills (DfES) carried out consultations on the introduction of standards and qualifications of FE teachers (Lucas, et al., 2012). In 1999 the Further

Education National Training Organisation (FENTO) was formed with the mandate of developing national standards for training FE teachers (Lucas, et al., 2012). The Further Education Teachers' Qualifications (England) Regulations 2001 were gazetted making it a requirement for new FE teachers to gain a teaching qualification (Department for Education and Employments, 2001). Since this statutory requirement was gazetted, the system for training FE teachers in England had been the subject of almost continuous government reforms (Lucas et al., 2012) and the qualifications have gone through a number of revisions in terms of content and regulatory status (Greatbatch & Tate, 2018) (see Table 2.1).

An Office for Standards in Education (2003) report on Her Majesty's Inspectorate (HMI) national survey on ITE of FE student teachers says the system of FE teacher training, based on FENTO standards, did not provide a satisfactory foundation of professional development for FE teachers at the start of their careers. The report identified few opportunities for trainees to learn how to teach their specialist subjects, **lack of systematic mentoring** (my emphasis), and insufficient observation and feedback as key weaknesses of the training.

Year	**Event**
1997 -99	DfES consultations on introduction of standards and qualifications of FE teachers
1999	Formation of FENTO and publications of national standards teaching
2001	FE teachers required to have qualifications
2003	Publication of the Ofsted report
2004	Publication of Equipping our teachers for the future
2005	FENTO replaced by LLUK. LLUK developed new national standards accompanied credit-based assessment approach that could build to a qualification over time.
2006	New qualifications introduced. The creation of Centres for Excellence in Teacher Training (CETTs)
2007	Mandatory units of assessment for initial teaching qualifications were introduced.
2012	Lord Lingfield report and the Learning and Skills Improvement Service (LSIS) was launched to lead a review of the teaching qualifications, to simplify and rename them
2013	The current 'core' qualifications launched, and Education and Training Foundation (ETF) was established to support the FE and Training sector. The requirement for teachers in publicly funded post 16 education and training to have prescribed teaching qualifications was revoked from September 1st, 2013.
2014	ETF published revised professional standards which are currently in use

Table 2. 1 Timeline of key reforms in FE ITE

In 2005 FENTO was replaced by Lifelong Learning UK (LLUK), and it developed new national standards accompanied by a credit-based assessment approach that could build up to a qualification over time.

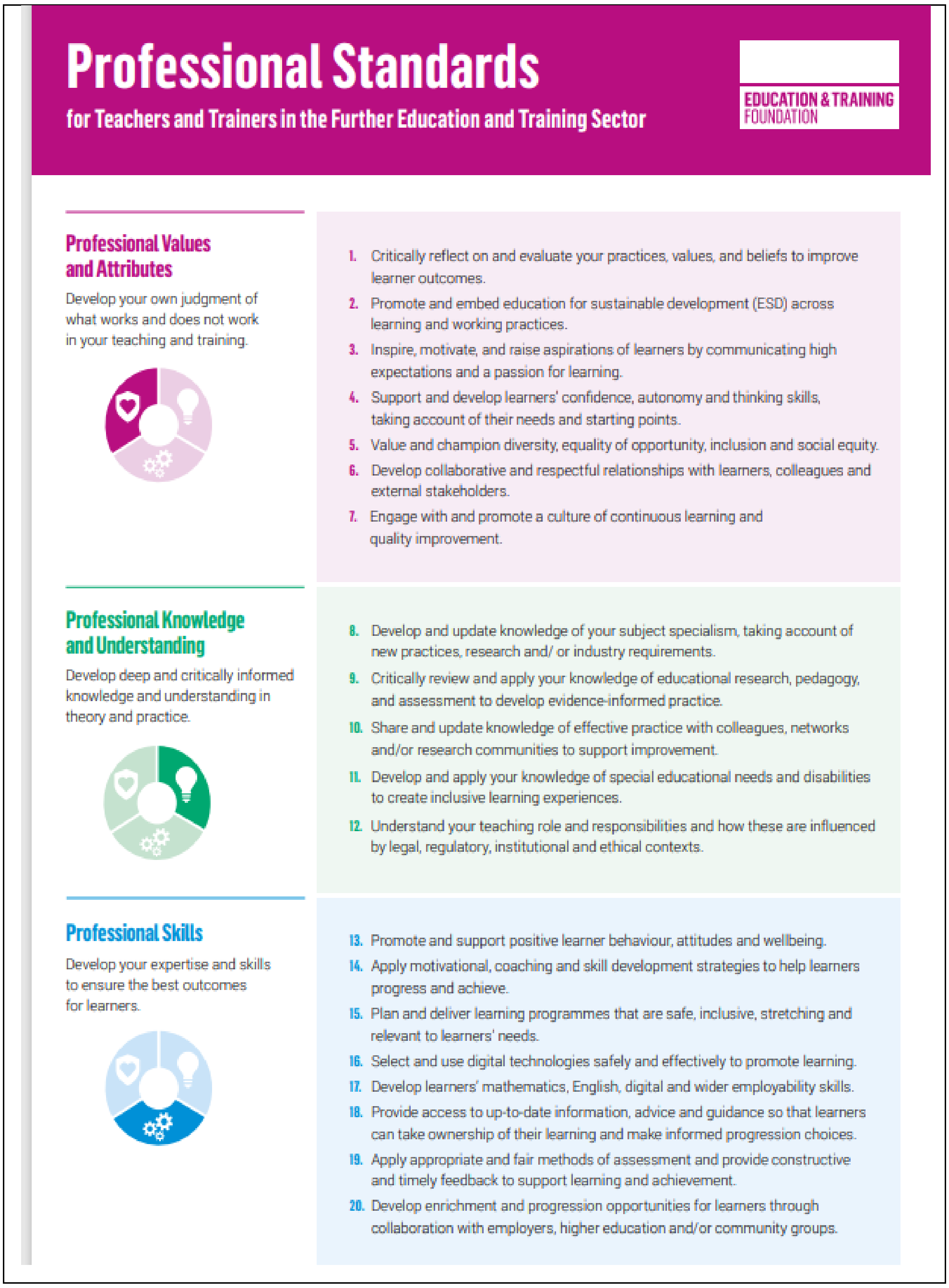
The new qualification structure introduced in 2006 consisted of three qualifications: Preparing to Teach in the Lifelong Learning Sector (PTLLS), the Certificate in Teaching in the Lifelong Learning Sector (CTLLS) and the Diploma in Teaching in the Lifelong Learning Sector (DTLLS) (Greatbatch & Tate, 2018). Lucas et al., (2012) report wide variations in the credit structures; differing numbers of modules and assessment demands for the same qualification and the range of different titles. This caused confusion among teachers and managers as qualifications with the same title were offered at different academic levels by different institutions (Greatbatch & Tate, 2018). This triggered the creation of Centres for Excellence in Teacher Training (CETTs) in 2006, regionally based partnerships that were expected to foster good practice amongst ITE providers in FE (Lucas et al., 2012). In 2007, mandatory units of assessment for initial teaching qualifications and compulsory continuous professional development (CPD) requirements were published in The Further Education Teachers' Qualifications (2007) (Lucas et al., 2012).

Lord Lingfield carried out an Independent Review of Professionalism (IRP) in FE. Following the interim report (Lingfield, 2012a), the Department for Business, Innovation and Skills (BIS) launched a consultation on the workforce regulations and in July 2012 the Learning and Skills Improvement Service (LSIS) was launched to lead a review of the teaching qualifications, to simplify and rename them (Greatbatch & Tate, 2018). The Education and Training Foundation (ETF) which is a government backed body was established in October 2013 to support FE and it has a strong relationship with DfE, which funds many of its programmes (Greatbatch & Tate, 2018).

After some years of mandatory training during the New Labour period, the Conservative Party and the Liberal Democrats party were in a coalition government between 2010 and 2015, and the requirement for teachers in publicly funded post 16 education and training to have prescribed teaching qualifications was revoked from 1st September 2013 (Education and Training Foundation, 2016):

> Employers now have the discretion to appoint to posts those that they feel are best suited in terms of qualifications, experience, and attributes for the roles they wish to fill. Many employers retain a preference for those who have, or who are willing to gain, a teaching qualification (p. 7).

In 2014 ETF published revised professional standards for the sector (Table 2.2) which were intended to be aspirational in nature, covering the values, attributes, skills, knowledge and understanding of teachers (Greatbatch & Tate, 2018). ETF developed 20 professional standards, to be followed by all training institutions, as a legal requirement. The standards are divided into three groups: Professional Values & Attributes, Professional Knowledge & Understanding and Professional Skills (Table 2.2).



Professional Standards

for Teachers and Trainers in the Further Education and Training Sector

EDUCATION & TRAINING FOUNDATION

Professional Values and Attributes

Develop your own judgment of what works and does not work in your teaching and training.

1. Critically reflect on and evaluate your practices, values, and beliefs to improve learner outcomes.
2. Promote and embed education for sustainable development (ESD) across learning and working practices.
3. Inspire, motivate, and raise aspirations of learners by communicating high expectations and a passion for learning.
4. Support and develop learners' confidence, autonomy and thinking skills, taking account of their needs and starting points.
5. Value and champion diversity, equality of opportunity, inclusion and social equity.
6. Develop collaborative and respectful relationships with learners, colleagues and external stakeholders.
7. Engage with and promote a culture of continuous learning and quality improvement.

Professional Knowledge and Understanding

Develop deep and critically informed knowledge and understanding in theory and practice.

8. Develop and update knowledge of your subject specialism, taking account of new practices, research and/ or industry requirements.
9. Critically review and apply your knowledge of educational research, pedagogy, and assessment to develop evidence-informed practice.
10. Share and update knowledge of effective practice with colleagues, networks and/or research communities to support improvement.
11. Develop and apply your knowledge of special educational needs and disabilities to create inclusive learning experiences.
12. Understand your teaching role and responsibilities and how these are influenced by legal, regulatory, institutional and ethical contexts.

Professional Skills

Develop your expertise and skills to ensure the best outcomes for learners.

13. Promote and support positive learner behaviour, attitudes and wellbeing.
14. Apply motivational, coaching and skill development strategies to help learners progress and achieve.
15. Plan and deliver learning programmes that are safe, inclusive, stretching and relevant to learners' needs.
16. Select and use digital technologies safely and effectively to promote learning.
17. Develop learners' mathematics, English, digital and wider employability skills.
18. Provide access to up-to-date information, advice and guidance so that learners can take ownership of their learning and make informed progression choices.
19. Apply appropriate and fair methods of assessment and provide constructive and timely feedback to support learning and achievement.
20. Develop enrichment and progression opportunities for learners through collaboration with employers, higher education and/or community groups.

Table 2. 2 Professional Standards for Teachers and Trainees (https://www.et-foundation.co.uk/professional-standards/teachers/)

The 2010–15 Coalition government introduced a number of significant reforms for post-16 education, including a renewed emphasis on English and mathematics study for any student who has not achieved grade A* to C (now 9 to 4) in mathematics and/or English GCSE, by age 16, to continue to work towards achieving these qualifications (Education and Training Foundation, 2014).

After all these ‘reforms,’ there is little evidence of their impact in improving the ITE in FE (Greatbatch & Tate, 2018), and the fragmentation and impoverishment experienced by trainees learning to teach in the FE remains a constant theme that the barrage of national standards, regulations and assessment units have done little (Lucas et al., 2012). The sector suffers from too much centrally driven change, too many initiatives, and too many policies. This creates instability for learners and for institutions. The pace of change and the proliferation of initiatives have been intense, and changes to targets, funding rules and paperwork have diverted staff attention away from the central task of teaching (Lawy & Tedder, 2011). Practitioners have dealt with wave after wave of new policies, updates to qualifications and teaching requirements, and this makes it very challenging to implement further recommendations into a sector which is suffering from initiative fatigue (Education and Training Foundation, 2014). However, since the establishment of the Education and Training Foundation (ETF) in 2013, the FE sector seems to be stable with regard to ITE policy changes; for example, professional standards introduced in 2014 were still in use by the time of finalising this study. This study was conducted in a period of relative regulatory stability.

2.1.2 Initial Teacher Education (ITE) in Further Education and Training sector (FE) after reforms

While a high proportion of teachers who practice in primary and secondary schools are trained in a pre-service university setting, FE colleges train the majority of their teaching staff on an in-service, part-time basis (Kentzer et al., 2019). Greatbatch and Tate (2018) observe that FE student teachers often undergo ITE as part of a career change or add a part-time teaching role to an existing technical profession and have a more diverse background in terms of educational and professional or vocational experience than is the case for those training to teach in schools. Maxwell (2014) observes that on entry to teaching, FE student teachers vary in age, career stage, education and work experiences and so they bring to the workplace diverse sets of subjective dispositions towards work and learning. In contrast to entry into school teaching, around 90% of FE teachers are employed untrained and complete their ITE on a part-time in-service basis at the average age of 37 (Greatbatch & Tate, 2018). This means around 10% of the teachers are trained at university and some come from secondary schools. Most student teachers in FE are pursuing teaching as a second or alternate career, and they face unique challenges such as difficulty in adapting to school culture often very different from the workplace culture they are accustomed to and developing an identity as a teacher (Brown & Everson, 2019). Research evidence shows that prior experiences as a learner, prior vocational experience, vocational identity and life experiences significantly influence workplace engagement (Maxwell, 2014).

ITE in FE is mostly generic (Lucas, et al, 2012) and the qualifications of teachers are too many and often confusing (see Section 1.2.6). FE colleges who are the main providers of ITE for the sector's student teachers offer ITE courses at levels 3, 4, 5, 6, and 7 and those offered at level 5 and above are often run in conjunction with university partners.

2.1.3 Teaching mathematics in the Further Education and Training sector (FE)

There is evidence that successful teaching of mathematics and English in FE has been hampered by lack of specialist mathematics and English teachers on one hand, and lack of mathematics and English expertise in vocational teachers on the other hand (Greatbatch & Tate, 2018). Noyes and Dalby (2020) observe that due to the shortage of mathematics teachers, some colleges have attracted mathematics teachers from secondary schools, but these teachers do not always have sufficient experience of teaching disaffected students, and this transition frequently requires a period of adjustment as the schoolteachers learn to adapt their pedagogy to suit FE students and also understand how to work within the complex systems and communication channels within FE colleges.

According to Noyes and Dalby (2020), FE teachers often describe a pastoral dimension of their roles, which requires patience with, and understanding of, these students as very important with teaching the subject content sometimes seeming like a secondary consideration. Noyes and Dalby (2020) observe a wide agreement amongst managers that teaching students who are retaking mathematics needs a special type of teacher, one who preferably has a background of working with lower-level learners and can build relationships with them but is also sufficiently robust to deal with the challenges, and some teachers feel they need specialist skills training to deal with the level of emotional and behavioural difficulties that they encounter in their mathematics classrooms. The teachers' mathematical knowledge is viewed with varying degrees of importance with opinions vary on whether the role is best suited to a mathematics specialist who has to adapt their approach to suit FE students or a good teacher who has to upgrade their mathematics knowledge, and some non-specialist teachers believe that their own struggles with mathematics in the past help them relate to students (Noyes & Dalby, 2020). Mathematics teachers need the skills to address factors which negatively affect FE student by using pedagogies that are responsive to students' needs, allowing them to build confidence and resilience (Noyes & Dalby, 2020). Teaching mathematics in FE primarily involves working with low-attaining students who consider themselves 'failures' meaning teaching GCSE mathematics in post-16 education can be very different from teaching the same qualification to pre-16s in school, and there is need for sector-specific training to prepare mathematics teachers for the FE context (Noyes & Dalby, 2020).

Teaching mathematics at FE (and probably at school) is challenging due to the attitude towards the subject in the UK. Mathematics education in the UK is arguably subject to greater political and media scrutiny than any other subject because of its importance to a number of key stakeholder groups, the growing influence of international league tables and, ultimately, its influence on individual and collective economic productivity (Dalby & Noyes, 2016). Unfortunately, there are popular views that mathematics is a hard and boring subject (Jaworski & Watson, 2014). Cornish and Richardson (2019) has the following to say about attitude towards mathematics:

> Along with many misconceptions about the value and usage of maths in adult life, the problem is exacerbated by a culture in the UK where it surprisingly acceptable to be negative about maths. It's not uncommon to hear people say, "I'm bad at maths" or "numbers aren't my thing," with some even wearing this as badge of pride (p. 1).

It seems these views are more pronounced in FE where many young adults on vocational courses can be disengaged from and have negative attitudes towards learning mathematics (Education and Training Foundation, 2014). This makes the teaching of mathematics challenging and the student teachers have to be properly mentored to deal with the challenges.

2.1.4 Mathematics students in the Further Education and Training sector (FE)

As mentioned while discussing reforms in ITE in FE (Section 2.1.1), the 2010–15 Conservative and Liberal Democrats Coalition Government introduced a number of significant reforms for post-16 education, including a renewed emphasis on English and mathematics study. In Autumn 2010, the then Secretary for Education, Michael Gove, tasked Professor Alison Wolf to review vocational education because of weak technical education which remains weaker than most other economically developed nations (Wolf, 2011). Following the Wolf Report, on 12 May 2011 the Government legislated that from September 2013, all young people who do not achieve at least a GCSE Grade C (now Grade 4) in mathematics and English have to continue studying those subjects post-16 until they achieve Grade C (4) (or above) (Department for Education, 2011). The implementation of the Wolf's recommendation led to an increase in the number of mathematics students in FE. The Education and Training Foundation (2014) reports that three quarters of full-time students who have not achieved a mathematics GCSE at Grade C (4) or above, by the age of 16, enter FE colleges.

These students enrol into college to learn trades of their choice like *Construction* and *Bricklaying*, and they are 'forced' to study mathematics; therefore, they become negative towards mathematics.

Besides being ‘forced’ this negativity can be caused by multiple factors, including negative prior experiences with learning, peer pressure and lack of confidence (Greatbatch & Tate, 2018). Additionally, Noyes and Dalby (2020) report teachers’ concerns about the number of students with ‘troubled backgrounds’ and issues in their home lives that affect progress, such as taking on increased responsibilities for siblings or being under pressure to make a contribution to family income by working part-time. Noyes and Daldy (2020) also view the prevailing culture in the local area as having an influence on students’ aspirations and values, which lead to different motivations and attitudes to mathematics. Those colleges located in socially deprived areas encounter significant challenges with mathematics, especially when students’ intentions are to get local low skilled employment while students in colleges located in affluent areas aspire more skilled positions or higher education for which GCSE mathematics is an entry requirement typically have stronger motivation (Noyes & Dalby, 2020).

Students having negative learning experiences of mathematics in the past, results in one or more of the following: low levels of confidence and self-efficacy, negative attitudes and emotions, and lack of motivation and engagement, and students not having some of the ‘basic’ mathematics knowledge and skills that would be expected (Noyes & Dalby, 2020). There is need to teach basic concepts and processes before progressing to other work to avoid over-reliance on memorisation of routines by students but developing understanding of fundamental concepts and processes is not compatible with the aims or pace of a one-year revision course and this presents FE teachers with a dilemma. This implies that students come to college without the basic concepts, and college mathematics teachers are ‘expected’ to have them pass with at least a Grade 4. Due to the pressure on teachers to improve the grades of the students in one year; understandably, procedural teaching is employed as teachers are teaching for examinations. The limited teaching time was reported in The Guardian (2014) with a heading, “College tutors can't do in 36 weeks what teachers fail to achieve in 11 years.”

In most cases the negativity towards learning of mathematics is shown through low attendance in lessons. Student attendance is typically polarised into a group of reliable, regular attenders and those with irregular patterns of attendance, including ‘persistent offenders’ who sometimes refuse to attend at all (Noyes & Dalby, 2020). However, students become motivated if the skills they are developing appear to have some personal relevance and ‘use-value.’ Connections to their vocational study programme can highlight the ‘use value’ of mathematics but when the content of mathematics lessons has no obvious connection or practical use, students are less inclined to engage with the subject matter (Noyes & Dalby, 2020).

After discussing the FE context in which this study is located, I now turn to the mathematical and pedagogical knowledge for teaching.

2.2 Mathematical and pedagogical knowledge for teaching

Ball and Bass (2002) discuss the work that teachers have to do in order to teach effectively and highlight the difference between being able to do a piece of mathematics oneself (mathematical knowledge) and being able to explain and contextualise it for learners (pedagogical knowledge). Teachers' knowledge is one of the factors that affect the teaching process, as it has implications for what teachers teach, how they teach it and why they choose to teach it in a specific way (Shulman, 1986). It cannot be taken as a contested area that mathematics teachers should have mathematical and pedagogical knowledge, but the type of the knowledge required to teach at a particular level is an area that needs debate.

2.2.1 What knowledge should mathematics teachers have?

Rowland et, al. (2005) observe an uninformed perspective that secondary (and FE) teachers already have mathematical knowledge needed for teaching, and elementary teachers need very little of it. There is evidence from the United Kingdom and beyond to refute both parts of that statement (Rowland et, al., 2005). The claim that prospective and qualified teachers might not have the 'adequate' mathematical knowledge can be evidenced by the Government initiatives to enhance the mathematics subject knowledge of prospective and serving teachers under the funded scheme: *Subject Knowledge Enhancement (SKE)* courses (Department for Education, 2020). The problem of teachers who do not have 'adequate' mathematical and pedagogical knowledge seems to be worse in FE as claimed by Greatbatch and Tate (2018) who observe that "Education and Training Foundation (ETF) offer over 20 different courses to support effective teaching of English and mathematics for teachers of GCSE, functional skills…." (p. 36).

It is generally agreed that 'good' subject knowledge is an important prerequisite for successful teaching; however, what constitutes 'good' subject knowledge is debatable, with multiple perspectives taken by policymakers, researchers and schools (Stevenson, 2020). It is not clear what the amount of knowledge needed to successfully teach at a particular level is, but it is clear that lack of teacher's content knowledge leads to ineffective teaching as Capraro et al. (2005) put it: "Lack of mathematical content knowledge leads to ineffective mathematics instruction" (p. 113).

There is an ongoing international debate as to what knowledge is essential for student teachers to acquire in order to become successful (Lin & Acosta-Tello, 2017). Campton and Stevenson (2014) view a comprehensive knowledge and understanding of academic mathematics as not important, but more an understanding of the mathematics within the curriculum that is taught; the quality of the teacher's mathematical knowledge and how this is used within teaching as of greater importance than its standing in the qualifications field. Campton and Stevenson's (2014) assertion is seen to be in agreement with Ma (1999) who argues that teachers must possess an in-depth understanding of the mathematics at the level being taught which she calls *Profound Understanding of Fundamental Mathematics' (PUFM)*. However, Ball et al. (2005) seem not to have a straightforward answer to the question: What constitutes good subject knowledge? They say that although many studies demonstrate that teachers' mathematical knowledge helps support increased student achievement, the actual nature and extent of that knowledge— whether it is simply basic skills at the grades they teach, or complex and professionally specific mathematical knowledge—is largely unknown.

Most of those who work in education would agree that whilst formal academic qualifications are important, as "[y]ou cannot teach what you don't know" (Kilpatrick et al., 2001, p. 373), they are not sufficient alone for successful teaching. Many researchers (for example, Nabb & Murawska, 2020; Hill & Ball, 2009; Turnukul & Yesildere, 2007) agree that knowledge of mathematics is necessary but insufficient to teach mathematics. Besides the mathematics knowledge, teachers have to know how to teach, that is having Pedagogical Content Knowledge (PCK) for teaching mathematics. Knowing what resources to use to teach a particular idea or process and being able to explain in a way that students understand are essential components of mathematics teaching (Rowland et al., 2009). Good teachers know both content (mathematical knowledge) and how to 'get it across' to their students (pedagogical knowledge) but specifying this knowledge has proven surprisingly difficult (Hill & Ball, 2009). Ball et al. (2008) observe that "[s]till, however, the field has made little progress on Shulman's initial charge: to develop a coherent theoretical framework for content knowledge for teaching. The ideas remain theoretically scattered, lacking clear definition" (p. 394). Since this observation was made in 2008, nearly two decades ago, and considering the substantial research activities in the area since then, it is possible that significant progress has been made.

The key to student learning is the teacher's mathematical knowledge for teaching. However, researchers acknowledge that its nature and role is still unclear (Nabb & Murawska, 2020), and there has been and there is still a lot of research activities in this area. Teacher knowledge: knowledge teachers use and need for their craft of teaching has been described as complex and existing in many facets (Livy, 2012). Although different scholars express different views on the knowledge bases of teachers, they do agree on some fundamental knowledge bases such as subject matter and pedagogy (Shing et al., 2015). The next section discusses how different researchers conceptualise teachers' mathematical and pedagogical knowledge.

2.2.2 Conceptualizations of mathematical and pedagogical knowledge

There are many different theoretical frameworks of mathematical knowledge needed for effective teaching, but there is no agreement on a widely accepted model that can be used to describe teachers' mathematical knowledge for teaching (Petrou & Goulding, 2011). "Throughout the past two decades [now more than three decades], researchers within the field of mathematics teacher education have been expanding the notion of PCK (Pedagogical Content Knowledge) through the developing of more fine-grained conceptualizations of this knowledge for teaching mathematics" (Silverman & Thompson, 2008, p. 500). In the sections that follow, I trace 'key' theoretical frameworks since 1985. My choice of 1985 is influenced by Shulman's publication - *Those who understand: Knowledge Growth in Teaching* - in 1986 which has triggered a lot of interest in teacher education, and I have decided to start my review a year before the publications. The importance of Shulman's work is noted by Mecoli (2013) who says, "Pedagogical Content Knowledge (PCK), Shulman's (1986) theoretical framework, has had a substantial influence on research in preservice teacher education, and consequently, schools of education" (p. 21).

2.2.2.1 Leinhardt and Smith's (1985) Subject Matter Knowledge to Lesson Structure Framework

Leinhardt and Smith (1985) use teachers' experience as a contrasting point to identify dimensions of mathematics knowledge for teaching. They study four expert and four novice fourth-grade mathematics teachers on the topic of fractions. The study includes three months of observational field notes, videotaped lessons and interviews. The study identifies two aspects of knowledge for teaching: subject matter knowledge and lesson structure knowledge. Subject matter knowledge consists of concepts, algorithmic operations, the connections among different algorithmic procedures, the subset of the number systems being drawn upon, the understanding of classes of student errors, and curriculum presentation. The lesson structure knowledge includes planning and running a lesson smoothly and providing clear explanations of the materials covered.

2.2.2.2 Shulman's (1986) framework of Content Knowledge in Teaching

Early studies dating from the 1960s reveal an assumption implicitly held regarding teacher knowledge which is: effectiveness in teaching resides simply in the mere subject matter knowledge a teacher has accrued. This assumption still hold water among many people including mathematics teachers, as observed by Turnukul and Yesildere (2007) who say the common belief in society is if a mathematics teacher knows mathematics very well, he or she is the best person to teach mathematics. This assumption ignores the “knowing to teach mathematics” (Turnukul & Yesildere, 2007, p. 1).

Research was exclusively focused on general aspects of teaching. Subject matter and its role in teaching or teacher thinking was less prominent, so little attention was devoted to examining content and its role in instruction. Shulman (1986) notes the existence of “a blind spot with respect to content that now characterizes most research on teaching” (p. 7) which he dubbed ‘the missing paradigm’. The most important claim in Shulman’s account is that both knowledge of the subject and knowledge of pedagogy are needed in effective teaching (Petrou & Goulding, 2011). The central contribution of Shulman and his colleagues was to reframe the study of teacher knowledge in ways that attend to the role of content in teaching (Ball, et al., 2008) by introducing the theoretical framework of *Content Knowledge in Teaching*, which is divided into three categories: *Subject Matter Knowledge (SMK), Pedagogical Content Knowledge (PCK)* and *Curriculum Knowledge (CK)* (Shulman, 1986).

SMK is the amount and organisation of knowledge in the mind of the teacher: it is knowledge of the content of the discipline per se (Shulman, 1986). Shulman’s (1986) conceptualisation of *SMK* includes Schwab’s (1978) distinction between substantive knowledge and syntactic knowledge. Substantive knowledge refers to the facts, concepts and processes of mathematics and the links between them such as knowing the properties of an isosceles triangle. Syntactic knowledge concerns the process of doing mathematics rather than the product of such activity which includes knowing how to prove an idea through deductive reasoning; for example, being able to demonstrate why the sum of two odd numbers must always be an even number (Rowland et al., 2005). *PCK* is the integration or amalgamation of pedagogy and content knowledge which basically covers the "what" and "how" of teaching, which is presented by Hyde and Jones (2014) as a Venn diagram (Figure 2.1). *PCK* consists of the ways of representing the subject to makes it comprehensible to others; how teachers transform their own knowledge into a form that makes it accessible to learners (Rowland et al., 2009). *Curriculum knowledge* refers to knowing what it is that students are expected to learn that includes knowledge of different programmes and corresponding materials (for example, textbooks and online resources)

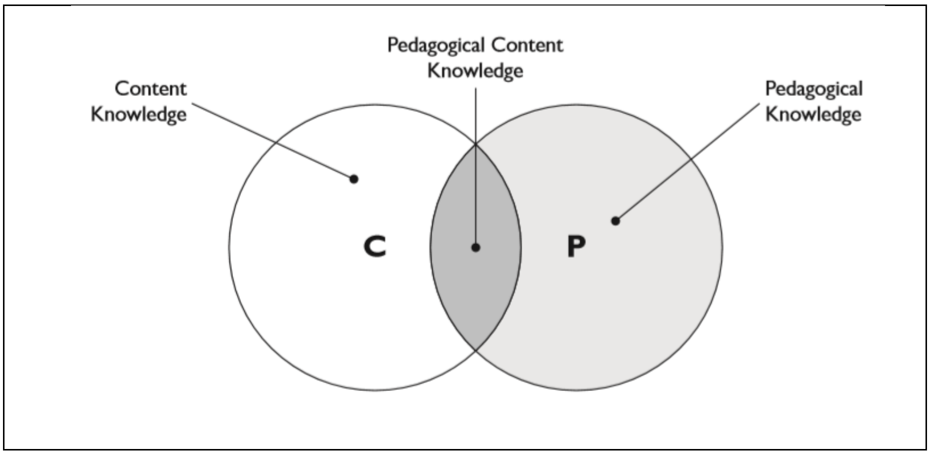


Figure 2. 1 Pedagogical Content Knowledge (Hyde & Jones, 2014. p. 34)

available for teaching the given content (Shulman, 1986). It goes beyond an awareness of the different programmes and materials to also include knowledge of the effectiveness and implications of programmes and materials for given contexts. *Curriculum knowledge* also entails knowledge of content and corresponding materials in other subject areas of students and consists of knowledge of how topics are developed across a given programme (Shulman, 1986).

In 1987, Shulman and his colleagues come up with seven categories of the knowledge base: content knowledge; general pedagogical knowledge; curriculum knowledge; pedagogical content knowledge; knowledge of learners and their characteristics; knowledge of educational contexts; and knowledge of educational ends, purposes and values, and their philosophical and historical grounds. From the seven, researchers like Rowland et al. (2009) and Ball et al. (2008) identify *SMK, PCK* and *Curriculum knowledge* as related to content specific knowledge.

The research findings by Shulman have added knowledge and expanded the available literature related to subject matter and pedagogical knowledge for teaching. Subsequently, researchers identify inadequateness in Shulman's conception, and they begin to refine, modify, expand and derive new conceptions (Shing et al., 2015). Shulman's work gives rise to new categorisations of teacher knowledge, and it is vastly reported in the literature with much of the research from the past two (now four) decades stemming from it (Liston, 2015). In the next sections, I discuss some of the frameworks with stem from Shulman's work.

2.2.2.3 Grossman's (1990) Model of Teacher Knowledge

With the aim of identifying the domains of *SMK* necessary for effective teaching, Grossman, one of Shulman's research team members, study six first-year English teachers in secondary schools. Based on her study, Grossman (1990) reorganises the seven categories defined by Shulman (1987) into four main categories: *Subject-matter knowledge, General pedagogical knowledge, Pedagogical Content Knowledge, and Knowledge of context* (Figure 2.2).

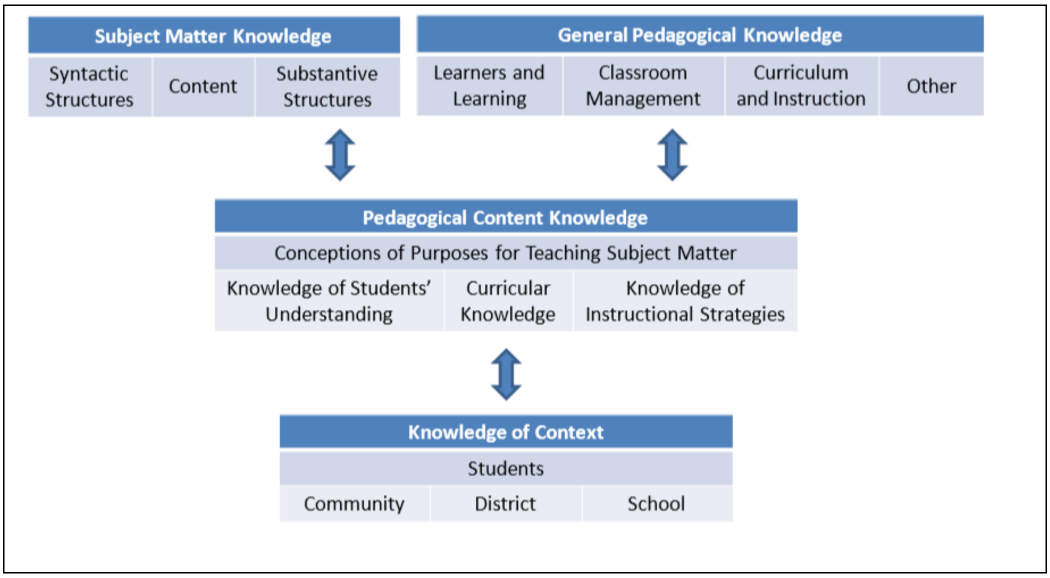


Figure 2. 2 Model of Teacher Knowledge (Grossman, 1990., p. 5).

Grossman (1990) retain Shulman's (1986) *SMK* category which includes Syntactic structures, Content and Substantive knowledge. Grossman (1990) comes up with the *General Pedagogical Knowledge* which contains Learners and Learning, Classroom Management, Curriculum, and Instruction and other. It is not clear what Grossman (1990) mean by 'other'. The third category which is at the heart of the model is *PCK* which is composed of Knowledge of Students' Understanding, Curriculum Knowledge and Knowledge of Instructional Strategies. The last category is *Knowledge of Context* which is composed of Students, Community, District and School.

Grossman (1990) places Shulman's third component of curriculum knowledge into the *PCK* category, separate from Curriculum and Instruction which is in *General Pedagogical Knowledge*. Knowledge of Instructional Strategies in the *PCK* category is separated from Instructions in the *General Pedagogical Knowledge* category. The overlapping and duplication of components in different categories make the model difficult to understand and more importantly extremely difficult to apply in practice.

2.2.2.4 Fennema and Franke's (1992) Model of Teachers' Mathematical Knowledge

In the *Handbook of Research on Mathematics Teaching and Learning*, Fennema and Franke (1992) propose a *Model of Teachers' Mathematics Knowledge* (Figure 2.3) that includes four categories related to knowledge: *Knowledge of Mathematics, Context Specific Knowledge, Pedagogical*

Knowledge, and *Knowledge of Learners' Cognition in Mathematics*. Teachers' beliefs are also part of the model interacting with teacher knowledge. The four components influence each other, and they are all situated in the classroom.

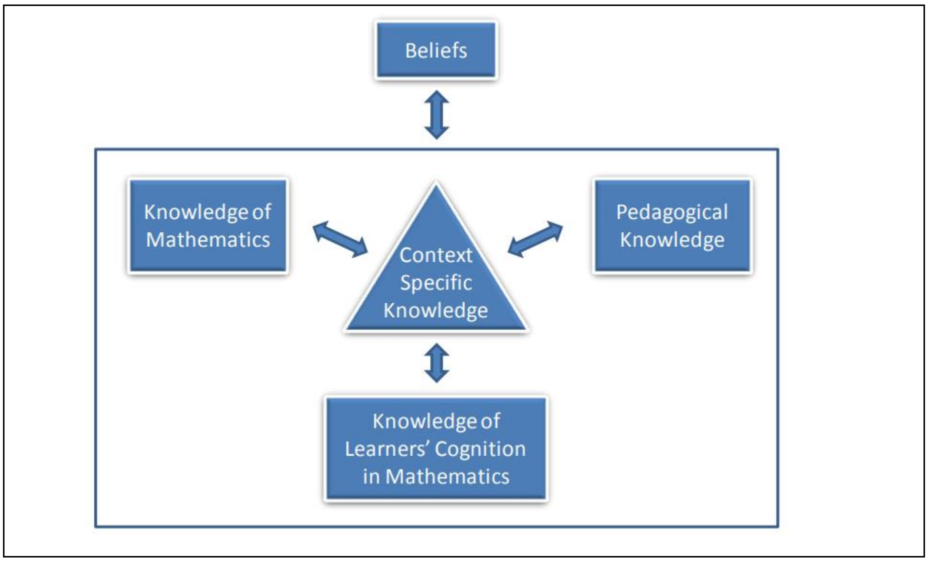


Figure 2. 3 Model of Teacher Knowledge (Fennema & Franke, 1992, p. 162)

The first component *Knowledge of Mathematics* comprises knowledge of the concepts, procedures, and problem-solving processes; this includes knowledge of the concepts underlying the procedures, the interrelatedness of these concepts, and how these concepts and procedures are used in various types of problem solving. Fennema and Franke (1992) argue that if a teacher has a conceptual understanding of mathematics, this influences classroom instruction in a positive way; however, procedural rules are also important. The component *Pedagogical Knowledge* includes knowledge of teaching procedures such as effective strategies for planning, classroom routines, behaviour management techniques, classroom organizational procedures, and motivational techniques. The third component, *Knowledge of Learners' Cognitions in Mathematics*, includes knowledge of students' thinking and learning processes. The last component, *Context Specific Knowledge*, is a unique set of knowledge that drives teachers' classroom behaviour. Central to Fennema and Franke's (1992) conceptualisation is the claim that knowledge is interactive in nature, and that, in a given context, teachers' knowledge of content is related to knowledge of pedagogy and students' cognition and combines with beliefs to create a knowledge set that determines teaching practices and teachers' behaviour in the classroom (Petrou & Goulding, 2011). According to this model, all aspects of teacher knowledge and beliefs are related to each other (Petrou & Goulding, 2011).

2.2.2.5 Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPCK)

Mishra and Koehler's (2006) framework articulating *Technological Pedagogical Content Knowledge (TPCK),* develops from the work of Shulman (1986) by adding a third circle labelled *Technology Knowledge (T)* which overlap this with *Pedagogical Knowledge (P)* and *Content Knowledge (C)* to form new categories of knowledge called *Technological Pedagogical Knowledge (TPK)* and *Technological Content Knowledge (TCK)* and, where all three circles overlap, is the *TPCK* (Figure 2.4).

Technology can be used to refer to artefacts: textbooks, pens, projectors, calculators and posters but the technology commonly used nowadays refers to digital technologies including computers and educational software (Mishra & Koehler, 2006). The term *Technological Knowledge* includes the skills required to operate hardware such as computers (and smart phones), to use 'standard' software tools such as word processors, web browsers and spreadsheets, and to manage documents, programmes and files (Hyde & Jones, 2014). *TCK* is about having an understanding of how technology and content, in this case mathematics, are related to one another (Hyde & Jones, 2014). *TPC* concerns the generic use of technology in teaching, and this relates to understanding how different tools and technologies can be used and how to select and use the appropriate tools in pedagogically appropriate ways in the classroom. *TPCK* is described as the basis of all good teaching with technology which requires a thoughtful interweaving of all the three key sources of knowledge: technology, pedagogy and content (Hyde & Jones, 2014).

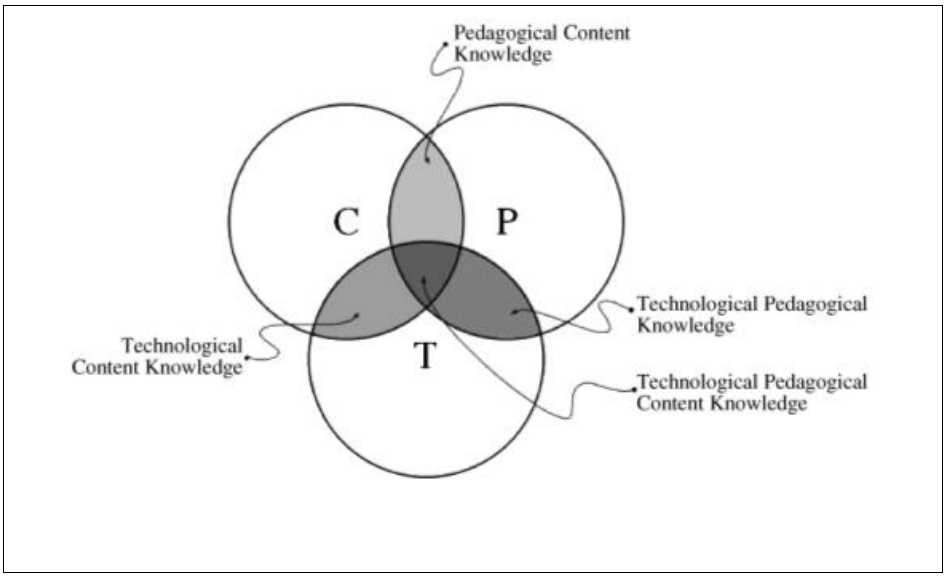


Figure 2. 4 Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006, p. 1024)

Despite several research studies proposing different theoretical frameworks, it seems many researchers (for example, Ball et al., 2008) are still influenced by Shulman's call for defining the role of content in teaching, and they use his work as a starting point for their studies.

2.2.2.6 Ball et al.'s (2008) Mathematical Knowledge for Teaching (MKT)

Shulman's ideas are not subject specific; they apply across the curriculum (Campton & Stevenson, 2014) and have been adopted and modified to a mathematics specific framework by Ball et al. (2008). While Ball et al. (2008) acknowledge Shulman's ideas as a breakthrough in understanding content knowledge for teachers, they argue that statements about 'what teachers need to know' are more normative than empirical; therefore, they develop a more empirical framework.

Ball's research team at the University of Michigan in the United States of America (USA) worked towards better understanding of the demands that the work of teachers places on their mathematical knowledge and understanding. Their work was grounded in the analysis of a database documenting a year of mathematics teaching in a third-grade public school classroom taught by Ball herself (Ball & Bass, 2002). The records included videotapes of teaching and student work, teacher planning and reflection (Ball & Bass, 2002). The theory which emerged from these studies is the *Mathematical Knowledge for Teaching (MKT)* (Figure 2.5). Ball and her colleagues created the term *Mathematical Knowledge for Teaching (MKT)* to refer to a special kind of knowledge required only for teaching mathematics (Ball et al., 2008; Hill et al., 2005).

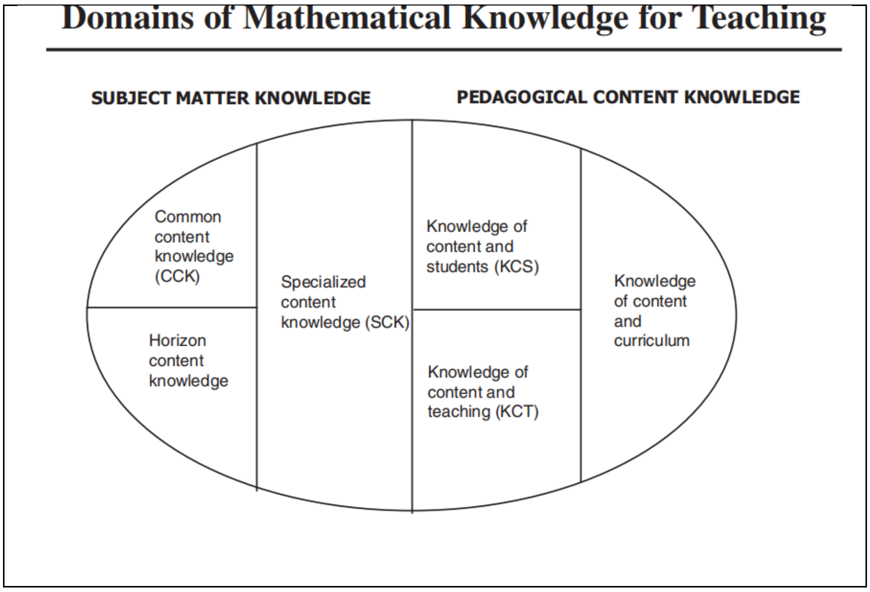


Figure 2. 5 Mathematical Knowledge for Teaching (Ball et al., 2008, p. 403).

The *MKT* unpacks and reconfigures the three kinds of content knowledge – subject matter, pedagogical and curricular – identified by Shulman (1986). *MKT* retains Shulman's distinction between *PCK* and *SMK*, but further subdivide them.

PCK is subdivided into three subdomains: Knowledge of Content and Students (KCS), Knowledge of Content and Teaching (KCT) and Knowledge of Content and Curriculum (KCC). KCS is the teacher's awareness of students' conceptions and misconceptions, and content for students of different ages, abilities, and background, KCT is the knowledge about the presentation of ideas to learners in the form of analogies, illustrations, examples, explanations and demonstrations, and KCC is the knowledge about teaching programmes designed for the teaching of particular subjects and topics at a given level (Ball et al., 2008). MKT like Grossman's (1990) framework, place Shulman's third category - curricular knowledge - within their PCK category. Ball at al. (2008) give two aspects of curriculum knowledge, which are often overlooked, as lateral knowledge and vertical knowledge. Lateral knowledge relates to cross-curricular connections which is the knowledge of what is taught in other subjects, and vertical knowledge is the knowledge of the mathematical experiences that precedes those of the current grade-level and what will follow in the next grades (Ball at al., 2008).

SMK is also subdivided into three subdomains: Common Content Knowledge (CCK), Specialised Content Knowledge (SCK) and Knowledge at the Mathematical Horizon (also known as Horizon Content Knowledge) (Ball et al., 2008). CCK is the mathematics knowledge which is not unique to teaching (Ball et al., 2008); for example, being able to calculate 34 x 87 is common knowledge as the calculation can be performed by any 'educated' person. Rowland (2013) describes SCK as that 'something extra' that mathematics teachers need in their work, and this 'something extra' refers to the knowledge unique to teaching as teachers need to know more than the procedure as they have to explain why the procedure works and what it means (Ball et al., 2008). SCK also includes building or examining alternative representations and evaluating unconventional student methods (Hill et al., 2004). Ball et al. (2008) say the demands of the work of teaching mathematics create the need for a body of mathematical knowledge that is specialized to teaching mathematics; for example, the knowledge and ability to analyse a piece of student's work such as a written calculation and understand the student's mathematical understandings and/or misconceptions. Rowland (2013) argues that this kind of mathematical knowledge, peculiar to teachers and teaching, was precisely what Shulman intended by PCK, and it appears to be similar to the idea of teachers knowing the 'how' and 'why' of mathematics. Knowledge at the Mathematical Horizon is an awareness of how mathematics topics are related over the span of mathematics included in the curriculum (Ball et al., 2008).

Like any theoretical framework, *MKT* has shortcomings; for example, the *MKT* developers, Ball et al. (2008) admit, “---we are not sure whether this category [knowledge of the mathematical horizon] is part of subject matter knowledge or whether it may run across the other categories.” (p. 403). It should also be noted that the boundaries between the categories are not always clear (Rowland, 2013; Nabb & Murawskab, 2020); for example, it may not be clear whether differentiating students’ mathematics tasks is KCT, KCS or SCK, and there is lack of a clear distinction between CCK and SCK (Flores et al., 2013). Rowland (2013) observe that “[t]he Michigan team is at pains to emphasize that the categories are not static, and that the boundaries are not always clear---” (p. 94). These and other criticisms led to the more conceptualisations; for example, the *Mathematics Teacher’s Specialised Knowledge (MTSK)* model.

2.2.2.7 Carrillo-Yañez et al.’s (2018) Mathematics Teacher’s Specialised Knowledge (MTSK)

Carrillo-Yañez et al. (2018) argue that the *MKT* categories focus “on practice as carried out in class, ignoring the knowledge that teachers might bring into play when carrying out any other kind of activity as a teacher” (p. 238). The starting point of Carrillo-Yañez et al.’s (2018) *Mathematics Teacher’s Specialised Knowledge (MTSK)* framework is the assumption that in order to carry out their role, the teachers needs specific knowledge. The definitions for each sub-domain of *MTSK* are constructed in terms of what the teacher use/need, without reference to external agencies (other professions), thus avoiding the problems of overlap as in Ball at al.’s (2008) *MKT*. Carrillo-Yañez et al. (2018) note that the teacher’s classroom practice is deeply influenced by what can be loosely termed a philosophy of mathematics, that is a more or less coherent set of conceptions and beliefs about mathematics, how it is learnt and how it should be taught, which permeate the teacher’s knowledge in each of the sub-domains. Therefore, *MTSK* also includes beliefs about mathematics and about mathematics teaching and learning, and these are represented at the centre of the framework (Figure 2.6) to underline the reciprocity between beliefs and knowledge domains. The *MTSK* has two main categories; *Mathematical Knowledge* and *Pedagogical Content Knowledge (PCK)*.

Mathematical Knowledge is similar to Shulman’s (1986) definition of content knowledge but goes on to consider the characteristics of mathematics as a scientific discipline, and the difference between mathematics per se and school mathematics (Carrillo-Yañez et al., 2018).

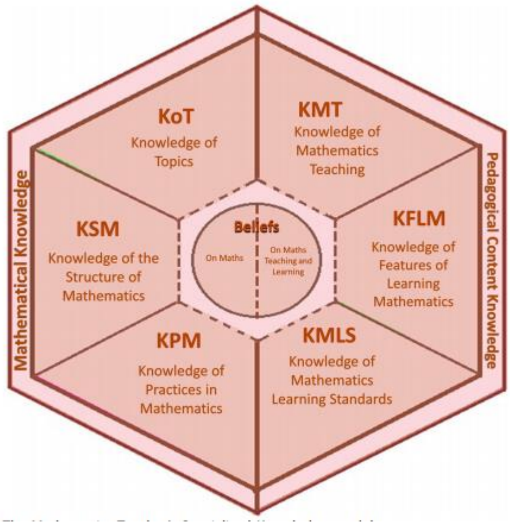


Figure 2. 6 The mathematics teacher's specialised knowledge (MTSK) model (Carrillo-Yañez et al., 2018, p. 241)

It includes three sub-domains: Knowledge of Topics (KoT) which is about knowing the mathematical content itself, Knowledge of the Structure of Mathematics (KSM) which is about the interlinks and connections between mathematical concepts, and Knowledge of Practices in Mathematics (KPM) which is about how one works systematically in mathematics (Carrillo-Yañez et al., 2018).

PCK includes pedagogical knowledge that arises mainly from mathematics and its teaching. It excludes general pedagogical knowledge even if it is applicable to mathematical contents. Its subdomains are Knowledge of Mathematics Teaching (KMT) which can be developed from familiarizing self with research or from personal experiences, Knowledge of Features of Learning Mathematics (KFLM) which focuses on mathematical content and how students construct meanings, and Knowledge of Mathematics Learning Standards (KMLS) which includes ways of assessing students' levels such as curriculum specifications (Carrillo-Yañez et al., 2018).

Theoretical frameworks; for example, Ball et al. (2008) *MKT* and Carrillo-Yañez et al. (2018) *MTSK* aim to unpack and clarify the elusive and theoretically underdeveloped notion of *SMK* and *PCK*, and categorise different teacher knowledge. In the next section, I discuss a framework - the Knowledge Quartet (KQ) - in which the distinction between different kinds of mathematical knowledge is of lesser significance than the classifications of the situations in which the mathematical knowledge surfaces in teaching (Rowland, 2013).

2.2.2.8 Rowland et al's (2003) Knowledge Quartet

The KQ is a framework for the analysis of mathematics teaching, with a focus on teacher knowledge, and in this sense, it is also a tool for organising the complexity of mathematics classrooms (Rowland et al., 2015), and it can also be defined as a practice-based framework for the observation, analysis and improvement of mathematics teaching […], with a focus on the contribution of the teacher's mathematics-related knowledge (Rowland & Turner, 2017).

In this section I discuss how the KQ was developed. I then move on to define and discuss the KQ dimensions and their respective codes. The section is concluded by discussing the rationale for selecting the KQ as the theoretical lens through which student teachers' mathematical and pedagogical knowledge enacted during teaching is made visible.

The development of the Knowledge Quartet

In 2002–2003, University of Cambridge researchers undertook some empirical research investigating student teachers' mathematics-related knowledge, and the ways that this knowledge is activated and made observable both in their planning and in their teaching in the classroom (Rowland & Turner, 2017). The purpose of the research was to develop an empirically based conceptual framework for lesson review discussions with a focus on the mathematics content of the lesson and the role of the student teachers' mathematics subject matter knowledge (SMK) and pedagogical content knowledge (PCK) (Turner & Rowland, 2010). "In a nutshell, the Cambridge team wanted to identify, and to understand better, ways in which elementary teachers' mathematics content knowledge, or lack of it, is made visible in their teaching" (Rowland, 2013, p. 17).

The researchers observed and videotaped 12 Postgraduate Certificate in Education (PGCE) primary student teachers in their final year twice, thus having 24 videotaped lessons (Rowland et al., 2009). Applying the grounded theory approach (Glaser & Strauss, 1999) to the videotapes, the researchers watched the tapes of lessons, usually in twos and threes, sometimes as a whole team identifying aspects of the trainees' actions in the classroom that seemed to be significant in the limited sense to be informed by the trainee's mathematical subject knowledge or mathematical pedagogical knowledge (Rowland et al., 2009). The researchers homed in on particular moments or episodes in the tapes and each such moment or episode was assigned a preliminary code, which the researchers invented, although some were repeated if they looked like the same kind of phenomenon in different episodes within the same, or another, lesson (Rowland et al., 2009). Different codes that seemed to be describing the same thing were merged and some codes which turned out to occur only a few times over all the 24 lessons were abandoned and 18 codes were left. Eventually the 18 codes were group into four ‘big idea’/ categories (*Foundation, Transformation, Connection,* and *Contingency*), which were later called the Knowledge Quartet (Rowland et al., 2009).

The KQ dimensions are not and should not be treated as separate entities. Rowland et al. (2009) demonstrated this by discussing fractions:

> In terms of the Knowledge Quartet, this means that teachers need a certain kind of foundation knowledge of fractions on which they base a transformation for teaching purposes. Without this knowledge, it is difficult to help children to make connections between the various ways that fractions can be represented. (p. 104).

Turner and Rowland (2010) advise that the practical application of the KQ depends more on the understanding of the characteristics of the broad four dimensions than the recall of the contributory codes. In the next section, I discuss the four ‘big ideas’ – the Knowledge Quartet dimensions - and their respective codes.

The Knowledge Quartet (KQ) dimensions and codes

Before getting into detailed discussion of the KQ dimensions, it is important to mention that three of the four dimensions: *Transformation, Connection,* and *Contingency,* rest on *Foundation* (see Figure 2.7 also in Chapter 1, Figure 1.2) and they are descriptions of situations that may arise in the course of a mathematics lesson, as opposed to types of knowledge as the other theoretical frameworks (Weston, 2013), discussed earlier.

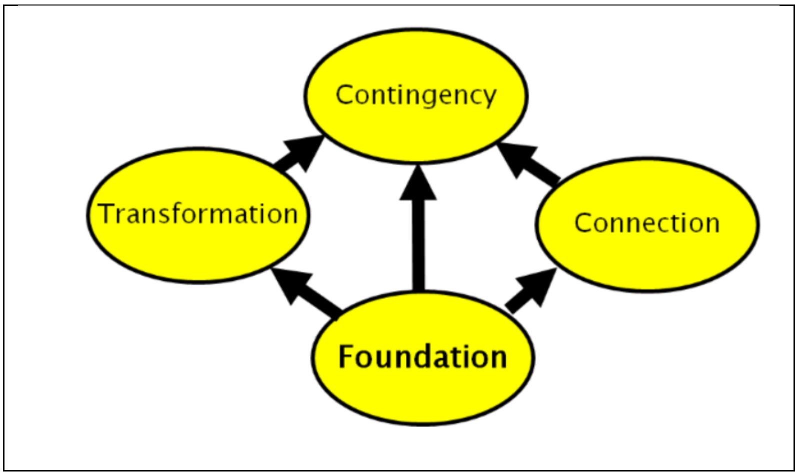


Figure 2. 7 The Knowledge Quartet (http://www.knowledgequartet.org/)

Foundation

Foundation involves theoretical background, which is the kind of knowledge acquired at school, or in teacher education, irrespective of whether it is being put to purposeful use (Rowland et al., 2009). The conceptualisation of this dimension includes trainees' beliefs, knowledge and understanding gained both in their personal education and in their learning in training, in preparation for their role in the classroom (Thwaites, et al., 2005). For example, a GCSE mathematics teacher might have been taught differential equations at A-Level. This knowledge is counted as foundation knowledge, but the teacher might not directly put it to use in the classroom. *Foundation* refers to the knowledge, conceptions and beliefs that beginning teachers bring with them from their own mathematical background. It is the knowledge that teachers bring to the teaching situation (Thwaites, et al., 2005). *Foundation* could be compared to Shulman's (1986) *Subject Matter Knowledge (SMK)* (Campton & Stevenson, 2014). *Foundation* knowledge may also be described as knowledge of the facts, concepts, processes, and connections within the subject (substantive knowledge) as well as the way in which knowledge within that subject is investigated and developed (syntactic knowledge) (Rowland & Turner, 2017). Both of these aspects of subject-matter knowledge - substantive and syntactic - are important facets of foundation knowledge, but they do not make up the whole picture (Rowland et al., 2009). *PCK* is also seen as a key component within foundation knowledge as teachers need to understand the ways in which pedagogical strategies relate to the mathematics, they are trying to teach in order to make decisions about which strategies to use (Rowland et al., 2009). The possession of such knowledge - substantive and syntactic- has the potential to inform pedagogical choices and strategies in a fundamental way (Rowland, 2013).

The codes for *Foundation* are: Theoretical underpinning of pedagogy; Adherence to textbook; Awareness of purpose; Reliance on procedures; Overt subject knowledge; Use of terminology; and Identifying student errors (Rowland & Turner, 2017).

- *Theoretical Underpinning of Pedagogy*

  According to a project by a team of researchers[7], one of the descriptors/aspects of Theoretical Underpinning of Pedagogy is drawing on knowledge of well-established results in

---

[7] The research team is composed of the following: Tim Rowland, University of East Anglia/University of Cambridge, UK; Tracy Weston, University of Alabama, US; Anne Thwaites, University of Cambridge, UK; Fay Turner, University of Cambridge, UK; Bodil Kleve, Oslo and Akershus University College of Applied Sciences, NO; Dolores Corcoran, St. Patick's University, IE; Ray Huntley, Brunel University, UK; Gwen Inson, Brunel University, UK; Marilena Petrou, Cyprus/UK; Ove Gunnar Drageset, University of Tromsoe, NO; Nicola Bretscher, Kings College London, UK; Mona Nosrati, University of Cambridge, UK/NO; Marco Bardelli, IT; Semiha Kula, Dokuz Eylül University, TR; Esra Bukova Guzel, Dokuz Eylül University, TR. http://www.knowledgequartet.org/103/theoretical-underpinning-of-pedagogy/

mathematics education research regarding pupils' misconceptions to underpin the planning and/or delivery of the lesson (whether this is implicit through lesson observation or revealed explicitly through post-observation interview) (Rowland et al., 2012); for example, being aware of the misconception of "adding the tops and adding the bottoms" when adding fractions (see Hart, 1981, p. 66).

- *Adherence to textbook*

  Research suggests that teachers interpret textbook messages (and internet resources) about the aims of instruction and about what is good mathematics teaching in different ways, and that their interpretation influences the ways they use textbooks (and internet resources) in their teaching (Ball & Cohen, 1996). Curricular materials, such as textbooks (and internet resources), serve as a starting point and a guide for teaching, but rigid adherence to given materials may indicate gaps in specialized content knowledge (Ball et al., 2008).

- *Awareness of purpose*

  Awareness of purpose refers to the use of realistic contexts for mathematical problems which helps to give purpose to the teaching and learning of mathematics as well as helping to support pupils in carrying out tasks with understanding. It is what the students need to know or practice in order to solve similar tasks (Rowland et al., 2012).

- *Reliance on procedures*

  Reliance on procedures refers to how teachers follow well laid down steps in explaining concepts or ideas to students. Teachers who are more procedural believe that mathematics is about rules which have to be remembered (Goulding et al., 2002). Clinging to procedural approach shows an insecurity about using more conceptually oriented approaches and this shows some limitations in foundation knowledge (Rowland et al., 2000).

- *Overt Subject Knowledge*

  Teachers display 'overt knowledge' all the time when they demonstrate that they know themselves the subject matter that has been selected for the class to learn (Rowland et al., 2012); for example, being able to work through mathematics questions confidently and correctly.

- *Use of terminology*

  'Good' examples of proper use of terminology include: demonstrating knowledge of the correct mathematical terms and their precise meanings; correct use of mathematical terms and evidence of efforts to teach these terms; use alternative ways and more precise words to describe shapes (for example, if child says 'round' then the teacher suggests 'curved' while linking new word to child's word or words) (Rowland et al., 2012). Campton and Stevenson

(2014) view incorrect use of symbols and misunderstanding of technical mathematical vocabulary as ‘weak’ use of terminology.

- *Identifying errors*

  Teachers identify student errors and correct them. Teachers who have secure foundation knowledge can identify errors and correct them without causing confusion and promoting misconceptions (Rowland et al., 2009).

Transformation

Transformation picks out behaviour that is directed towards a pupil (or a group of pupils), and this follows from deliberation and judgement informed by foundation knowledge (Rowland, 2013). This is the dimension in which Shulman’s (1986) *PCK* may be observed, and it concerns teachers’ ability to transform their own mathematical knowledge into ways that make it accessible to learners (Campton & Stevenson, 2014).

The codes for *Transformation* are: Teacher demonstration; Choice of examples; Choice of representation; and (Mis)use of instructional materials (Rowland & Turner, 2017).

- *Teacher demonstration*

  Teacher’s demonstration refers to the way the teacher makes procedure/concept understandable to students and should relate to what the students already know. It involves the teacher’s knowledge to enable accurate demonstrations of how to carry out procedures (Campton & Stevenson, 2014).
- *Choice of examples*

  Teachers use examples in their lessons which Rowland et al. (2009) explain by saying, “Examples play an essential role in the teaching of concepts, in the teaching of procedures, and as exercises through which children become familiar with new ideas and fluent in the use and application of procedures” (p. 99).
- *Choice of representations*

  When assessing the effectiveness of a representation, Rowland et al. (2009) suggest two questions that might be considered:
    - Does this representation helpfully illustrate the concepts or procedures being taught?
    - Do the students have the prerequisite knowledge and understanding to make use of this representation? (p. 59).

Resources are used as representations and "---may be used in different ways, one of which might be as a representation to bridge the gap between the physical world and the abstract world of mathematics" (Rowland et al., 2009, p. 42).

- *Mis(use) of instructional materials*

  The instructional materials are used to explain the reason for a concept/procedure; for example, using counters to teach addition to children. Instructional materials could be used as scaffolds as Rowland et al., (2009) say, "[t]he use of such charts and cards reflects the move away from developing understanding through the physical manipulation of materials and towards a concentration on the relationship between the spoken and written forms of numbers" (p. 48).

Connection

Connection is anchored on the fact that mathematics differs to some extent from, say literature and history, which arguably make use of fewer technical interlocking concepts. This explains the rather linear form of the mathematics curriculum, at school and beyond as it is not possible to learn most mathematical topics without already having studied others (Rowland et al., 2009); for example, a student first understands addition before understanding multiplication, and should understand the connection as well. Mathematics is notable for its coherence as a body of knowledge and as a field of inquiry, and the cement that holds it together is reason. Mathematics is a network of related ideas, and learners make sense of mathematics by understanding how different ideas are related and linked to each other, and how some concepts build upon others (Rowland et al., 2009). According to Fennema and Franke (1992) mathematics is seen as a composition of a large set of highly related abstractions. Shulman's (1986) third aspect of his content knowledge model, *Curricular Knowledge*, can be observed within the *Connection* dimension, which is concerned with the ordering of topics and tasks, the level of challenge, and the links made with other areas of the curriculum (Campton & Stevenson, 2014).

According to Ma (1999), connectedness is a characteristic of teaching performed by the teacher who possesses *Profound Understanding of Fundamental Mathematics (PUFM).* A study by Askew et al. (1997) of King's College London, concludes that students of teachers with a strongly connectionist orientation are more likely to make greater gains than students of teachers with strong discovery or transmission orientations. The connective model (Figure 2.8), developed by Haylock (1982), helps to make explicit the connections between different mathematical representations: symbols, mathematically structured images (pictures), language and contexts (concrete experiences).

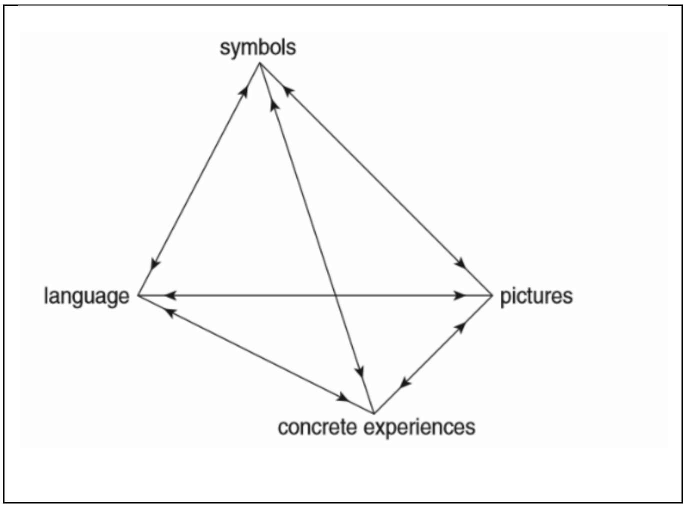


Figure 2. 8 Haylock connective model (adapted from Rowland et al., 2009, p. 113)

The codes for *Connection* are: Decisions about sequencing; Making connections between concepts; Making connections between procedures; Making connections between representations; Anticipation of complexity; and Recognition of conceptual appropriateness (Rowland & Turner, 2017).

- *Decisions about sequencing*
  Rowland, et al., (2009) explain this dimension as to "[i]ntroduce ideas and strategies in an appropriately progressive order" (p. 37); for example, when teaching addition of fraction, the examples should progress from fractions with the same denominator to fractions with different denominators.
- *Making connections between concepts*
  This code is about whether a teacher makes instructional decisions with an awareness of connections across the domain of mathematics. After all, mathematics is not a subject that contains discrete topics. This involves making appropriate conceptual connections within the subject matter; for example, between fractions of shapes and fractions of numbers (Rowland et al., 2009).
- *Making connections between representations*
  Representations used in a lesson should be connected; for example, two or more representations used to explain a concept should be connected. Rowland et al. (2009) gives an example of a student teacher participating in their study who attempted to use representations to make a connection between two models of the fraction concept: regions of shapes and subsets of discrete sets of objects.

- *Making connections between procedures.*

  Teachers' demonstration of procedures should not be disjoined when teaching the same concept (Rowland et al., 2009); for example, teaching multiplication using the grid method should not be seen as different from using the column method; the connection should be visible.

- *Anticipation of complexity*

  Teachers should anticipate complexity when introducing new topics (Rowland et al., 2009); for example, a teacher should anticipate that students might 'add numerators and add denominators' when teaching addition of fractions (see Hart, 1981), and this anticipation usually comes through experience.

- *Recognition of conceptual appropriateness*

  This is where decisions will typically follow from a teacher's ability to anticipate what is complex and what is conceptually appropriate for an individual or group of pupils (Rowland et al., 2009). As an example, the teacher should understand that it is conceptually appropriate to teach quadratic equations when students understand linear equations.

Contingency

Contingency dimension is about the ability to 'think on one's feet.' It is about contingent action (Rowland & Turner, 2017). Contingency involves the teacher's ability to make cogent, reasoned and well-informed responses to unanticipated and unplanned events (Rowland, 2013); for example, students' unexpected ideas while answering and asking questions or contributing during class/group discussions. Usually, the teacher deviates from the lesson agenda in response to an unplanned opportunity as mathematics teaching rarely proceeds according to plan, if ever (Rowland et al., 2015). The implementation of the actual teaching often differs from the actual planning (Shing et al., 2015) as the teacher cannot know in advance everything that will happen in the lesson, and at times s/he will be taken by surprise, necessitating some kind of improvisation (Rowland et al., 2015). Nevertheless, knowledge of individual students, common errors and misconceptions, and what students generally find difficult can inform prediction, and reduce surprises (Rowland et al., 2015).

The construct *Professional noticing of students' mathematical thinking* (Jacobs, et al., 2010) which is introduced as a way to unpack the in-the-moment decision making that is foundational to the complex view of teaching can be seen in the light of *Contingency*. *Contingency* code 'use of opportunities' (to be discussed later) can also be seen as what Stockero and Van Zoest (2013) refer to as instances in a classroom lesson in which an interruption in the flow of the lesson provides the teacher an opportunity to modify instruction in order to extend or change the nature of students' mathematical understanding. Stockero and Van Zoest (2013) refer the instances as *pivotal teaching moments*, and Bishop (1976) refers the instances as *immediate decision-making* by teachers in the classroom. Usually, the teacher's response is not very immediate, it is characterised by a pause while the teacher thinks about the implications of the student's idea (Rowland et al., 2009).

The contingency dimension are: Teachers' deviation from the agenda; Responding to student ideas; Responding to the (un)availability of tools and resources; Insight during instructions; and Use of opportunities.

- *Teachers' deviation from the agenda*
  When the teacher moves from his/her plan and teach something not in the plan is deviation from the agenda. Rowland, et al., (2012) give examples of deviations that offer opportunities for learning and deviations that challenge opportunities for learning. Examples of deviations which offer opportunities for learning are when the teacher displays deeper subject matter knowledge to enhance pupils' understanding, and when the teacher takes a pupil's remark as a starting point for deeper enquiry. Examples of deviations which challenge opportunities for learning are when the teacher let a pupil hijack the lesson which may result in less mathematical focus, and the lesson is deviated in direction of only one (or a few) pupil(s).
- *Responding to students' Ideas*
  This code includes the ability to make cogent, reasoned and well-informed responses to unanticipated ideas or suggestions from students where the teachers' responses are to use students' contributions to the mathematical development of the lesson. (Rowland et al., 2012). For example, when a student says the factors of 12 are 24, 36, 48, …., and the teacher takes time to question the students to bring about the difference between factors and multiples.
- *Responding to the (un)availability of tools and resources*
  This is when the teacher draws on alternative resources and makes significant epistemological accommodation in response to (un)availability of (un)planned for technology or resource and finding an alternative means to explain a concept or demonstrate a procedure in the intended way (Rowland et al., 2012); for example, when a teacher is using PowerPoint presentation and suddenly the interactive whiteboard stops functioning and the teacher resort to explaining using paper worksheets.

- *Teacher insight*

  This is when the teacher stops to reflect-in- action and changes course of the lesson (example or representation being used) (Rowland et al., 2012). For example, during a lesson a teacher might notice that students find solving linear equations easy and decide to move to quadratic equations.
- *Use of opportunities*

  This is when the teacher takes advantage of a student's idea or mistake to explain the concept better or extent to related concepts; for example, a student might give a wrong answer to a ratio question and the teacher uses the opportunity of the wrong answer and explain ratio and proportion. Also, when the student appears to deviate from the teacher's expectations, it provides an opportunity for exploring the basis on which the learner is making the perceived rational decisions (Rowland et al., 2009)

There are many conceptualisations of teacher knowledge, but I use the KQ as the lens through which FE mathematics student teachers' mathematical and pedagogical knowledge enacted during teaching is made visible. In the following section, I attempt to justify my choice.

Rationale for selecting the Knowledge Quartet

Identifying, developing and deepening teachers' mathematical content knowledge has become a priority for policy makers and mathematics educators around the world due to the shift to enquiry-based approaches to learning, which has been influential in curriculum reform in several countries; this arguably requires teachers to have a greater depth of mathematical content and pedagogical knowledge than was needed for teaching more 'traditional' mathematics (Turner & Rowland, 2010). The question for researchers and educators is: How could we be identifying, developing and deepening teachers' mathematical and pedagogical knowledge? The KQ is a useful tool for identifying, developing and deepening that knowledge.

Rowland et al. (2009) argue that it is difficult to judge one's *Subject Matter Knowledge (SMK)* and *Pedagogical Content Knowledge (PCK)* for effective mathematics teaching and suggest that "[m]athematical content knowledge for teaching will be most clearly seen in the action of teaching" (p. 25). Several researchers (for example, Hegarty, 2000) have argued that mathematical content knowledge needed for teaching is not located in the minds of teachers, but rather is realised through the practice of teaching. Knowledge for teaching is constructed in the context of teaching and can therefore be observed only as 'in vivo' knowledge in the context of teaching (Turner & Rowland, 2010).

The KQ, which can be defined as a framework for the analysis of mathematics teaching, with a focus on teacher knowledge (Rowland et al., 2015), is the appropriate tool to bring the knowledge enacted in teaching to surface.

Assessing *SMK* and *PCK* for teaching mathematics would seem to be straightforward but we cannot simply rely on levels of formal qualifications. Rowland et al., (2009) argue that "[i]f we simply look at the level of formal qualifications in mathematics held by teachers, then no direct relationship is found between teacher knowledge and effective teaching" (p. 22). Many studies (for example Hill et al, 2005; Ma, 1999) which find teachers' mathematical content knowledge to be linked to the effectiveness of teaching, go beyond looking at formal qualifications. The KQ framework identifies situations in which such knowledge can be seen in the act of teaching (Thwaites et al., 2011), and not on paper as certificates.

Neubrand (2018) puts forward the following argument in supporting the KQ:

> If one wishes to identify, describe and develop the mathematical and subject-bound pedagogical knowledge of future teachers, one option beyond just testing that knowledge by questionnaires could be to observe how the knowledge learned in the teacher education program really plays out in the classroom. However, to judge that knowledge needs a framework that can be used rationally to analyse lesson observations under the perspective of how professional knowledge works. This is, in a UK context, the starting point for the KQ (p. 608).

In support of this argument, Burgess (2006) argues that in spite of the data about teacher knowledge being obtained from a survey or an interview, or from an examination of evidence 'artefacts' such as the teachers' lesson plans, what actually happens in the classroom could be considered to be of greater importance; therefore, research needs to occur within the classroom, searching for evidence of what knowledge a teacher has and uses in the immediate act of teaching, and the KQ does exactly that.

Teacher's knowledge is a complex combination of different types of knowledge that interact with each other to inform teaching, making it difficult to identify different aspects of teacher knowledge that have an impact on teaching from observations of that teaching (Rowland et al., 2009). Both the *SMK* and the *PCK* aspects of teachers' knowledge, as well as knowledge of the curriculum, must interact to enable teaching to be effective (Rowland et al., 2009). This makes it difficult to identify which aspect has been employed by the teacher. The Knowledge Quartet provides a framework for analysis of the mathematics content knowledge that informs teacher insights when they are brought together in practice, so that the distinction between different kinds of mathematical knowledge is of lesser significance than the classification of the situations in which mathematical knowledge surfaces in teaching (Rowland, 2013).

Liston (2015) notes that while the KQ framework, is very similar to the work of Ball et al. (2008) and Shulman (1986), its four quadrants offer clear guidance for lesson observation which is key for use in mathematics teacher education programmes. Thus, whilst categorisation models of teacher knowledge such as those developed by Shulman (1986, 1987), Grossman (1990) and Ball et al. (2008) are useful in developing a discourse of teacher knowledge, they are limited and contested; they cannot alone capture the dynamic and social aspects of knowledge in the interaction between learners and the teacher (Stevenson, 2020), of which KQ can do. The KQ comes from the needs of direct and personal lesson observation, a viewpoint which is partly, but not systematically present in the Michigan project's *Mathematical Knowledge for Teaching (MKT)* (Neubrand, 2018).

The KQ has been and is still being used by researchers in different countries for the analysis of classroom data. As it has the advantage of simplicity as well as being comprehensive in covering key aspects of teacher knowledge, some schools and universities use the KQ for mathematics lesson observations (Campton & Stevenson, 2014). More recently, Maher et al. (2022) report that the KQ has been integrated into teacher education programs, where pre-service teachers are trained to use the framework to develop their teaching skills. This includes reflective exercises where they observe and critique their own and others' teaching through the lens of the KQ.

However, the KQ should not be used blindly as it had some limitations like any other theoretical frameworks. The majority of the writings on the KQ have focused on explaining the essence of each of the four dimensions rather than identifying definitions for each of the underlying codes (Weston et al., 2013). This makes the KQ challenging to use, as understanding the codes should lead to understanding the four dimensions. The fact that one incident in teaching can be seen in different KQ dimensions and codes also makes the KQ not so easy to use.

Having discussed different conceptualisations of the mathematical and pedagogical knowledge for teaching and justifying the choice of the KQ as the analytic tool for this study, my attention is now on how this knowledge is (can be) developed in student teachers through mentoring.

2.3 Mentoring

2.3.1 Origin and evolution of mentoring

Mentoring can be traced back to the Greek mythology where *Mentor* was an advisor to Odysseus' son. Mentoring has evolved from the Greek mythology, through the pre-industrial era and later apprenticeships in industrial trades. "The idea of a more experienced individual assisting the transmission of knowledge and skills has become culturally embedded" (Callan, 2012. p. 5).

Modern mentoring has its professional origins in the world of business and has evolved to many professions including teaching. In teacher education mentoring is reported to have originated in the United States of America (USA) and spread to European teacher education systems (Kerry & Mayes, 2013). There had been little research in the field of mentoring in teacher education for a very long time and increases were observed in the 1970s when mentors were involved in the induction of newly qualified teachers (Turner, 1993). During the 1990s, mentors became involved in all stages of teacher education, which are pre-service, in-service, induction and Continuous Professional Development (CPD) (Turner, 1993). In the United Kingdom (UK), it is not clear when mentoring started in FE as there is no literature pointing to that. I estimate that it might have started in 2001 when FE teachers in England were legally bound to gain a teaching qualification (Department for Education and Employment, 2001).

2.3.2 Definitions of mentoring

After reviewing literature on mentoring in adult growth and development; mentoring in the business world; and mentoring in academic setting, Merriam (1983) comes to a conclusion that there is very little agreement in literature as to what is and what is not mentoring. The definition of mentoring varies from study to study (Merriam, 1983), and views on mentoring are quite diverse (Leshem, 2014). Woodd (1997) view mentoring as hierarchical, with the mentor being more powerful and having more knowledge than the mentee. Bozeman and Feeney (2007) support the hierarchical view of mentoring when they argue that mentoring is about 'the spread of knowledge' from a more experienced and skilled teacher to a less experienced one. However, it can be argued that hierarchical mentoring tends to be judgemental as managers or people up in the hierarchy, are responsible for judging subordinates according to performance.

Mentoring is also conceptualised as a developmental activity in which mentors adopt a range of supportive roles to empower mentees and support their professional learning and development, and wellbeing (Hobson & Malderez, 2013). Kalbfleisch (2002) views mentoring as a personal relationship between a more sophisticated mentor and a less advanced mentee with the mentor willing and able to share practices that have assisted him or her to be successful while the mentee has potential and desire to learn. Anderson and Shannon (1988) define mentoring as a nurturing process in which a more skilled or more experienced person, serving as a role model, teaches, sponsors, encourages, counsels and befriends a less skilled or less experienced person for the purpose of promoting the latter's professional and/or personal development.

Beyene et al. (2002) observe that definitions of mentoring range from the simple and romantic images of Greek mythology's Mentor to the complex, multivariate processes of structured human interaction within institutional contexts. The definitions earlier show two different perspectives of mentoring: supportive and relationship which is developmental, and hierarchical which is judgemental (Manning & Hobson, 2017). The two perspectives agree that the mentee learn from the mentor, but the point of disagreement is how the learning takes place. The definitions earlier seem to have been influenced by or have influenced mentoring models and learning theories discussed in the next section.

2.3.3 Developmental and Judgemental models of mentoring

Mentoring can be looked at as developmental or judgemental. Association of Colleges (AoC) and FENTO were commissioned by the Further Education Funding Council (FEFC) to undertake research focusing on 'excellence' in teaching and the way that mentoring might contribute to developing the 'excellence' (Tedder & Lawy, 2009). The resulting publication *Mentoring towards excellence* advocates for a formative and developmental mentoring which emphasizes good mentoring relationships (Tedder & Lawy, 2009). Cullimore and Simmons (2010) trace successive Ofsted reports of 2008 and 2009 and have expressed concern over a growing expectation that mentors should be engaged in processes of making judgements on trainees against teaching standards. "The [then] most recent Ofsted summary reports (Ofsted 2008 and 2009) firm up this expectation of both tutors and mentors to set targets and make judgements" (Cullimore & Simmons, 2010, p. 229). This is a move from the developmental model advocated in *Mentoring towards excellence* to a model that is more judgmental. Lawy and Tedder (2011) observe the shift in rhetoric from an approach that is essentially developmental to an approach that is essentially judgemental and focused on assessment.

2.3.4 Theories of mentoring: Learning by reflecting and Learning through apprenticeship

The models of mentoring discussed in the previous section are related to the theories of mentoring discussed in this section. Mentoring practices can be understood in relation to theories of mentoring. Among the theories in literature, two: *Learning by reflecting* and *Learning through apprenticeship* (Cain, 2009) are discussed more comprehensively than others.

The theory of *Learning by reflecting* (Cain, 2009) is based on the practice of counselling which provides a suitable model for encouraging reflection; for example, mentor meetings can trigger the student to reflect deeply on their experience of teaching, and to arrive largely at their own conclusions where they can be encouraged to examine specific, problematic events in order to articulate their 'ideal situation' (Cain, 2009). Schön's model of *Learning through reflection-in-action and reflection-on-action* (Schön, 1983) supports this approach by emphasizing the importance of thinking about what we are doing while we are doing it (reflection-in-action) and after the activity has been completed (reflection-on-action). Several studies show how student teachers develop their *PCK* through reflection on episodes together with more capable persons who are their mentors (Nilssen, 2003). The process which takes place between the student teachers and their mentors is of crucial significance to how the student teachers manage to bring their potential in use and make it part of their own teaching (Nilssen, 2003).

The theory of *Learning by reflecting* has been challenged by those who view learning to teach as an apprenticeship. Brown and McIntyre's (1993) empirically based work present teacher thinking as largely a matter of craft knowledge which is defined as "[t]hat knowledge of teaching which teachers acquire not through their formal training but through their practical experience in the classroom" (p. 113); the experienced teachers are 'master craftsmen'. Those who advocate for the apprenticeship model argue that student teachers should learn through gaining access to the 'craft knowledge' of experienced teachers (Brown & McIntyre, 1993). In characterising teaching as a 'craft,' Brown and McIntyre (1993) say that 'craft' is work in which experience improves performance. Student teachers learn by observing mentors and by imitating their teaching practices and the mentor is a major agent for the trainee's development, advising, directing and offering 'practical tips' (Cain, 2009). Lave and Wenger's (1991) *Theory of situated learning* further supports this apprenticeship model. They argue that learning occurs in a social context through participation in a *Community of Practice (CoP).* In this view, student teachers become legitimate peripheral participants in the teaching community, gradually moving towards full participation as they acquire the practical skills and knowledge needed for teaching. The process involves observing experienced teachers, receiving guidance, and engaging in teaching practices under the mentorship of these teachers. This interaction within the community of practice is essential for the development of the student teacher's professional identity and competencies.

"At the heart of the reflective/apprenticeship distinction is the issue of whether the mentor offers advice (a directive approach) or encourages reflection (an inquiry-oriented approach)" (Cain, 2009, p. 58). Although the *Learning by reflecting* and *Learning through apprenticeship* theories are often presented in opposition to each other, Furlong and Maynard (1995) suggest that mentors might usefully alter their mentoring approach, starting with apprenticeship-style coaching methods and moving towards a reflective stance. This implies that mentoring can be described as a hybrid of the two theories. This might be the reason behind some interesting observations: some researchers find that mentors tend to use a directive approach, even when the mentors claim to espouse inquiry as a means of development. Manning and Hobson (2017) observe that mentors believe that their mentoring is developmental while their mentees think it is judgemental mentoring. Strong and Baron (2004) find that mentors rarely give direct advice, preferring 'indirect suggestions' in which the advice is tempered with expressions implying tentativeness (such as 'perhaps' or 'maybe').

After discussing theories of mentoring: *Learning by reflecting* and *Learning through apprenticeship*, I now focus on models of mentoring.

2.3.5 Mentoring models

In this section, I discuss models that can be seen to be between (or a hybrid of) *Learning by reflecting* and *Learning through apprenticeship*. I first discuss general mentoring models, then move to mathematics specific mentoring models, and finally FE mathematics student teachers mentoring models.

2.3.5.1 Wang and Odell's (2002) Humanistic, Situated apprenticeship and Critical constructivist model

Wang and Odell (2002) review 135 empirical studies on novices' learning to teach and their relationship with mentors, and identify three perspectives of teacher mentoring: *Humanistic, Situated apprenticeship* and *Critical constructivist*, which may coexist within one mentoring programme. The humanistic perspective is concerned with the importance of emotional support where mentors are expected to act as counsellors, friends, and good listeners. From the apprentice perspective, learning to teach emphasizes the importance of working with expert teachers and mentors who are expected to function as coaches or models of teaching for novices. This perspective allows teachers to develop contextualized and structured knowledge about classroom instruction, teaching techniques, the use of resources and the ability to assess. From the critical constructivist perspective, mentors and prospective teachers are regarded as generators and learners of new knowledge and practices.

2.3.5.2 Hobson's (2016) 'terrors of judgementoring' and ONSIDE Mentoring

Hobson's (2016) study focuses, in particular, on the nature, reach, causes and consequences of the phenomenon of judgementoring. Wright et al. (2021) observe that a particular version of mentoring, judgementoring, has become widespread in the schools and FE colleges. In judgementoring, the mentor's role is to assess or evaluate the student teacher and ensure minimum standards are met, to make key decisions, steering discussions, deciding how the student teacher needs to improve and providing strong guidance (Wright et al., 2021). Hobson and Malderez (2013) describe judgementoring as an inappropriate enactment of mentoring on the grounds that mentors are explicitly evaluative and judgemental and practised an 'unnecessarily' directive form of mentoring

Judgementoring impedes the development of safe and trusting relationships between mentors and student teachers, and that this is detrimental to student teachers' professional and learning development. Fear of being judged cause student teachers to be reluctant to seek the support of a mentor, refraining from being open and honest with mentors about their perceived needs and avoiding forms of behaviour and interaction that they fear may draw attention to perceived weaknesses in their teaching capability or gaps in their knowledge (Hobson & Malderez, 2013). Judgementoring can also impede beginner teachers' well-being as Hobson and Malderez (2013) note that some student teachers who encounter judgementoring describe themselves as disheartened, demoralised, isolated or lonely.

Hobson (2016) suggests four broad and somewhat interconnected causes of judgementoring. The mentors assigned to student teachers have conflict roles of formally evaluating and assessing the beginner teachers on the one hand and supporting their professional learning development (PLD) on the other. In some cases, the situation is compounded where mentors of student teachers are also their line managers or supervisors, a role which necessarily requires formal evaluation of the work of the student teacher. Many institutions selectively employ judgementoring as a remedial strategy to address perceived under-performance, where their teaching is judged through lesson observations which are graded in Ofsted terms rather than enabling all teachers to access mentoring support for their professional learning and development (PLD) (Hobson, 2016). Another reason for mentors resorting to judgementoring is what Ball (2003) refers to as 'the terrors of performativity', which are characterised by government control over the curriculum and workforce, monitoring and 'inspection' of schools and colleges, and teacher effectiveness or 'performance'. Hence, vast amounts of time, energy and resource are committed to preparing for Ofsted inspection, given the very serious consequences of an unfavourable Ofsted grade. School and college leadership teams focus on seeking to bring about an immediate improvement in teachers' 'performance,' as measured against external evaluation criteria, at the expense of a more developmental approach that might better support teachers' ongoing, medium to longer-term professional learning, development and effectiveness (Hobson, 2016). Another major cause of the widespread enactment of judgementoring is the absence of appropriate provision for mentor education and training, and this leads to mentors drawing upon their own experiences of being mentored as student teachers and/or on 'common sense' pedagogical constructs such as 'teaching (and mentoring) is telling' (Hobson, 2016).

It might be argued that one of the reasons why policymakers, school and college leaders, and individual mentors have got it so wrong in encouraging and presiding over the 'terrors of judgementoring' is the lack of a specific research-informed framework for the mentoring of student teachers (Hobson, 2016). To fill the gap Hobson (2016) offers a framework: ONSIDE Mentoring[8] which may be used across a range of contexts internationally, and which, if employed, would likely restrict the enactment of judgementoring and its undesirable effects. The ONSIDE Mentoring is based on the research-informed assumption that establishing relational trust is pivotal to the success of the mentoring relationship which leads to enhancing student teachers' learning, development and well-being (Hobson, 2016).

2.3.5.3 Hobson's (2016) appropriate conditions for effective mentoring

In support of views against judgementoring, Hobson (2016) warns that unless appropriate conditions for mentorship are created, mentoring can be ineffective and even harmful; causing anxiety and stress and contribute to student teachers' decisions to leave the profession. The appropriate conditions for effective mentoring, according to Hobson (2016), are:

- Student teachers should have characteristics and traits of openness, willingness to change and preparedness to operate outside of their comfort zones. In case these traits are not present at the start of the mentoring, mentors should develop them;

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[8] Due to space limitations, ONSIDE mentoring is not discussed in detail. It is available at https://doi.org/10.1108/IJMCE-03-2016-0024

- There should be existence or development of relational trust between student teachers and mentors
- Individualised mentoring where mentoring is tailored to the specific support needs and stages of development of individual student teachers
- Careful selection of mentors against relevant criteria and where care is taken to ensure an appropriate match of mentor and student teacher
- Teachers should receive training before assuming mentoring duties
- Regular and sustained contact between student teacher and mentor; meetings to be timetabled during working hours
- Mentors to receive financial recognition and
- Mentoring to be taken as ‘promotion’

2.3.5.4 Boodt et al’s (2021) mentoring cycle

Using the ONSIDE framework as a springboard, Boodt et al. (2021) carry out a research study commissioned by ETF, and funded by the DfE which proposes a *three-stage mentoring cycle* (Figure 2.9):

1. Establishing mentoring by setting up the mentoring relationships within the FE organisation;
2. Enabling developmental mentoring by ensuring that the mentoring is nurturing, collaborative and meets the needs of individual mentees; and
3. Reviewing and enhancing mentoring by exploring how the mentoring can be developed so it is continually evolving and improving.

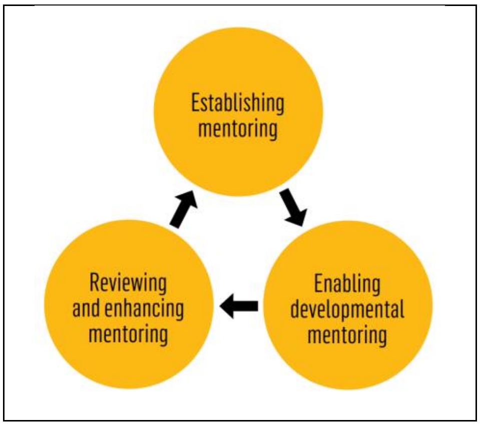


Figure 2. 9 ETF Mentoring cycle (https://www.et-foundation.co.uk/news/etf-launches-mentoring-framework-and-guides/).

2.3.5.5 Li et al.'s (2021) Roles of mentoring

Li et al. (2021) find that "[m]entor teachers need to play and perform their roles constantly when mentoring preservice teachers in teaching practicum. Despite the plentiful literature on teaching practicum in the Malaysian context, research on mentor teachers' roles played is still sparse" (p. 365). To address this the gap, Li et al. (2021) investigate the roles played by mentors using a sequential explanatory mixed-method design. One hundred and twenty-four mentor teachers completed a questionnaire, and seven of them were interviewed. Descriptive analysis was conducted, and the following roles are identified:

- *Creating a Good Relationship with the Pre-Service Teachers*
  Li et al (2021) view mentor teachers' personal attributes in fostering positive relationship as crucial and say, "It will boost the relationship between both parties in the mentoring process. If a mentor teacher chooses to approach the pre-service teachers using good personal attributes, it will directly affect the relationship for both sides" p. 371
- *Informing Pre-Service Teachers about the School System*
  Mentor teachers need to inform the pre-service teachers about various kinds of system requirements including professional dress, execute the yearly teaching plan, understanding the school vision and expectations, and the job scope and responsibility of the pre-service teachers (Li et al., 2021)
- *Sharing Pedagogical Knowledge*
  Mentor teachers are encouraged to share their pedagogical knowledge with pre-service teachers, adapting the sharing process to different times and teaching contexts to maximize learning (Li et al., 2021)
- *Being observed by Pre-Service Teachers*:
  Li et al. (2021) highlight the importance of being observed by student teachers:

  > Modelling is needed because it is an opportunity for the mentor teachers to translate their pedagogical knowledge into real practices and form expectations to the pre-service teachers, enabling them to strive and achieve these expectations, ultimately resulting in positive development as teachers (p. 274).

- *Addressing Various Aspects when Providing Feedback*:
  Providing feedback is arguably one of the most important roles mentor teachers must play in improving the pre-service teachers' teaching practices. This is because it is an opportunity for the pre-service teachers to be informed clearly on the quality of the teaching observed

by their mentor teachers and reflect on the aspects and issues highlighted during the discussion after observation Li et al. (2021).

2.3.5.6 Ndebele and Legg-Jack's (2022) Five-factor model of mentoring

Ndebele and Legg-Jack (2022) carry out a study which explores the impact of mentorship on pre-service teachers by interviewing 26 Bachelor of Education Honours degree students, and using thematic analysis to analyse the data.

Findings from the analyses reveal that mentoring impacts mostly in the development of pedagogical knowledge, system requirements, personal attributes, modelling, and feedback (Ndebele & Legg-Jack, 2022).

- *Pedagogical Knowledge*

  The study reveals mentors' impact on participants (preservice teachers) in the development of pedagogical knowledge which is revealed at various stages of the teaching, namely, planning, preparation, and implementation of lessons (Ndebele & Legg-Jack, 2022)
- *Systems requirements*

  The study reveals that participants are impacted by their mentors in executing other school programmes outside the normal teaching and learning exercise.
- *Personal attributes*

  The mentor's personal features impact on the mentee's professional growth; these are the conditions and situations that make mentees feel successful in their own career.
- *Modelling*

  Modelling includes the mentor assisting student teachers by demonstrating the use of appropriate classroom language for students' learning, teaching, classroom management, hands-on lessons, and well-designed lessons (Hudson, 2013).
- *Feedback*

  An effective mentor clearly communicates expectations and offers valuable guidance to the mentee (pre-service teacher) to support their professional growth (Hudson, 2004). Ndebele and Legg-Jack's (2022) study findings indicate that student teachers who receive constructive feedback feel they have been sufficiently mentored, and their professional development is largely influenced by the quality and extent of the feedback provided.

2.3.5.7 Campton and Stevenson's (2014) Mentoring strategy

Research shows that mentor meetings typically focus heavily on organisational features of the lesson, with very little attention to mathematical aspects of lessons (Brown et al., 1999; Capraro et al., 2005; Lin et al., 2017). In one study, only 2% of mentors' suggestions to beginning teachers relates to the subject matter being taught (Strong & Baron, 2004). Cain (2009) observes that the practical business of teaching and classroom management tend to dominate conversations between mentors and their student teachers because such matters are major concerns of both parties, and mentors rarely relate practice to theory.

In an effort to increase the 'mathematics' in mentor meetings discussions, Campton and Stevenson (2014) advise that it is important discussions with beginning (and student) teachers do not focus only upon generic features; for example, classroom organisation, behaviour management and lesson structure, but also upon the mathematics itself. Discussions should include how the mathematics being taught has informed choice of examples and tasks, how learners' understanding developed, and how the teacher's own understanding has changed through the process of preparing to teach a topic (Campton & Stevenson, 2014).

2.3.5.8 Hyde and Edwards' (2014) Straightforward practical advice model

Hyde and Edwards (2014) when introducing a book, they edited: *Mentoring Mathematics Teachers,* offer straightforward practical advice, underpinned by the latest research and theory, designed to support both mentors and university-based tutors in mentoring preservice and newly qualified mathematics teachers at both primary and secondary levels. They say the mentoring process should focus on the following:

- Recognition of the importance of *PCK*
- Building upon subject knowledge
- Developing skills of self-evaluation in order to reflect and develop practice
- The on-going need to address issues of equity and diversity within the profession
- The need for beginning teachers and their mentors to work together effectively as a partnership, and
- The importance of collaboration, shared goals, mutual benefit and growth.

The practical advice seems to be generic but the 'Building upon subject knowledge' which refers to mathematics is subject specific. The model covers how mentors and university-based tutors assist in the development of mathematical and pedagogical knowledge of mathematics student teachers – an area of interest to this study.

2.3.5.9 Gu and Gu (2016) Strategies of post lesson debriefing

Gu and Gu (2016) report findings of a study, conducted in China, based on a systematic, fine-grained analysis of 107 hours of videotaped mentoring meetings of 20 groups of teachers and teaching research specialists from different elementary schools.

The findings of the study show that the interactions between teachers and mentors contribute to the improvement of classroom teaching in mathematics, possibly resulting in students' success in mathematics assessments such as *Programme for International Student Assessment (PISA).* In the Chinese educational system, teachers and mentors work together to design, deliver, and revise lessons to promote high quality student learning; this is known as the lesson study.

The mentors debriefing (mentor meetings in the English education context) within the context of Chinese lesson study focuses on two dimensions: the types of teachers' knowledge that mentors pay attention to, and the dynamics between mentors and the practicing teachers. The types of teachers' knowledge include mathematical knowledge, pedagogical knowledge and practical knowledge. The dynamics between mentors and the practicing teachers includes the nature of the mentor comments, from directive comments to collaborative conversation. The mentors usually advise teachers through general comments based on their own experiences, with less attention paid to problems that were generated in particular lessons. To facilitate the shift from generic comments to comments on the mathematical issues that are generated in the lesson, Gu and Gu (2016) suggest mentors assist student teachers develop:

- a profound understanding of mathematical knowledge and mathematical thinking methods, and a deep understanding of modern pedagogical theories and perspectives
- understandings of instructional practice, particularly in the context of current curriculum reforms, and
- an understanding of what really happens in current classrooms, what new concerns or issues occur, and how students learn differently at different grades (p. 451).

2.3.5.10 Norley's (2017) Stages of mentoring

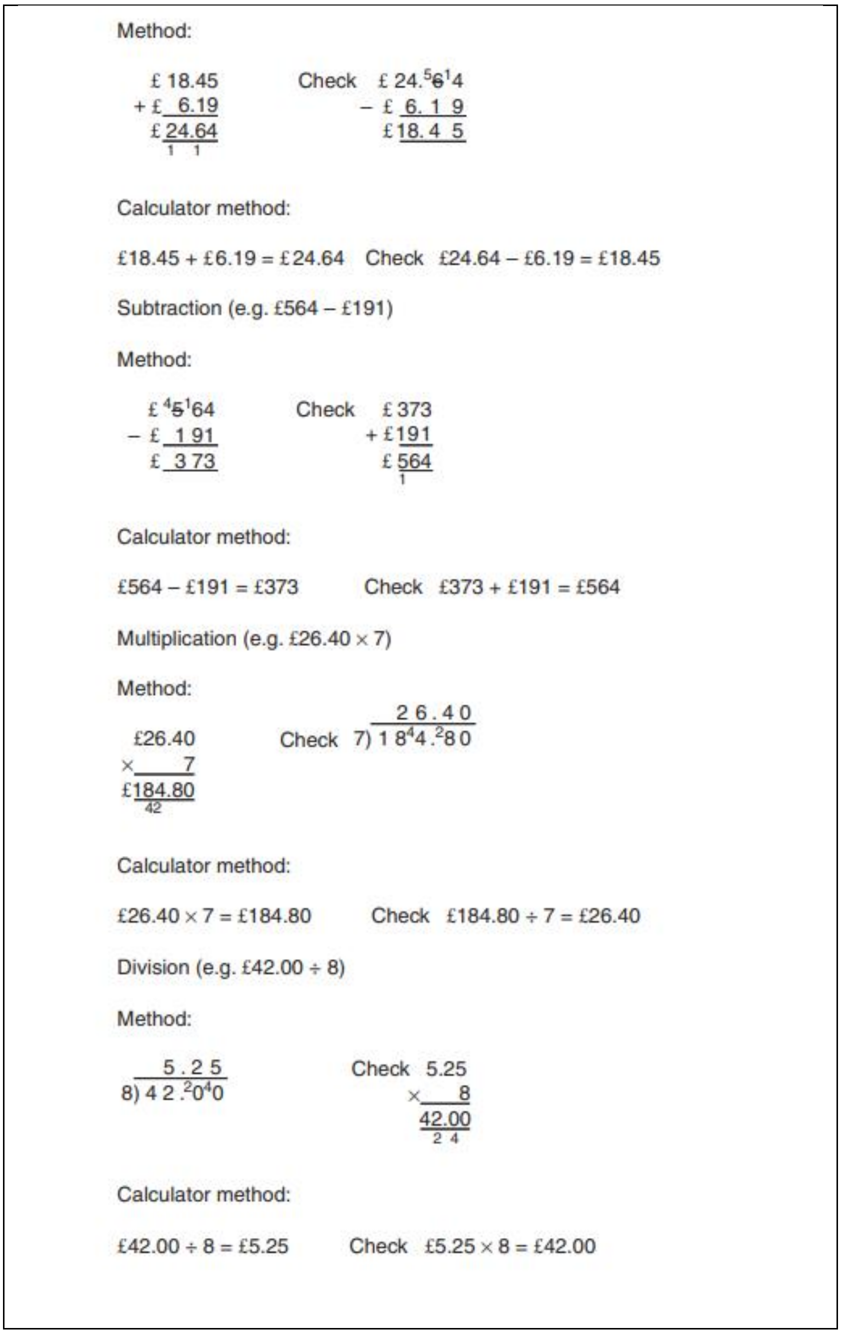
As mentioned in *Chapter 1*, while identifying the gap this study tries to fill, there is a shortage of literature on mentoring mathematics student teachers in FE. At the moment, it seems (at the time of completing this thesis) only Norley (2017) has ventured into the area.

In the academic year 2014-2015, Kevin Norley was asked to mentor three student teachers undertaking *Postgraduate Certificate in Education (PGCE)* in post-compulsory education in an FE college in England (Norley, 2017). Kevin Norley gives the stages of the mentoring process he followed over the year which are: initial discussion with the student teacher; student teacher observation of the mentor; initial observation; questioning and challenge; area of development; summary and reflective practice; concluding the mentor/mentee relationship; and looking into the future (Norley, 2017).

- *Initial discussion with the student teacher*

  During the initial discussion, the mentor assesses the student teachers' level of teaching knowledge by observing them teaching mini lessons and discussions which includes a brief induction in terms of policies, procedures, and administration requirements, etc. within the department and wider college. It is at this initial stage that the student teachers are made aware of the backgrounds and prior achievement of the learners they would be teaching. The student teachers are also made aware of how any group of learners starting a class are motivated to learn mathematics through a mixture of intrinsic factors, and a range of teaching and learning strategies. Norley (2017) says he informs the student teachers on: planning and preparation of the lesson, opening the session, presenting materials, suitability of resources, range of activities and teaching methods deployed, checks on learning, management of session, equal opportunities, concluding the session and action points for future development, etc.
- *Mentee observation of the mentor and other teachers*

  Mentees are encouraged to observe other teachers and their mentors teaching mathematics to a variety of classes studying on a range of vocational programmes across the college. During this stage, "[t]he mentor needs to be able to demonstrate pedagogical approaches whereby methods used in problem solving are accepted and encouraged provided that they lead, through workings that can be followed and checked, to a correct mathematical answer" (Norley, 2017, p. 67). What follows are example of methods with checking given by Norley (2017, p.68) (see Figure 2.10):



Method:

$$\begin{array}{r} \pounds\ 18.45 \\ +\ \pounds\ \underline{\ \ 6.19} \\ \pounds\ \underline{24.64} \\ {\scriptstyle 1\ \ \ 1} \end{array} \qquad \text{Check} \quad \begin{array}{r} \pounds\ 24.{}^{5}\cancel{6}{}^{1}4 \\ -\ \pounds\ \underline{\ 6.\ 1\ \ 9} \\ \pounds\ \underline{18.\ 4\ \ 5} \end{array}$$

Calculator method:

£18.45 + £6.19 = £24.64 Check £24.64 – £6.19 = £18.45

Subtraction (e.g. £564 – £191)

Method:

$$\begin{array}{r} \pounds\ {}^{4}\cancel{5}{}^{1}64 \\ -\ \pounds\ \underline{\ 1\,91} \\ \pounds\ \underline{\ 3\,73} \end{array} \qquad \text{Check} \quad \begin{array}{r} \pounds\ 373 \\ +\ \pounds\ \underline{191} \\ \pounds\ \underline{564} \\ {\scriptstyle 1\ \ \ \ \ } \end{array}$$

Calculator method:

£564 – £191 = £373 Check £373 + £191 = £564

Multiplication (e.g. £26.40 × 7)

Method:

$$\begin{array}{r} \pounds 26.40 \\ \times\ \underline{\ \ \ \ \ \ 7} \\ \pounds\underline{184.80} \\ {\scriptstyle 42\ \ \ \ \ } \end{array} \qquad \text{Check} \quad \begin{array}{r} 2\,6\,.\,4\,0 \\ 7)\ \overline{1\,8^{4}4\,.^{2}8\,0} \end{array}$$

Calculator method:

£26.40 × 7 = £184.80 Check £184.80 ÷ 7 = £26.40

Division (e.g. £42.00 ÷ 8)

Method:

$$\begin{array}{r} 5\,.\,2\,5 \\ 8)\ \overline{4\,2\,.^{2}0^{4}0} \end{array} \qquad \text{Check} \quad \begin{array}{r} 5.25 \\ \times\ \underline{\ \ \ \ 8} \\ \underline{42.00} \\ {\scriptstyle 2\ \ 4\ } \end{array}$$

Calculator method:

£42.00 ÷ 8 = £5.25 Check £5.25 × 8 = £42.00

Figure 2. 10 An example of methods and checking (Emerald_IJMCE_IJMCE590398 64..77)

Student teachers are encouraged from the early stages to assist learners; for example, by walking around the classroom and supporting students individually and/or in small groups. This enables the student teachers to get to know the learners gradually as well as to gain confidence. The students in FE colleges come from different educational backgrounds; therefore, it is important for the student teachers to be able to anticipate and understand that a range of different methods may be drawn upon by the learners in solving problems, and to have strategies in place to deal with them.

- *Initial observation*

This stage is about the mentor observing the student teacher's lesson. During the first observation feedback session, the mentor should ask the student teacher how they felt their lesson (or part lesson) had gone, and then give them time to reflect on it. Student teachers should be allowed to have the first say so as to give them control and the opportunity to identify development needs or problem areas for themselves. During the feedback, the discussion should focus on how effectively they had created opportunities to demonstrate methods, to facilitate practice of methods and to check for clarity and accuracy of methods.

- *Questioning and challenge*

During future observations feedback, the student teacher should be asked a range of open and probing questions to give her/him the opportunity to reflect further upon her/his sessions. The first questions are ideal for exploring issues and getting information, and for helping the student teachers to open up. The next question would usually be a probing question such as, "Tell me a bit more about how you felt the ending of the session/opening of the session/group activities, went, etc." (Norley, 2017, p. 72)

- *Areas for development*

Areas for development relating to the observations should be discussed (and not dictated) with the student teacher. These include issues such as: the need to set times for class activities; allowing time to be spent on the demonstration of methods (as a whole class, and individually); ensuring learners have the opportunity to practise methods; supporting learners individually and in groups; checking understanding of methods; terminology and relevant vocabulary; and marking and giving feedback. Mentors should ensure that the student teacher focuses on only two or three key areas of development in order to concentrate on things that can be changed.

- *Summary and reflective practice*

Summary and reflective practice provide the opportunity for the mentor to reiterate the positive aspects of the observed lessons, and to afford the student teachers the chance to confirm and agree any areas requiring development.

- *Concluding the mentor/mentee relationships and looking to the future*

The final stage of the mentoring process is entering into discussions with the student teacher relating to his or her possible future CPD requirements, and the student teacher is given the opportunity to give feedback on their mentoring experience.

After discussing mentoring, I turn to electronic mentoring (e-mentoring) as the study was conducted during the COVID 19 lockdown, and e-mentoring was the only option available to support student teachers.

2.4 Electronic Mentoring (E-Mentoring)

2.4.1 Background to e-mentoring

The COVID-19 global pandemic widely affected education across the world and engendered unprecedented scenarios that required expeditious responses (Chirinda et al., 2021). Ramploud et al., (2022) say the beginning of the COVID-19 pandemic was a big challenge for schools and all other education institutions all over the world. Education was in a crisis. The situation was not a planned digital transformation, it was a crisis learning (Badawi, 2021). The process of overcoming crisis situations is by means of a new organization of the self; an emergence from crisis always involves the development of a new and different organization of the self (Ramploud et al., 2022). The cultural change teachers faced during the COVID-19 emergency had not been a training experience proposed, controlled and accompanied by any group of researchers, rather, it was a violent and uncontrolled cultural change that teachers had to face at a moment of extreme isolation, since communication with students (and colleagues) and among students was to be necessarily combined with technological tools, changing the nature of communication (Ramploud et al., 2022).

As concerns about Covid-19 rapidly escalated in March 2020, all levels of education were affected, and a unique population; student teachers faced challenges on two fronts: as students and as teachers who were ‘forced’ to learn and teach from a distance (Thomas et al., 2021). The COVID-19 pandemic affected education in various ways, as a result of the closure of universities, colleges, and schools; teachers and students had to rapidly adapt to remote teaching, and teacher education was no exception (Carrillo & Flores, 2020). Mentoring had to go online as well (to what is referred to as e-mentoring). Student teachers were deprived of the actual classroom experience (Badawi, 2021).

2.4.2 What is e-mentoring?

Virtual mentoring is known by a number of terms, including e-mentoring, computer-mediated mentoring, tele-mentoring, e-mail mentoring, internet mentoring, online mentoring, cybermentoring, and virtual mentoring (Bierema & Hill, 2005). To avoid the confusion of using multiple terms whose differences are not clear and are not of any importance to this study, I use the term e-mentoring. Bierema and Merriam’s (2002) define e-mentoring as “[a] computer mediated, mutually beneficial relationship between a mentor and a mentee that provides learning, advising, encouraging, promoting, and modelling, that is often boundaryless, egalitarian, and qualitatively different from traditional face-to-face mentoring" (p. 214).

Before I get into a detailed discussion, it is important to understand that e-mentoring has always been in existence, but the e-mentoring during the pandemic which I call COVID-19 triggered electronic-mentoring, which is of interest to this study, has not been well organised; it was a reaction to unprecedented situation.

2.4.3 Difference between e-mentoring and face-to-face mentoring

Bierema and Hill (2005) say that e-mentoring, unlike face-to-face mentoring, is not place dependent. The mentor and mentee can literally be in different parts of the globe and e-mentoring relationships can be struck up and nurtured using many technical mediums including e-mail, chat groups, intranets, and computer conferencing. Mentors and mentees can literally leave messages for each other at any time when asynchronous technologies are used. The asynchronous form of e-mentoring enables more flexibility than face-to-face mentoring although it lacks verbal communication and is lower in social presence (Bierema & Hill, 2005).

E-mentoring is not without challenges which are not seen (or rare) in face-to-face mentoring. Access to technology is a challenge often overlooked; e-mentoring requires the hardware: the computer itself and access to the internet. There are some places (or some rooms in the same house) which might have internet problems, and this can negatively impact on the quality of the e-mentoring meetings. Access is not limited to physical access as intellectual access can also be a challenge with using online technologies; that is, some student teachers and some mentors may not have the technological literacy skills that will enable successful involvement in e-mentoring (Bierema & Hill, 2005). Privacy is another significant challenge with online mentoring. Unlike face-to-face mentoring where the interactions simply 'disappear' after they occur (unless recorded), e-mentoring via e-mail can be and often are by default recorded and captured in 'public record' (Bierema & Hill, 2005). Finding ways to sustain the relationship is another challenge associated with e-mentoring. As with face-to-face mentoring, ongoing contact is important not just in the beginning but throughout the mentoring process. The e-mail message can be more easily ignored than someone standing in the doorway (Bierema & Hill, 2005).

2.4.4 E-mentoring student teachers during COVID 19 pandemic

A study by Ersin and Atay (2021) during the COVID 19 lockdowns show that overall, student teachers mostly had a positive experience of e-mentoring but when asked about their expectations from e-mentoring, the student teachers said they needed more time with mentors, and more attention from the mentors. The findings also revealed that mentors partially fulfilled their mentoring functions because they were too busy with the technology themselves and did not have time for mentees. One student teacher in the study by Ersin and Atay (2021) had the following to say:

> I think, during distance education our mentors were not able to pay attention to us as much as they would in face-to-face mentoring. Our mentors were themselves also trying to adapt to this process, the pandemic conditions. I think that was the reason. I would prefer face-to-face education, especially when it comes to mentoring (p. 209).

In support of the student teacher's observation or experience, Ersin and Atay (2021) view the inadequacy of the mentorship training programme on online mentoring as a reason for mentors partially fulfilling their duties. Teachers who had been trained to be mentors were trained for face-to-face mentoring. In most cases the mentors and the student teachers were trained at the same time on the online technology; there was no training specifically for mentors.

Tsotetsi and Mile (2021) carry a study in South Africa to explore mentors and mentees experiences in teaching practice during the COVID-19 period. Data were collected through telephone interviews employing the semi-structured interview method, and thematic analysis (Braun & Clarke, 2006) was used to analyse the data. The results present challenges experienced by mentees which, amongst others, include a feeling of inadequacy or lack of confidence in their abilities to use online technologies. The study also show that pre-service teachers feel that there is no formal programme (structure) guiding the mentoring process. Mentors guide pre-service teachers as they deemed fit.

Howard (2021) carries a reflective observation study, to explore what has allowed mentors and Initial Teacher Education (ITE) providers to continue to provide high-quality training and support despite such unprecedented times of change caused by the pandemic. Howard's (2021) reflective observations covered the period from March 2020 to January 2021, and is related to his school-based mentoring of primary school post-graduate trainees on a primary initial training school direct pathway.

Howard (2021, p. 129) says:

> Having heard of many innovative approaches and adaptations by training providers, rather than us all seeking to reinvent the wheel surely there is a need now for the capturing and dissemination of the most successful and innovative of approaches used to support our trainees during these times.

This observation has highlighted the need to share ideas more than before; it might be between institutions or between mentors in the same institution.

According to Howard (2021), the biggest challenge with regards to e-mentoring was for mentors to quickly become digitally upskilled to match the technological changes needed to support student teachers and successfully carry out a mentor's 'traditional' practices such as assessment and feedback. The upskilling, although not smooth sailing, has many benefits. COVID 19 forced online teaching and learning has increased mentees and mentors' (and all teachers and people in other professionals) technological literacy. COVID 19 has taught us that change is nothing to be feared and when it is forced upon us, it allows us to revisit our 'traditional' practices (and learn from them), as it is said necessity is the mother of invention (Howard, 2021).

2.4.5 E-mentoring mathematics student teachers during COVID 19 pandemic

During and after COVID 19, there were a lot of research activities about the teaching and learning during the pandemic; in this section, I discuss studies about mentoring mathematics student teachers during the lockdowns.

Güler and Çelik (2022) report a pretest-posttest study, conducted in Turkey, whose aims was investigating the impact of e-mentoring on novice mathematics teachers' lesson analysis skills. The participants were one-group of 12 in-service mathematics student teachers. The participants' ability to analyse lessons was measured through an open-ended assessment of a lesson video both before and after the intervention, which was e-mentoring. The e-mentoring started with an introduction to the basics of *Pedagogical Content Knowledge (PCK)* (Shulman, 1986) and *Mathematical Knowledge for Teaching (MKT)* (Ball et al., 2008). This was followed by viewing video clips and lesson plans, and discussions. The Güler and Çelik study (2022) conclude that, "[t]he findings reveal that e-mentoring improve the mathematics student teachers' lesson analysis skills significantly" (p. 1).

Rakes et al. (2022) examined how 17 secondary mathematics student teachers, in four university teacher preparation programmes, implemented technology in their classrooms to teach for conceptual understanding using online, hybrid and face to face classes during COVID-19. The student teachers, their mentors and university lecturers discussed a commonly agreed upon problem of practice and a change idea to implement in the classroom. Lessons taught by student teachers were observed. Participants documented how student teachers implemented technology for mathematics conceptual understanding. *The Mathematics Classroom Observation Protocol for Practices (MCOP^2)*[9] (Gleason et al., 2017) was used to examine how effective mathematics teaching practices by student teachers were. MCOP^2 results indicate that student teachers increased their use of effective mathematics teaching practices.

A study by Guler et al. (2023) aimed to investigate the effectiveness of e-mentoring for mathematics teachers (E-MMT) in improving novice teachers' noticing skills (Jacobs et al., 2010). The main goal of E-MMT was to ensure the development of novice teachers' *PCK* with a special focus on increasing their attending to student thinking, interpreting and decision making in order to improve their teaching. The single group pre-test and post-test study was conducted with the participation of 17 student teachers who are novice middle school mathematics teachers. Participants' noticing skills were assessed through a whole class teaching video shown to them before and after the intervention. During the implementation of E-MMT, teachers were expected to actively participate, share their reflections on teaching as a group, and receive feedback from each other and mentors. E-MMT was designed as a 10-week project composed of three main phases: The initial phase (determining the teachers and the goals), the cultivation phase (implementing the content), and the separation phase (completing the group mentoring and continuing with the one-on-one mentoring). The responses of the teachers to the video assessment were analysed considering attending, interpreting and decision-making dimensions of noticing (Jacobs et al., 2010). The results of the study shows that E-MMT contributed positively to the development of teachers' noticing skills.

The studies discussed above give some insight into mentoring but do not focus on the role of mentoring in the mathematical and pedagogical knowledge development of mathematics student teachers in Further Education and Skills (FE) sector. As mentioned in the introduction chapter (Section 1.3), this is a research gap this study intends to address.

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[9] The Mathematics Classroom Observation Protocol for Practices (MCOP^2) is a lesson observation instrument which takes into consideration both direct and dialogic instruction encompassing classroom interactions for the development of conceptual understanding, specifically examining teacher facilitation and student engagement.

2.5 The Conceptual Framework of the study

A conceptual framework can be viewed as a visual representation of a study's organization (Ravitch & Riggan, 2012); therefore, I conclude this chapter with a brief description and the diagrammatic representation of this study's conceptual framework (Figure 2.11). The conceptual framework of this study serves to connect three key elements of the research process: theoretical framework, topical research and personal interests (Ravitch & Riggan, 2012).

The theoretical framework, which represents an aggregation of formal theories (Ravitch & Riggan, 2012), includes conceptualizations of mathematical knowledge for teaching proposed by different researchers like Mishra and Koehler's (2006) and Ball et al. (2008). However, the emphasis is on the Knowledge Quartet (KQ), which grounds the study. The study places a significant focus on the KQ, which serves as the foundational framework for this study. This is evident from its prominent placement in the diagrammatical representation (Figure 2.11). The KQ is utilized as a key analytical tool throughout the study, guiding the examination and interpretation of data collected using mathtasks[10], observations, interviews, and documents in form of mentor reports. Section 3.5 provides a detailed explanation of these methods and illustrates how the Knowledge Quartet is integrated into the analysis process.

Topical research refers to work that has focused on the subject of interest (Ravitch & Riggan, 2012) which is *Mentoring*. This includes exploring mentoring as a means of supporting students through theoretical frameworks: *Learning by reflection* and *Learning through apprenticeship*, and approaches like *Judgementoring* and *Developmental* mentoring. Topical research also encompasses models of mentoring: general models, mathematics-specific models, and models specific to FE mathematics student teachers. The mentoring process is interpreted using the KQ dimensions: *Foundation, Transformation, Connection* and *Contingency*.

My Personal interests (not included in the diagrammatic representation) which include my curiosities, biases, ideological commitments, epistemological assumptions, and professional interests influence the process of carrying out the study (Ravitch & Riggan, 2012), although I try to limit the influence.

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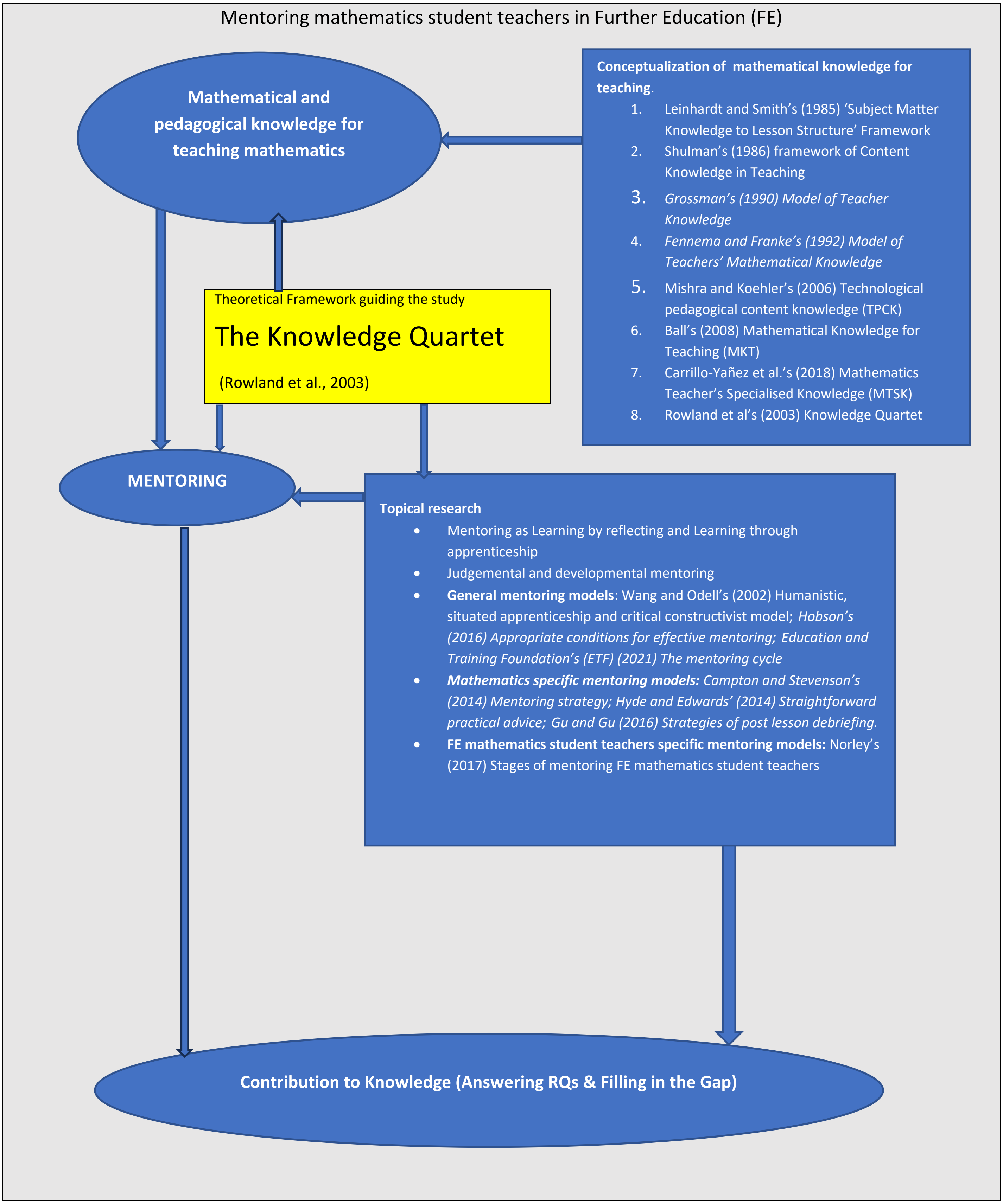
[10] Mathtasks can be described as classroom situation-specific incidents which are hypothetical but grounded on learning and teaching issues that previous research and experience have highlighted as seminal and are likely to occur in actual practice (Biza et al., 2007). See Section 3.4.1.1 for more detail about mathtasks.



Conceptualization of mathematical knowledge for teaching.

1. Leinhardt and Smith's (1985) 'Subject Matter Knowledge to Lesson Structure' Framework
2. Shulman's (1986) framework of Content Knowledge in Teaching
3. *Grossman's (1990) Model of Teacher Knowledge*
4. *Fennema and Franke's (1992) Model of Teachers' Mathematical Knowledge*
5. Mishra and Koehler's (2006) Technological pedagogical content knowledge (TPCK)
6. Ball's (2008) Mathematical Knowledge for Teaching (MKT)
7. Carrillo-Yañez et al.'s (2018) Mathematics Teacher's Specialised Knowledge (MTSK)
8. Rowland et al's (2003) Knowledge Quartet

Topical research

- Mentoring as Learning by reflecting and Learning through apprenticeship
- Judgemental and developmental mentoring
- **General mentoring models**: Wang and Odell's (2002) Humanistic, situated apprenticeship and critical constructivist model; *Hobson's (2016) Appropriate conditions for effective mentoring; Education and Training Foundation's (ETF) (2021) The mentoring cycle*
- ***Mathematics specific mentoring models:*** *Campton and Stevenson's (2014) Mentoring strategy; Hyde and Edwards' (2014) Straightforward practical advice; Gu and Gu (2016) Strategies of post lesson debriefing.*
- **FE mathematics student teachers specific mentoring models:** Norley's (2017) Stages of mentoring FE mathematics student teachers

Figure 2. 11 Diagrammatical representation of the Conceptual Framework of the study

2.5 Conclusion

In this chapter, I have discussed the conceptual framework of the study under four broad sections: *The Further Education and Training sector (FE), The mathematical and pedagogical knowledge for teaching, Mentoring,* and *E-mentoring.* In the FE context section, I discussed the reforms which were initiated by the Government in ITE, the ITE after the reforms, teaching mathematics, and mathematics students. In the mathematical and pedagogical knowledge for teaching section, I traced 'key' theoretical frameworks in mathematics education since 1985 and justify my selection of the KQ as the framework which ground this study. In the mentoring section, I discussed the definitions of mentoring; theories of mentoring: *Learning by reflecting* and *Learning through apprenticeship*. *Judgementoring* and *Developmental* approaches, and some 'key' mentoring models were discussed. During the last section, I discussed e-mentoring and how it was employed during the COVID 19 pandemic. I concluded the chapter with a brief description and the diagrammatic representation of the study's conceptual framework.

In Chapter 3, I discuss the methodology of the study focusing on the methodological approach and the research design which includes data collection, participants, and data analysis. I also discuss my actions to ensure the trustworthiness of this study, and ethical issues I considered when conducting the study. Before concluding the chapter, I discuss the impact of the COVID 19 pandemic on how I conducted this study and potential methodological limitations.

3 Methodology

3.0 Introduction

In this chapter, I discuss the methodology of the study. I specifically focus on the methodological approach. I present the research design and research questions, participants, data collection and analysis. I then discuss my actions to ensure the trustworthiness of the study, and ethical issues I considered when conducting this study. As data were collected during the COVID-19 lockdowns, the impact of the pandemic on how I conducted the study and potential methodological limitations are discussed before giving the diagrammatic representation of the research process.

3.1 Methodological approach

In this study, which seeks to develop empirically based models into how mentoring can assist in the development of mathematical and pedagogical knowledge of FE mathematics student teachers, I take the socio-constructivist perspective of ontology and the interpretivist perspective of epistemology. I believe knowledge is produced through interaction of social actors, (who are mentors, student teachers and students in this study), and the interpretation of such interactions.

This follows that the methodology is qualitative established on an interpretative research methodology that values the participant's views and reflections, and looks for meanings within the participant's environment (Merriam & Tisdell, 2016; Stake, 2010). A qualitative research methodology helps me understand how student teachers and mentors "[i]nterpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences" (Merriam & Tisdell, 2016, p. 6). As in other qualitative studies, in this study "[t]he focus is on process, understanding, and meaning; the researcher is the primary instrument of data collection and analysis; the process is inductive; and the product is richly descriptive" (Merriam & Tisdell, 2016, p. 15).

The qualitative approach based on interpretive research methodology is committed to multiple views of social reality whereby the participant becomes 'the expert'—it is his or her view of reality that the researcher seeks to interpret. Social reality is assumed to be subjective and varied; there is not just one story but multiple stories of lived experience (Hesse-Biber, 2010). This implies that the qualitative approach values participants' reflections and empower them but does not eliminate the researcher's subjectivity and the impact of the theoretical framework on the analysis (Merriam & Tisdell, 2016).

Bryman (2016) says, "[w]ith an inductive stance, theory is the outcome of research which involves drawing generalizable inferences out of observations" (p. 22). In agreement with this view, this study aims to develop a ‘theory’ in form of an empirically grounded normative model on how mentoring can assist the development of mathematical and pedagogical knowledge of further education mathematics student teachers (and probably student teachers in other subjects as well).

3.2 Research Design and Research Questions

Having the interpretive research methodology in mind and with an inductive stance, I designed the participant selection, data collection, and analysis in a way that gave me the opportunity to answer the research questions (RQs) which are:

- **RQ 1**: What mathematical and pedagogical knowledge is enacted by further education mathematics student teachers in teaching, and what are the student teacher needs?
- **RQ 2**: How does mentoring address the student teacher needs, and what institutional issues influence mentoring practices?
- **RQ 3:** What are the challenges and lessons learnt during e-mentoring further education mathematics student teachers during COVID-19 lockdowns?

3.3 The participants

The participants in this study are mentors, student teachers and students. Adler et al. (2005) note that research in teacher education is often more complex since it deals not only with the beliefs, knowledge and practices of teachers but also students’ beliefs and knowledge, as well as with the interaction between teachers and students, and the interaction between teacher educators (mentors in this study) and student teachers. Thus, having teachers as the focus of research leads to high complexity, and this increases the tendency to keep the sample small in order to reduce complexity (Adler et al., 2005). At the time of data collection, there were 228 FE colleges in England (Association of Colleges, 2019). This population is too large for a novice researcher with limited resources; therefore, I used volunteer sampling to reduce the number to manageable levels and also in volunteer sampling participants are all happy and willing to participate and they do not feel coerced in any way (Psych Teacher UK, 2015).

The recruitment process started by identifying colleges which had the teacher training provisions by looking at colleges websites. After identifying colleges, I emailed the gatekeepers, who are the principals, seeking permission to carry out the study in their colleges. At the same time, I requested contact details of heads of mathematics departments (HoDs) (Appendix 10: G.1). I was granted permission to carry out the study in several colleges. I recruited the participants by emailing a questionnaire (developed on Qualtrics[11]), with a hypothetical classroom situations: *Mathtask 1[12]: Addition of Fractions* (Figure 3.1) embedded, to HoDs who distributed it to student teachers in their departments. The mathtask was used for recruiting student teachers and also as a data collection instrument. Student teachers showed willingness to participate by completing the mathtask (recruitment tool) (Appendices 10: G.2) and the responses were analysing (data collection tool) (Appendices 10: G.3). The responses came directly to me. For ethical reasons, the HoDs did not know who had or who had not completed the questionnaire. As mentioned several times, the data were collected in two phases.

3.3.1 Phase 1 participants

In an attempt to find the mathematical and pedagogical knowledge enacted by FE mathematics student teachers in teaching, the student teachers' needs (RQ 1), how mentoring addresses the student teacher needs, and institutional issues which have the potential of influencing mentoring practices (RQ 2), data were collected from five student teachers and two mentors using mathtasks, lesson observations, mentor meeting observations, interviews with student teachers, interviews with mentors, and documents which are mentoring reports.

Five student teachers: Cain, Job, Kate, Suzy and Mary completed the questionnaire and expressed their willingness to take part in the study (Table 3.1). I emailed the five student teachers *PARTICIPANT INFORMATION STATEMENT – Student teacher* (Appendix 10A), and only Job and Cain consented to all data collection methods. Suzy consented to mathtasks and interviews, and Mary and Kate consented to *Mathtask 1* only. Through their HoDs, I identified Job and Cain's mentors and one class from each. I sent the two mentors: Alex (Job's mentor) and Julie (Cain's mentor) *PARTICIPANT INFORMATION STATEMENT – mentor* (Appendix 10.B), and they both consented to all data collection methods.

One class from each student teacher: Job and Cain became participants and they were asked by their teachers (the student teachers) whether they like to participate (or not) and they consented by writing "YES" in the chat. Job's class had 20 students who were studying for a *Level 2 Diploma in Applied Science.* Cain's class had 15 students who were studying for a *Level 2 Diploma in Business Studies*. The students had obtained lower than Grade 4 in mathematics at GCSE; therefore, as a Government

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[11] Qualtrics is a management platform used as a survey tool for developing questionnaires with responses captured by the developer. https://login.qualtrics.com/login

[12] The origin, definition, development, trialling and adjustment of mathtasks are discussed in section 3.4.1.1

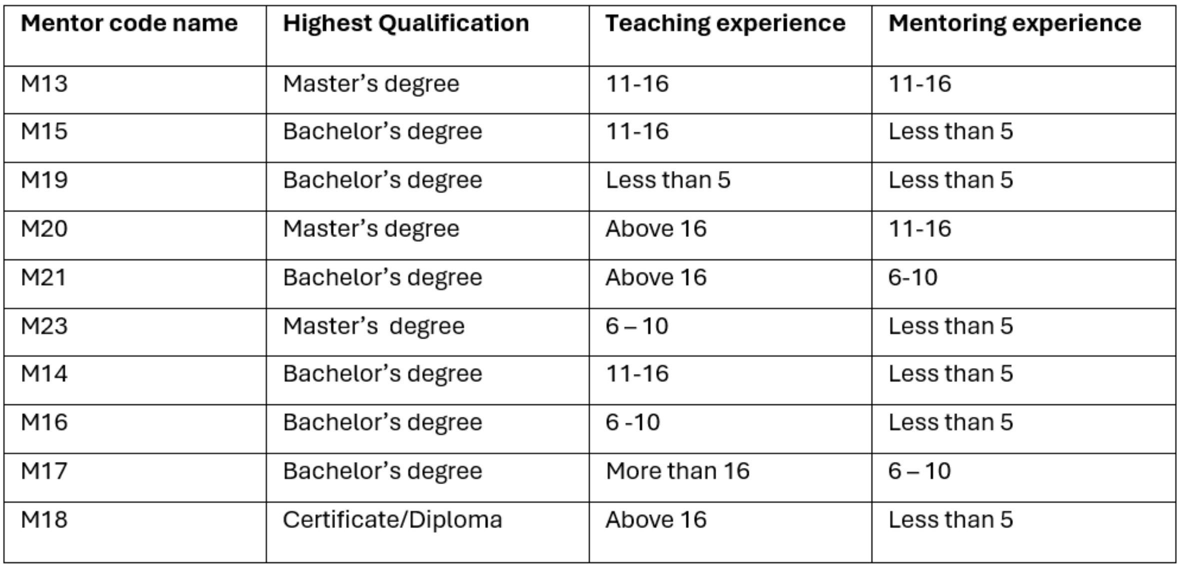
requirement they were studying mathematics. As discussed in Section 2.1.4, on 12 May 2011 the Government legislated that from September 2013, all young people who do not achieve at least

Student teacher	**Mentor**	**Age**	**Highest qualification**	**Mentoring experience**	**Experience in teaching mathematics**
Suzy		46 - 55	Degree in mathematics (no detail given)		No experience
Kate		46 - 55	A-Level (discipline subject not given)		10 years
Job		Less than 25	Diploma in Media & TV at Level 3 Grade C GCSE maths		No experience
	Alex	36 -45	Bachelor of Education (Early Years) degree	Job is his first mentee	5 years
Cain		36 - 45	Mathematics at A-Level and Bachelor of Science (Engineering) degree		No experience
	Julie	46 - 55	Level 4 Certificate in Education & Training. No mathematics at GSCE.	Cain is her first mentee	10 years
Mary		36 - 45	Master's degree (discipline not given)		Less than 5 years

Table 3. 1 Profiles of Phase 1 participating student teachers and mentors

a GCSE Grade C (now 4) in mathematics and English have to continue studying those subjects post-16 until they achieve Grade C (4) (or above) (Department for Education, 2011).

3.3.2 Phase 2 participants



Mentor code name	Highest Qualification	Teaching experience	Mentoring experience
M13	Master’s degree	11-16	11-16
M15	Bachelor’s degree	11-16	Less than 5
M19	Bachelor’s degree	Less than 5	Less than 5
M20	Master’s degree	Above 16	11-16
M21	Bachelor’s degree	Above 16	6-10
M23	Master’s degree	6 – 10	Less than 5
M14	Bachelor’s degree	11-16	Less than 5
M16	Bachelor’s degree	6 -10	Less than 5
M17	Bachelor’s degree	More than 16	6 – 10
M18	Certificate/Diploma	Above 16	Less than 5

Table 3. 2 Phase 2 Mentors who completed the questionnaire

I collected the data by sending an anonymous questionnaire to the Education and Training Foundation (ETF) who distributed it to all colleges in England through their invitation to colleges for mentor training. Ten mentors responded to the questionnaire (Table 3.2), and out of the ten, seven offered to be interviewed (Table 3.3).

Mentor	Highest Qualification	Teaching experience	Mentoring experience
Martin	Masters, PGCE (post compulsory)	11-16	11-16
Darren	PGCE (post compulsory)	11-16	Less than 5
Alex	PGCE (post compulsory)	6-10	Less than 5
Judy	Master’s degree & EdD student	More than 16	11 -16
Don	Bachelor	More than 16	Less than 5
Esther	Master’s degree	6-10	Less than 5
Paul	Bachelor of Science (Mathematics) & Diploma in Teaching in the Lifelong Learning Sector (DTLLS)	5 -10	5 – 10

Table 3. 3 Phase 2 Interviewed mentors

3.4 Data collection

3.4.1 Data collection methods

In this section, I discuss data collection methods employed by this study which are mathtasks, observations, interviews, documents and questionnaire, and how they are related to the research questions (RQs) stated in Section 3.2. In other words, I discuss how the data collection methods are designed to answer the RQs.

3.4.1.1 Mathtasks

This study attempts to access student teachers' mathematical and pedagogical knowledge enacted during teaching and identify student teacher needs (see RQ 1) by using mathtasks. Mathtasks are developed following the MathTASK programme principles. Biza (2023) has the following to say about the MathTASK programme:

> MathTASK is a research and development programme that engages mathematics teachers with challenging and highly contextualised classroom situations in the form of tasks (mathtasks). Teacher responses to these tasks reveal their mathematical and pedagogical discourses and provide opportunities to articulate, reflect and shift said discourses. These tasks have been used as instruments for research as well as teacher education and professional development in the UK, Greece and Brazil (p. 1).

Mathtasks can be described as classroom situation-specific incidents which are hypothetical but grounded on learning and teaching issues that previous research and experience have highlighted as seminal and are likely to occur in actual practice (Biza et al., 2007). Biza et al. (2007) argue that the use of fictitious incidents reduces the load of reporting the details of the real situation and the exposure of potentially sensitive issues (Biza et al., 2007). Biza et al. (2007) explain that in teacher education, a task can be used to trigger student teacher's reflection and to explore their mathematical knowledge for teaching. There is often an overt discrepancy between theoretically and out-of-context expressed teacher beliefs about mathematics, pedagogy and actual practice; therefore, teacher knowledge is likely to be better explored in situation-specific contexts (Biza et al., 2007). The mathematical content of the mathtasks concern topics or issues that are known for causing difficult to students and the student's response to the mathtasks reflects the difficulty and provides an opportunity for the teacher to reflect and demonstrate the way in which s/he would overcome the difficulty (Biza et al., 2007).

Before discussing the mathtasks individually, I outline the development, trialling and adjustment of the mathtasks, giving examples from mathtask 1 (Figure 3.1) as I followed the same process when developing all the mathtasks.

The development of the mathtasks began by identifying key topics that students commonly find challenging. The significance of these mathematical topics for the tasks is discussed in detail later in this section (pp. 75-79). I identified the topics in consultation with experienced Further Education (FE) mathematics teachers. For mathtask 1, *Ratio and proportion*, *Algebra (solving simultaneous equations)*, *Fractions (addition and subtraction)*, and *Trigonometric ratios (sine, cosine, and tangent)* were initially identified as topics which pose challenges to students. Based on discussions with the experienced teachers, relevant literature (for example; Hart, 1981, on the addition of fractions), and my own experience, I narrowed the focus for mathtask 1 to *Addition of fractions*. The next step involved designing hypothetical scenarios (based on my experience) and initial sets of questions related to the topics. Feedback from the experienced FE mathematics teachers was pivotal during this phase. For instance, my initial idea for the scenario for mathtask 1 was on "add the tops" and "add the bottoms" only and the experienced teachers highlighted the importance of common denominators which I included. Subsequent revisions were undertaken in consultation with my supervisors, who provided valuable suggestions to improve the clarity of the mathtasks. The revised mathtasks were then presented to the Research in Mathematics Education (RME) group at the University of East Anglia (UEA). Feedback from the RME group was thoroughly evaluated and discussed with my supervisors, resulting in further refinements. Notably, the inclusion of Question 4 in mathtask 1: "What do you think is the aim/objective of teaching this topic?" was inspired by RME group input. This iterative and collaborative process ensured the mathtasks were carefully refined and rigorously evaluated before their application in the field.

Phase 1 of this study, which is longitudinal, employed three mathtasks. The mathtasks are *Addition of Fractions* (Figure 3.1), *What fraction is halfway?* (Figure 3.2) and *What is the area of the shaded part (area between two concentric circles)?* (Figure 3.3). *Phase 2* which is cross-section employed a questionnaire with an embedded mathtask: *Area of circle and semi-circle* (Figure 3.4). In the section that follows, I discuss the subtlety of the topics; *Fractions* and *Area of circle*, I selected for the mathtasks.

Fractions are a key component of the mathematics study programmes at all levels in the UK. The Department for Education (2020), referring to Key Stage 3 (11 -13-year-olds) curriculum, reads, "… use the four operations, including formal written methods, applied to integers, decimals, proper and improper fractions, and mixed numbers, all both positive and negative" (p. 5). Fractions are selected for the mathtasks as they are difficult to learn and teach (Newton, 2008), because they have several different conceptual meanings: a part of a whole; a portion of a discrete set of objects; a measurement point on a number line; or one number divided by another (Leinhardt & Smith, 1985).

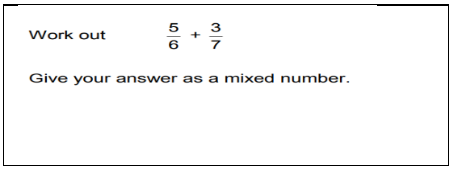
Mathtask 1 is used as an example to show how mathtasks are used to bring the mathematical and pedagogical knowledge of student teachers to surface, and identify student teacher needs.
Mathtask 1: *Addition of fractions* (Figure 3.1) was influenced by Hart (1981) whose study on fractions found that "[m]any children misremembered rules when dealing with the computations; one of the most popular being 'to add fractions, add tops and add bottoms'" (p. 13). In this mathtask, Student A is seen adding numerators and adding denominators, and Students B and C know the common denominators but not sure about how to use the common denominators in adding fractions. The student teacher's response to Question 1: "Find the answer to the question showing all the steps", reveals his or her ability to add fractions, which is bringing his/her mathematical knowledge to surface. The responses to Question 2, 3 and 4 reveal the student teacher's *Pedagogical Content Knowledge (PCK)*: how the student teacher explains to students who do not understand the mathematical concept.

All the mathtasks follow the same format, and they are intended to bring student teachers' mathematical and pedagogical knowledge to surface, and also identify the student teachers' needs.

Mathtask 2: What fraction is halfway? (Figure 3.2) was influenced by Alan Bishop's anecdote where he recounts the occasion when a class of 9- and 10-year-olds were asked to give a fraction between $\frac{1}{2}$ and $\frac{3}{4}$, and one student answered $\frac{2}{3}$, "[b]ecause 2 is between the 1 and the 3, and on the bottom the 3 lies between the 2 and the 4" (Bishop, 1976, p. 41).

Addition of fractions

You give a GCSE mathematics class an exercise with the question below.

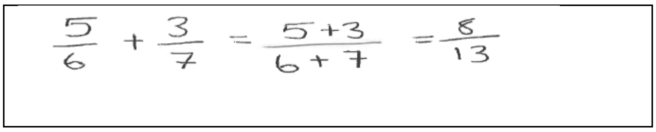


Work out $\frac{5}{6} + \frac{3}{7}$

Give your answer as a mixed number.

You hear this conversation; students arguing about the correct method of solving the problem.

Student A This is my work.



$\frac{5}{6} + \frac{3}{7} = \frac{5+3}{6+7} = \frac{8}{13}$

This is correct because we add the top numbers, we add the bottom numbers, and we get the answer. Deal done. This is like in multiplication.

Student B: Hmmmmmmm. I don't agree with you. In addition, and subtraction, we first find the common denominator. I can’t remember what it is.

Student C: I know the common denominator, but why is it necessary?

Student A (interjecting)**:** You are wrong. You don't know your fractions. Listen to me. You don't know what you are talking about. Listen to me.

You no longer want the discussion to continue because you know this might end up being a class management problem. You stop the class and want to explain from the front as you are aware many students have the same problem.

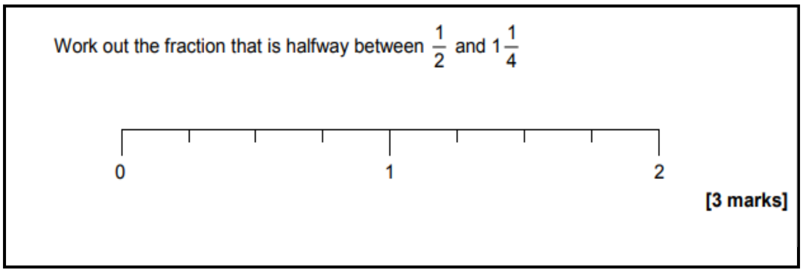
Questions

1. Find the answer to the question showing all the steps.
2. How would you respond to students A, B and C? Explain why you would respond in that way.
3. If you were working with a different class, how would you teach ‘Addition of fractions with different denominators’ and why would you use this approach?
4. What do you think is the aim/objective of teaching this topic?

Figure 3. 1 Mathtask 1:Addition of fractions

What fraction is halfway?

You gave to your GCSE mathematics class the mathematical problem below.



Work out the fraction that is halfway between $\frac{1}{2}$ and $1\frac{1}{4}$

[3 marks]

When you invited the students in the class to share their ideas, you received the following responses from three students:

Alice: (using two pencils pointing at and $1\frac{1}{4}$ moving them to $1\frac{3}{4}$ and 1, respectively). If we use the number line the answer is between $\frac{3}{4}$ and 1. What is halfway between $\frac{3}{4}$ and 1? We are looking for a fraction between $\frac{3}{4}$ and $\frac{4}{4}$ because 1 is $\frac{4}{4}$. I need to find this number.

Ben: I am not sure … what about adding the two fractions and then dividing the total by 2? Let me give you an example. What is between 3 and 5? It's 4! … because, if we add 3 and 5 and then divide by 2, we get 4. We should use the same idea for fractions. We add $\frac{1}{2}$ and $1\frac{1}{4}$ and then divide by 2.

Chloe: This is rubbish and confusing. (Looking at Alice) There is no number between $\frac{3}{4}$ and $\frac{4}{4}$. Look, there is no number between 3 and 4. (Looking at Ben) We should use the number line. If you do not use a number line, then why is it there? Also, why 3 and 5? These numbers are not fractions. We are talking about fractions. For me, what is between $\frac{1}{2}$ and $1\frac{3}{4}$ is 1. The correct answer is 1. Simple!

Questions

1. Find the answer to the mathematical problem by showing all the steps.
2. What do you think is the purpose of giving this mathematical problem to the students? (for example, to check whether students know how to add a fraction and a mixed number).
3. How would you respond to Alice, Ben, Chloe and the whole class? Explain why you would respond in that way.
4. Can you suggest a follow-up activity? Justify your choice.

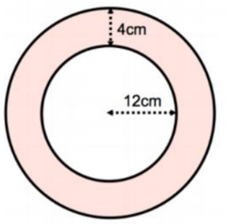
Figure 3. 2 Mathtask 2: What fraction is halfway?

The third mathtask is about *What is the area of the shaded part* (*area between two concentric circles)* (Figure 3.3) and the fourth mathtask is about *Area of a circle and semi-circle* (Figure 3.4). According to the English National Curriculum: Mathematics, *Area and Circumference of the Circle* is introduced at Key Stage 3 (11 – 13-year-olds) (Department for Education, 2020). Area and perimeter of geometrical shapes are essential parts of mathematics curriculum because of their applicability in daily lives' activities such as painting and tiling, and they are needed to introduce many other mathematical ideas (Rujeki & Putri, 2018). Students experience difficulties with these topics due to many factors; for example, using the formula for circumference when finding area and vice versa and also, learning experiences provided in schools give more focus on memorizing formulae, rather than understanding concepts (Rujeki & Putri, 2018).

What is the area of the shaded part?

You have given to your GCSE mathematics class the mathematical problem below.

Shown below is a circular photo surrounded by a frame.



The photo has radius 12cm.
The frame has width 4cm.

Work out the area of the frame leaving your answer in terms of π

The students are working in groups, and you hear this discussion from one of the groups.

Tom: *The formula of area of circle is* $A = \pi r^2$ *(writing the formula down). So, area of the small circle is pi times 12 times 12 which is 144 pi. Let's leave the answer in terms of π (pointing the instruction). The area of the bigger circle is pi times 4 times 4 cm which is 16π. We calculate the area of the bigger circle and the area of the smaller circle and subtract. This takes us to 144 pi - 16 pi which is 128 pi.*

Julie: *No Tom. The area of the bigger circle is pi times 16 times 16 . The radius of the bigger circle is 12 plus 4.*

Adam: *You are good at complicating things. The area of the shaded part is pi times 4 times 4 . The 12 has no use. It is just there to confuse us.*

Julie: *Adam! This is not a circle (moving her figure around the shaded part).*

Tom: *The area of the bigger circle is not pi times 16 times 16 but pi times 4 times 4 (pointing at the 4 cm on the diagram).*

Adam: *I am now confused (looking dejected).*

Julie: *It doesn't make sense, Tom. Let's ask the teacher.*

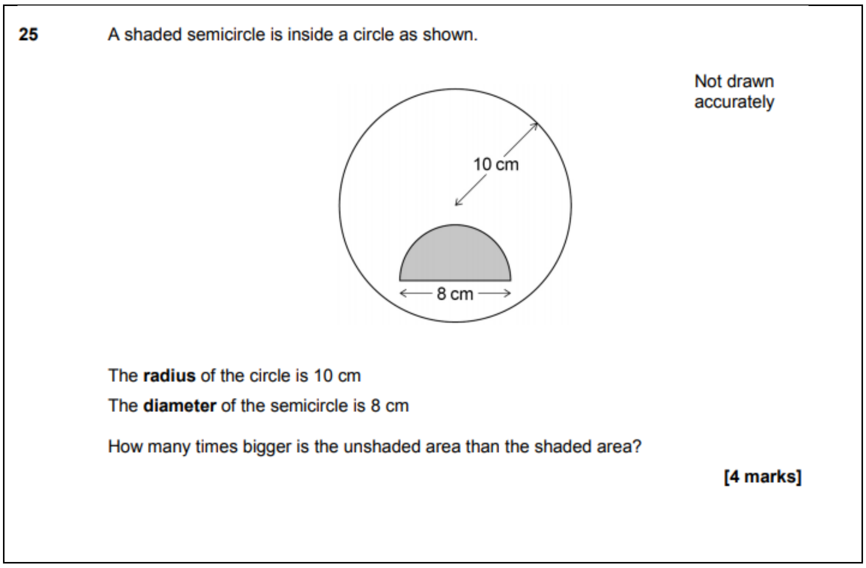
Questions

1. *Find the answer to the mathematical problem by showing all the steps.*
2. *What do you think is the purpose of giving this mathematical problem to the students?*
3. *How would you respond to Tom, Julie, Adam and the whole class? Explain why you would respond in that way.*
4. *Can you suggest a follow up activity? Justify your choice.*

Figure 3. 3 What is the area of the shaded part?

Area of circle and semi-circle

You observe a student teacher you are mentoring explaining this question to a GCSE class.



25 A shaded semicircle is inside a circle as shown.

Not drawn accurately

The **radius** of the circle is 10 cm

The **diameter** of the semicircle is 8 cm

How many times bigger is the unshaded area than the shaded area?

[4 marks]

Teacher*: Remember area of circle is pi times diameter.*

George*: Is it not pi times radius squared?*

Teacher*: Thank you, George. Remember the difference between diameter and radius. What is radius? What is diameter?*

Peter*: Radius is inside half and diameter is from side to side.*

Teacher*: Well done. Let's go back to our question. Radius of the big circle is 10 cm and diameter of the half circle is 8 cm. So, we say how many times is 10 bigger than 8.*

Anna*: I don't get it. We should find area.*

Teacher*: That's correct Anna. Let me check the answer. The answer is 11.5. Let's move on to the next question. We are running out of time. Exams are around the corner.*

Questions

1. *How would you help the student teacher work out the question?*
2. *How would you help the student teacher explain to the class?*

Figure 3. 4 Mathtask 4:Area of circle and semi-circle

3.4.1.2. Observation

It is important to remind the reader that the lessons and mentor meetings were online on *Zoom* and *Microsoft Teams* as data collection was carried out during the COVID-19 lockdowns. I recorded the lessons and mentor meetings, and downloaded transcripts for analysis.

In an attempt to capture student teachers' mathematical and pedagogical knowledge enacted during teaching and identify student teacher needs (see RQ 1), I observed the actual teaching of two student teachers throughout the 2020/21 academic year. To gain insights into how mentoring addresses the student teachers' needs (see RQ 2), I observed mentor meetings throughout the same academic year.

The study employed structured observation which "[i]s a method for systematically observing the behaviour of individuals in terms of a schedule of categories" (Bryman, 2016, p. 267). The schedule of categories used in this study were the Knowledge Quartet (KQ) theoretical framework (Rowland et al., 2009) dimensions and their respective codes. However, I did not shut away other observables which are not covered by the KQ dimensions but are related to the research questions.

The key advantage of observation is noted by Burgess (2006) who says much of the research on teacher knowledge has been conducted away from the classroom, the main context or site in which teachers use their knowledge. Burgess (2006) argues for research to be carried out within the classroom, searching for evidence of what knowledge a teacher has and uses in the immediate act of teaching, thus allowing behaviour to be observed directly (Bryman, 2016). The distinctive feature of observation as a research method is that it offers an investigator the opportunity to gather 'live' data from naturally occurring social situations. In this way, the researcher can look directly at what is taking place *in situ* rather than relying on second-hand accounts (Cohen, et al., 2017). Cohen et al. (2017) explain that the use of immediate awareness, or direct cognition, as a principal mode of research has the potential to yield more valid or authentic data than would otherwise be the case with mediated or inferential methods. The most talked about disadvantage of the observation is the researcher presence effects; the behaviour of the observed participants would be different from their behaviour in a natural unobserved environment (Bryman, 2016).

3.4.1.3 Interviews

As data collection was carried out during COVID-19 lockdowns, I interviewed student teachers and mentors online using *Microsoft Teams*, and the interviews were recorded. I downloaded the transcripts for analysis.

In an attempt to capture mathematical and pedagogical knowledge enacted by student teachers in teaching, student teacher needs (see RQ 1), how mentoring addresses student teacher needs, institutional issues that could influence mentoring (see RQ 2), and challenges and lessons learnt during e-mentoring (RQ3), I interviewed student teachers and mentors. During *Phase 1*, the interview questions for mentors included highlights of student teachers' collective responses to mathtasks and what was observed in lessons with no individual responses and lesson observed mentioned, while interview questions for student teachers include follow up to mathtask responses and observed lessons (Appendices 1, 2 & 3). In *Phase 2* mentors' interview questions were a follow up to questionnaire responses in general (Appendix 4). Due to ethical reasons, I was not able to connect questionnaire responses to the interviewees; therefore, the questions were not specific to individual responses.

This study employed semi-structured interviews, also known as the general interview guide approach (Bryman, 2016), where topics and issues to be covered are specified in advance, in outline form and the interviewer decides sequence and working of questions in the course of the interview (Cohen, et al., 2017). The strength of the general interview guide approach is the ability of the researcher to ensure that the same general areas of information are collected from each interviewee, but still allows a degree of freedom and adaptability in getting information from the interviewees (Turner, 2010). In addition, the researcher must be prepared with follow-up questions or prompts in order to ensure that s/he obtain optimal responses from participants (Turner, 2010). The obvious issues with this type of interview is lack of consistency in the way research questions are posed because the researchers can interchange the way s/he poses them (Turner, 2010), and important and salient topics may be inadvertently omitted (Cohen, et al., 2017).

3.4.1.4 Documents

In an attempt to capture the mathematical and pedagogical knowledge enacted in teaching, student teacher needs (RQ 1), and how mentoring addresses student teacher needs (RQ 2), documents in form of mentor reports about student teachers' performance based on mentor observations (Appendices 5, 6 & 7) were collected. Bryman (2016) describes documents "--- as a source of data such as letters, diaries, autobiographies, newspapers---. The emphasis placed on documents that have not been produced at the request of the social researcher---" (p. 546). Bryman (2016) warns that documents cannot be regarded as providing objective accounts of state of affairs; they have to be interrogated and examined in the context of other sources of data; hence, in this study different sources of data are employed.

3.4.1.5 Questionnaire

Phase 1 employed a questionnaire (developed on Qualtrics), with a hypothetical classroom situations: *Mathtask 1 : Addition of Fractions* (Figure 3.1) embedded. This was used to recruit student teachers and to collect data as discussed in the *Participants* section (see Section 3.2.3). *Phase 2* of the study employed an anonymous questionnaire to collect data on how mentoring addresses student teacher needs, and institutional issues which influence mentoring practices (RQ 2), and challenges and lessons learnt during e-mentoring (RQ 3). The questionnaire (follow link: Mentor questionnaire) was developed on *Microsoft Forms*. It is divided into three sections: demographic information about the mentors, mathtask (Figure 3.4) and general information: mentoring structure, challenges of mentoring during COVID-19 lockdowns, use of technology in mathematics teaching and learning, engaging students during online lessons, connecting mathematics to real life and vocational course, teaching for examinations, and mentor training.

Questionnaires which are completed by respondents themselves are one of the main instruments for a survey design (Bryman, 2016). Questionnaires are quick, easy and cheap to administer especially when distributed to a geographically dispersed area (Bryman, 2016). Besides these advantages, questionnaires lack prompts and one cannot probe for more information, and in case of anonymous questionnaires, it is not possible to know who has (and who has not) responded to the questionnaire (Bryman, 2016) making it difficult to connect the responses to the respondents and plan for follow up interviews. Questionnaire are also known for low response rate (Bryman, 2016).

3.4.2 Data collection process

As mentioned several times in earlier sections, data were collected in two phases.

Phase 1 followed a longitudinal research design, defined as a research design in which data is collected on a sample (of people, documents, etc.) on at least two occasions in order to capture social changes (Bryman, 2016; Cohen et al., 2017). Longitudinal approach, besides being expensive and the possibility of participants dropping out, allows relationships to be discovered over time and has considerable potential for yielding rich data with great accuracy (Cohen et al., 2017).

During *Phase 1*, data were collected in three cycles (Table: 3.4). In *Cycle 1*, all the five student teachers: Job, Cain, Suzy, Kate and Mary completed *Mathtask 1*. I also observed four and two lessons being taught by Job and Cain, respectively. I interviewed Job, Cain and Suzy once each. I also interviewed Alex (Jobs mentor) and Julie (Cain's mentor) once each and collected reports they wrote about their student teachers. I analysed the data and the analysis informed designing *Cycle 2* where Cain and Suzy completed *Mathtask 2*. I also observed Job and Cain teach eight and four lessons, respectively. I observed Cain and Julie in a mentor meeting, and interviewed Suzy and Alex. The analysis of the data informed *Cycle 3* where Job and Cain completed Mathtasks 3 and I observed them teaching three times each. I also interviewed both Job and Cain and their mentors, observed their mentor meetings and collected a mentor report from Julie. I analysed all the data from the three cycles. The analysis informed *Phase 2.*

	Mathtasks			Lesson observations															Mentor meetings observations			Student teachers interviews			Mentor interviews			Documents		
Cycles/student teacher	1	2	3	1				2								3			1	2	3	1	2	3	1	2	3	1	2	3
Job	🟩		🟩	🟩 1	🟩 2	🟩 3	🟩 4	🟩 5	🟩 6	🟩 7	🟩 8	🟩 9	🟩 10	🟩 11	🟩 12	🟩 13	🟩 14	🟩 15			🟩	🟩		🟩	🟩	🟩	🟩	🟩		
Cain	🟩	🟩	🟩	🟩 1	🟩 2			🟩 3	🟩 4	🟩 5	🟩 6					🟩 7	🟩 8	🟩 9		🟩	🟩	🟩		🟩	🟩		🟩	🟩		🟩
Suzy	🟩	🟩																				🟩	🟩							
Kate	🟩																													
Mary	🟩		-																											

Table 3. 4 Phase 1 Data collection overview

Phase 2

As mentioned earlier (see *Phase 2* Participants in Section 3.3.2), ten mentors responded to an anonymous questionnaire, and out of the ten, seven were interviewed.

Phase 2 employed a cross-section design, which is defined by Bryman (2016) as a design that "[e]ntails the collection of data on a sample of cases at a single point in time" (p. 53). The cross-section design which is often called a survey design is closely connected with questionnaire and structured interviews. Bryman (2016) says while the cross-section design is firmly placed in the context of quantitative research, qualitative research follows a form of cross-section design as well. In fact, research methods are much more free-floating than is sometimes supposed (Bryman, 2016); therefore, I am not restricted to methods usually associated with qualitative research.

3.5 Data analysis

Analytic frameworks employed

As mentioned earlier, this study employed the Knowledge Quartet (KQ), which was discussed in detail in the *Conceptual Framework* chapter (Section 2.2.2.8), in tandem with thematic analysis (discussed below), as data analysis tools.

Braun and Clarke (2006) say, “Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data. It minimally organises and describes your data set in (rich) detail” (p. 79), and Bryman (2016) describes thematic analysis as the extraction of key themes from the data. I selected thematic analysis due to its flexibility as it is not wedded to any pre-existing theoretical framework; therefore, it can be used within different theoretical frameworks (although not all) and can be used to do different things within them (Braun & Clarke, 2006). Thematic analysis is a relatively straightforward form of qualitative analysis, which does not require detailed theoretical and technical knowledge; therefore, it is relatively easy to conduct a good thematic analysis on qualitative data, even when one is still learning qualitative techniques (Braun & Clarke, 2006). However, Braun and Clarke (2006) warn that thematic analysis has some pitfalls of which one is associated with the using of the data collection questions (such as from an interview schedule) as the ‘themes’ that are reported. In such a case, no analytic work would have been carried out to identify themes across the entire data set. Being aware of the pitfall, in this study, I try to make sense of the patterning of the responses to come up with the themes. In the section that follows, I discuss the data analysis detailing the stages followed.

Data analysis procedures

The process of data analysis is not a linear and simple step-by-step procedure but on-going and iterative (Braun et al., 2016). My data analysis began while I was collecting data, which helped me to cycle back and forth between thinking about the existing data and generating strategies for collecting new, often better, data (Miles & Huberman, 1994).

Phase 1

The data collected during *Phase 1* of the study using mathtasks, lesson observations, mentor meeting observations, interviews with student teachers, interviews with mentors, and mentor reports were analysed using the KQ dimensions and corresponding codes in tandem with thematic analysis. As a methodological contribution, this study broadens the use of the KQ, which is mostly employed to analyze lesson observation data, by adapting it to examine data collected through various other methods as well (see Section 6.4.3). The analysis followed eight stages which were not pre-determined but came up during the analysis.

Stage 1: Familiarizing myself with the data and identifying episodes

The first stage of data analysis was reading the data for each student teacher several times. I then identified episodes which could be seen as belonging to the KQ dimensions, and also showing student teacher knowledge enacted in teaching (or intentions), student teacher needs, and how mentors assist (or not) the student teachers in addressing the needs. I highlighted the episodes.

Stage 2: Categorising episodes into KQ dimensions by student teachers

Cain Transformation	**Job Connection**
• I would use an adapted concrete, pictorial, abstract method and show a correct approach alongside a representation of the incorrect. • When teaching Volume of prisms & Volume of cylinders, Cain gave a prism with two 4 cm. This caused some confusion. • When teaching gradient of a line, Cain explained, "I paused for a moment. I said to myself I've got a learning tool that will work for this. I've got autograph on that computer, so I opened up autograph on that computer. I explained using autograph and they all got it."	• When introducing Area and Perimeter of Shapes, Job explained: We are going to cover perimeter, but we are focusing mainly on area and the reason for this is area can get really confusing and you need to go over it quite a few times because it's the formulas you need to remember. Perimeter you add the entire outside of the shape. […]. Sometimes you don't get all the sides. A while ago you learnt rules of shapes like square all sides are equal, rectangle opposite sides are equal. • When teaching Simplifying ratio, Job displayed the ratio (Figure 4.33) and explained: Ratios can be simplified just like fractions by dividing each part by the highest common factor. The highest common factor of 14 and 35 is 7. 14 divided by 7 is 2 and 35 divided by 7 is 5. The answer is 2 to 5.
Mentor Julie assisting Cain	**Mentor Alex assisting Job**
• During one of the observed mentor meetings, Cain said that he was using Diagnostic Questions for starters, and he was running out of them. Julie said, "Since you are running out of starters, you can use Level 2 Functional Skills questions for your GCSE maths classes."	• Alex did not discuss teaching specific topics with Job but more general pedagogic aspects. Alex said, "So it might be somewhat more general, which would work for all topics. Maybe the pace things like that. But if the student teacher comes with a specific topic like Venn diagrams, I can help."

Figure 3. 5 Example of categorising data

The next stage was to categorise the highlighted episodes into KQ dimensions, and how mentors assist student teachers (see Figure 3.5). I ended up having five sets of episodes (*Foundation, Transformation,* *Connection* and *Contingency,* and *Mentor assisting student teacher)* for Job, five for Cain and one each for Mary, Suzy and Kate. The episodes (plus flagship episodes) are presented in Chapter 4 (Section A: *Initial data analysis*).

Stage 3: Identifying codes and categorising them under KQ dimensions by student teachers

From the episodes in Stage 2, I identified codes and colour coded them. I then listed them under the KQ dimensions: *Foundation, Transformation, Connection* and *Contingency,* for each student teacher (see example in Figure 3.6).

Cain's response to mathtask 1: Addition of fractions

Fraction addition - so find lowest common denominator. 5/6+3/7 becomes 35/42+18/42=53/42=1 11/42. Or box method, but unsure how to write that here... 2. A: Depends on other students' knowledge. Would deal with challenging behaviour first and ask them to slow down a bit. If they understand equivalent fractions or simplifying, could ask them to compare their answer to the numbers they started with. (I want to lead to potential cognitive conflict between their understanding that addition makes things get bigger while their workings here do not) B & C: Can have C explain to B what the common denominator is, and then explain why they need it. (I want some peer learning to take place, and not purely transmit information at my learners) 3. This is actually approaching as a topic, and today I have given some learners a similar question as an initial/diagnostic assessment. About half the students used this incorrect method. In ideal circumstances I would go for an adapted concrete, pictorial, abstract method and show a correct approach alongside a representation of the incorrect. My reasoning being that I suspect learners may remember that 'just adding' is wrong if they see why, rather than being told. I will likely use the 'box method' as well, as it is a different way of doing this topic to how I was taught, and not many students seem to know it.

Foundation 🟥	*Transformation* 🟦	*Connection* 🟩	*Contingency* 🟨
1: - so find lowest common denominator. 5/6+3/7 becomes 35/42+18/42= 53/42=1 11/42. *2: I want to lead to potential cognitive conflict* *3: not purely transmit information at my learners*	*1. I would go for an adapted concrete, pictorial, abstract method and show a correct approach alongside a representation of the incorrect* *2. I will likely use the 'box method' as well.*	*1. If they understand equivalent fractions or simplifying, could ask them to compare their answer*	*1. Depends on other students' knowledge.*

Figure 3. 6 Example of Phase 1 initial data analysis

I had four sets of codes for each student teacher with Job and Cain having longer lists as they participated in all the data collection methods.

Stage 4: Aggregating and categorising codes into KQ dimensions and corresponding codes

At this stage everything was brought together by aggregating the data; for example, all *Foundation* codes for all participants were brought together and listed under *Foundation*. Unlike Stages 1, 2 and 3, the names of the student teachers were of less importance. I had four sets of data representing the four KQ dimensions.

Stage 5: Identifying mathematical and pedagogical knowledge enacted by student teachers in teaching

I read the sets of data in each KQ dimension in Stage 4 highlighting what I considered *mathematical and pedagogical knowledge enacted* codes. I grouped the codes in each KQ dimensions under the corresponding codes, and this is discussed in Chapter 4 (see 4.3.1 Section B: *Data analysis and discussion*).

Stage 6: Identifying student teacher needs and categorising them into themes

I read the codes in Stage 4 several times highlighting what I saw as student teacher needs. I listed the *student teacher needs* and combined similar needs into themes and invented names. I ended up with eight themes. Figure 3.4 is an example of how I identified the themes later called the *student teacher needs*.

Job's response to an interview question: We were in the same team room. Mariam (pseudonym) (an experienced FE mathematics teacher) was very approachable. She put me under her wings. Whenever, I had a question she answered. If I had a resource from the internet, she helped me improve on it. If I had a gap in subject knowledge, especially in algebra, I would go to Peter (pseudonym) (another experienced FE mathematics teacher).

Job's observed episode. After displaying the answers Job spotted an incorrect answer (the HCF of 100 and 60 = 5. He changed it to 20). He did not spot that the HCF of 112 and 42 = 2 is incorrect.

Figure 3. 7 Example of student teacher needs identification

Looking at the example in Figure 3.7, the highlighted codes were combined into a theme which I named *Gaps in subject knowledge* student teacher need. This is discussed in Chapter 4 (see Section 4.3.2: *Student teacher needs)*.

Stage 7: Identifying how mentoring addresses student teacher needs and categorising them into themes

I went back to codes in Stage 4 looking for evidence of how mentors assist student teachers addressing their needs identified in Stage 6. I highlighted the codes (see for example in Figure 3.8).

During one of the observed mentor meetings, Cain said that he was using Diagnostic Questions[13] for starters, and he was running out of them. Julie said, "Since you are running out of starters, you can use Level 2 Functional Skills questions for your GCSE maths classes." This led to Cain and Julie working out mathematics questions together ---.

Figure 3. 8 Example of mentors assisting student teachers analysis

I grouped similar codes into themes and invented names of each theme; for example, the second code: 'Cain and Julie working out mathematics questions together ---' combined with other codes come up with *Doing mathematics* theme. This is discussed in Chapter 4 (see Section 4.3.3: *How mentoring addresses student teacher needs*).

Stage 8: Identifying Institutional issues that could influence mentoring in FE

At this point, I realised that there are some issues which are important to mentoring but could not be categorised under the KQ dimensions. These issues cover the wider institutional mentoring practice that are seen as having the potential of influencing mentoring. I ploughed back into original data and identified codes which are seen to have the potential of influencing mentoring. I listed the codes and grouped similar codes into themes, and I invented the names. I came up with four themes: *mentoring structure; training mentors; teaching for examinations;* and *contextualising the teaching of mathematics to vocational courses and real-life*. This is discussed in Chapter 4 (see Section 4.3.4*: Institutional issues that could influence mentoring in FE).*

At this stage, I decided to collect more data to further understand what was found during *Phase 1* about *How mentors address student teachers needs* and *Institutional issues that could influence mentoring*. It is important to remind the reader that data were collected during the COVID-19 pandemic; therefore, data about *Challenges and lessons learnt during e-mentoring and e-teaching* were also collected.

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[13] Diagnostic questions is an assessment tool that provides detailed insights into student understanding https://diagnosticquestions.com

Phase 2

During Phase *2* data were collected from ten mentors who completed a questionnaire and seven out of the ten who were interviewed. The analysis followed the stages of thematic analysis proposed by Braun and Clarke (2006).

Stage 1: Familiarizing myself with the data

I read the ten mentors' responses to the questionnaire with Mathtask 4*: Area of circle and semi-circle* (Figure 3.4) embedded and seven interview transcripts (Microsoft transcribed) several times, noting down initial ideas.

Stage 2: Generating initial codes

Alex's Interview response

I would firstly ask the teacher to do homework about the topic before teaching it. When you are being observed is different from teaching in a relaxed manner. Everyone makes mistakes, I would give this teacher chance to make mistakes and grow. I would work maths questions with the teacher. I would invite him/her to observe me teaching the topic and other teaching.

Alex's Interview response to another interview

Advantage is being able to continue mentoring. The ability to record what you are doing in lessons. You can come back and watch. The use of interactive resources like Century[14] Tech, BKSB and other online programmes. Disadvantages are teachers have to start from zero to learn online teaching. To engage learners has proved to be challenges; they easily disengage. The main problem is we don't have answers to problems mentees brings about online teaching. Some of the things in teaching come through experience like driving. I instil the notion of reflection. If a lesson does not go well reflect on what went wrong and improve. Be creative. Don't be afraid to test new waters.

Julie's interview response

I need time allocated for mentoring. When we are really busy, we make our own slots, but it needs to be allocated for both mentee and mentor. There should be a structure. Training offered. The mentor needs to be there for general day-to-day support. There should be guidelines. The [training] university may produce some mentor handbooks. They gave us some paperwork. It was just about Cain.

M13 response to questionnaire

Time is a challenge when mentoring. Too often mentoring a trainee is an additional duty and without incentive for the mentor. Through COVID lockdowns there was improved conversation and discussion due to more free time as team planning exercises saved individuals planning time.

Figure 3. 9 Example of coding

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[14] Century is a teaching learning platform that uses digital technology to assess and assign students work due to their understanding. (https://www.century.tech)

This involves coding features of the data, which relate to the research questions, in a systematic fashion across the entire data set, collating data relevant to each code (Braun & Clarke, 2006). I highlighted codes which show *mentors assisting student teachers* and *institutional issues which have the potential of influencing mentoring*. Codes on *challenges and lessons learnt while e-mentoring during COVID-19* were also identified and highlighted. Figure 3.9 is an example of how I identified and highlighted the codes.

Stage 3: Categorising codes

I listed the highlighted codes under the headings: *mentors assisting student teachers; institutional issues,* and *challenges and lessons learnt.* Codes which were similar were not repeated but a tick was given each time a similar code appears. Figure 3.10 shows how the codes were categorised.

Mentors assisting student teachers	**Institutional issues**	**Challenges and lessons learnt**
1. I would firstly ask the teacher to do homework about the topic before teaching it. 2. I would work maths questions with the teacher. 3. I would invite him/her to observe me teaching. 4. I instil the notion of reflection 5. Be creative	1. I need time allocated for mentoring. 2.Training offered. 3. There should be a structure. 4. There should be guidelines	1. The ability to record what you are doing in lessons. 2. The use of interactive resources like Century Tech, BKSB and other online programmes, 3. . To engage learners has proved to be challenges; they easily disengage.

Figure 3. 10 Example of coding

Stage 4: Searching for themes

At this stage I collated codes in Figure 3.10 into potential themes, and this translated Figure 3.10 into Figure 3.11. Some codes which appeared few times and seen as not relevant to the research questions were left out; for example, “4. I instil the notion of reflection and 5. Be creative” were left out.

Mentors assisting student teachers	Institutional issues	Challenges and lessons learnt
1. Doing mathematics. 2. Observing (and learning) experienced teachers 3. Teaching mathematics	1.Mentoring structure 2. Mentor training 3. Teaching for examination 4. Contextualising the teaching of mathematics	1. Teamwork 2. Digital Technology 3. Personal and professional relationships 2. Mathematics teaching needs physical demonstration 4. Recording lessons

Figure 3. 11 Themes generated

Stage 5: Reviewing themes

I checked if the themes work in relation to the coded extracts and the entire data set.

How *Phase 1* and *Phase 2* data come together to address the research questions

For RQ 1: *What mathematical and pedagogical knowledge is enacted by further education mathematics student teachers in teaching, and what are the student teachers' needs?,* data collected during *Phase 1* were analysed to answer the research question. For RQ 2: *How does mentoring addresses the student teacher needs, and what institutional issues have the potential to influence mentoring practices?,* data collected and analysed during *Phase 1* were added to data collected and analysed during *Phase 2*, to answer the research question. For RQ 3: *What are the challenges and lessons learnt during e-mentoring FE mathematics student teachers during COVID-19 lockdowns?,* data collected during *Phase 2* were analysed to answer the RQ. See Figure 3.9 about how the phases relate to RQs.

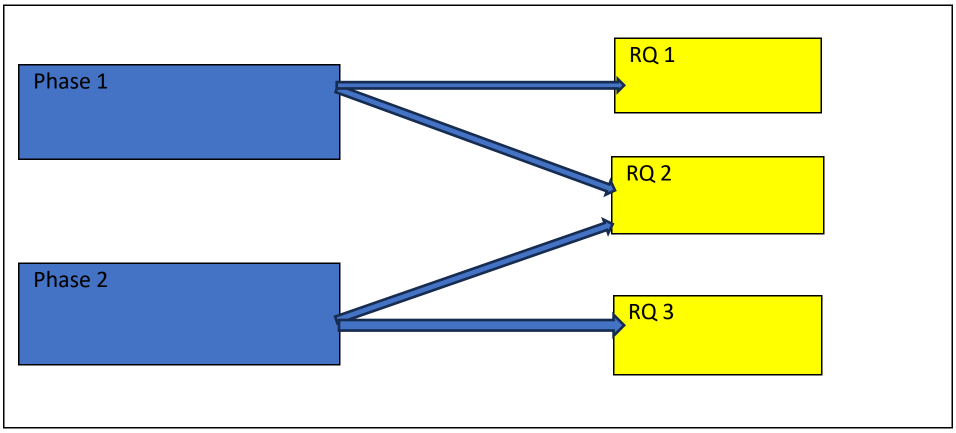

Figure 3. 12 How Phases were designed to answer RQs

Finally, I refined and generated clear definitions and names of themes in each of the five broad categories: *The mathematical and pedagogical knowledge enacted during teaching; Student teacher needs; Mentors assisting student teachers; Institutional issues;* and *Challenges and lessons learnt during e-mentoring*.

I conclude this section with diagrammatic representations of the research design linking to the research questions (Figure 3.10).

Diagrammatic representation of how the research design links to the research questions

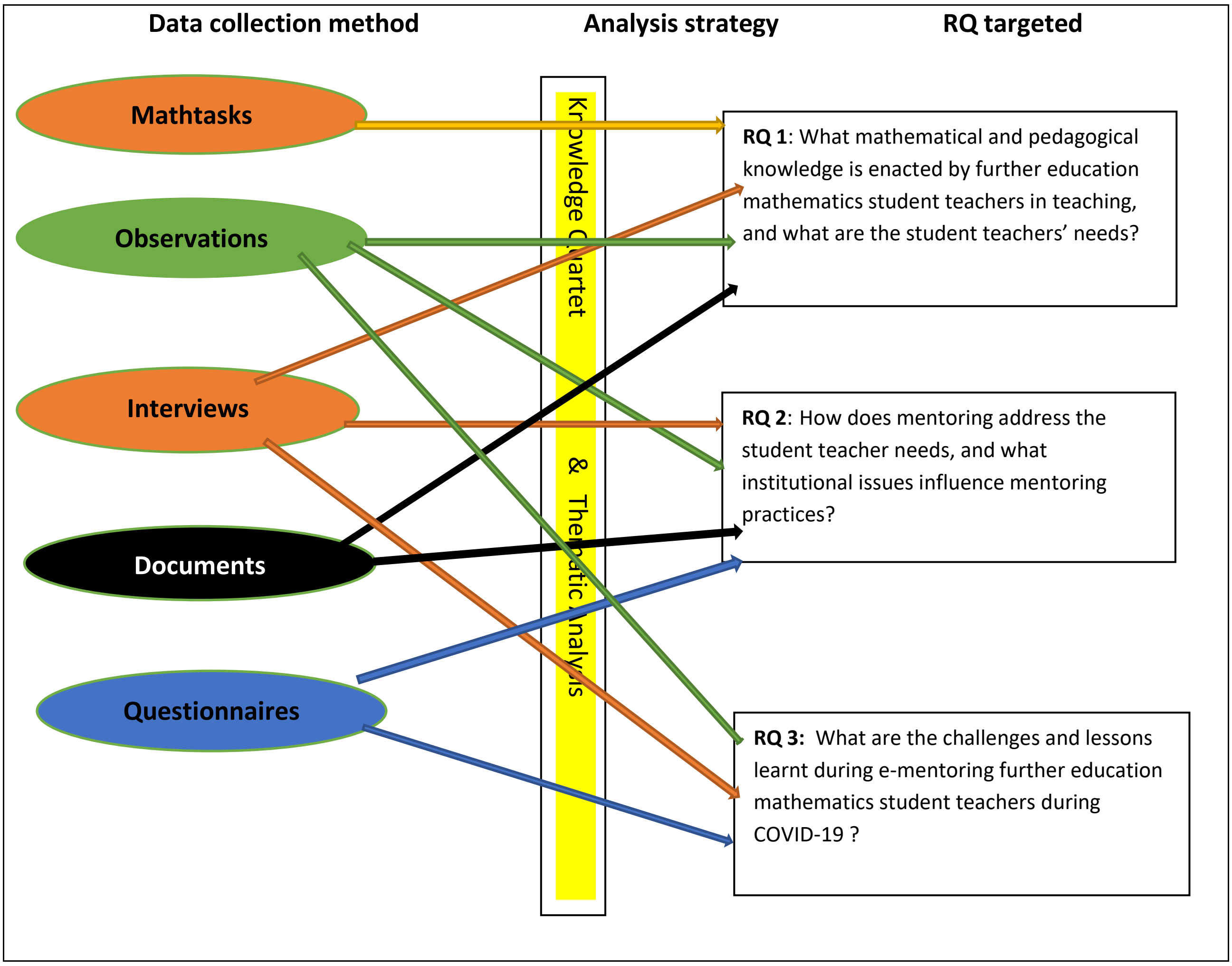

Figure 3. 13 Diagrammatic representation of how the research design links to the research questions

3.6 Trustworthiness of the study

Validity, which is the accuracy of results, and reliability, which is the consistency of the results are associated with evaluating quantitative research. Guba and Lincoln (1994) argue that the use of the terms in qualitative research could imply a positivist perspective of a universal truth; therefore, they propose the notion of trustworthiness which has four aspects: credibility, dependability, transferability and confirmability, as a criterion of how good a qualitative study is. Credibility is how believable the findings are; dependability is the applicability of the findings at other times; transferability is about the applicability of the findings in other contexts; and confirmability is concerned with how the researcher allowed his/her values to intrude in the findings (Guba & Lincoln, 1994).

I used triangulation which Bryman (2016) describe as, "[u]sing more than one method or source of data in a study" (p. 386). Triangulation is important to achieve credibility and confirmability of a study as the results of the data analysis comes from different sources; the story told by different people. This reduced the influence my personal values in carrying out this study. I discussed the results of my study with new and experienced researchers during Research in Mathematics Education (RME) group meetings at the University of East Anglia (UEA) and at British Society for Research into Learning Mathematics (BSRLM) conferences. The scrutiny of my work made me reflect and improve it and this increased my study's credibility and confirmability. The use of the KQ, which has been used in different contexts locally (in the UK) and internationally, as the theoretical framework guiding my study increased the dependability and transferability of the results of the study. The study relied on primary data as a principal mode of research, and this has the potential to yield more valid or authentic data than would otherwise be the case with mediated or inferential methods (Cohen et al., 2017), and this increased the trustworthiness of the study.

3.7 Ethical Considerations

Before data collection, my plans for *Phase 1* and *Phase 2* had to be approved by the University of East Anglia (UEA) Ethics Committee (see Appendix 9). I had to conform to the ethics standards of the Research Committee of the School of Education and Lifelong Learning (EDU) at UEA, UEA's Research Ethics Policy and the Economic and Social Research Council (ESRC)'s Framework for Research Ethics.

It was made clear to the participants that it is their right not to answer any question(s) or all questions and to withdraw from the study at any time before the data were analysed and combined with data from other participants. In the sections that follow, I discuss how the data collection instruments conform to the ethics.

Mathtasks

I emailed the heads of departments (HoDs) an online survey link to a questionnaire with a mathtasks embedded to distribute to student teachers in their departments. Distributing the mathtasks through the HoDs might be taken as coercing the student teachers. The student teachers completed the mathtask and the responses came to me directly via Qualtrics, an online survey software. It was made clear to the student teachers that HoDs would not know who would have (or not) completed the mathtasks. It was also emphasized that the information provided would not be available to anyone and the data would be anonymised.

Classroom observations

After gaining access from the gate keepers to the colleges, I obtaining consent from mentors and student teachers for data collection methods: mathtasks, observations, interviews and documents, and from the students to be observed in lessons. The research was explained to students by their teachers (the student teachers), and they had to consent by writing 'YES' in the chat. Students in college, who were observed being taught, were aged above 16 so they consented on their own without parental approval. After getting consent, I observed the student teachers' lessons which were taught online on *Microsoft Teams*[15] and *Zoom*[16]. My presence in the virtual classrooms, though my camera was always switched off, might have affected the normal classroom working, but this was minimized by reassuring the participants that the data collected would be anonymised making it untraceable to individuals. As I observed the same classes for the whole year the students and their teachers (the student teachers) got used to a 'faceless object on the screen' and this reduced the researcher presence effect.

Mentor meeting observations

Mentors and student teachers were observed during online mentor meetings. To reduce the researcher presence effect, I started recording and went away only to come back after the meeting to view the recordings. However, it is most likely that knowing that their meetings were recorded affected the mentor/student teacher discussion. The researcher presence effects were minimized by reassuring the participants that the data collected would be anonymised making it untraceable to individuals.

Interviews

Data were also collected by interviewing student teachers and mentors. In an interview, participants were not obliged to answer questions they did not want to answer. Some interview questions were

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[15] Microsoft Teams is a collaboration and video conferencing platform that helps people communicate effectively across a number of different mediums. (https://www.microsoft.com/microsoft-teams)

[16] Zoom is an online audio and web conferencing platform. People use it to make phone calls or to participate in video conference meetings. (https://www.lifewire.com/what-is-zoom-and-how-does-it-work-4800476)

about particular incidents in the lessons, and this might have caused some uneasiness in the participants, but it was made clear that data from the participants would be anonymised and not traceable to an individual.

Documents

Mentoring reports were collected from mentors only if they and the student teachers consented to that. It was made clear that it is the mentor and the student teachers' rights to refuse sharing the documents with the researcher. It was also stated that the mentors and student teachers had the right to withhold any information they did not wish to share with the researcher.

Questionnaires

Data were also collected using anonymous questionnaire. The participants were made aware that it is their right not to answer some or all the questions. It was also made clear that once submitted it would be impossible to identify individual responses.

By adhering to these ethical guidelines, the integrity of the research was maintained while protecting the rights and privacy of all participants involved.

3.8 The impact of the COVID-19 pandemic and potential methodological limitations

Immediately after my research had been approved by the University of East Anglia's School of Education and Lifelong Learning Ethics Committee and just before data collection, colleges and other educational institutions had to move from face-to-face to online teaching and learning due to the COVID-19 lockdowns. Mentoring also moved online to e-mentoring. My plan obviously changed. E-teaching and e-mentoring were new grounds, and I had to collect data online which was new to me and to the participants. This was challenging.

It was during the recruitment of participants that all face-to-face lessons were moved online. This affected the recruitment as many colleges were not clear about their own e-teaching and e-mentoring. There were lots of training of teachers on how to use online platforms; for example, *Microsoft Teams, Google Classroom* and *Zoom*. Physical visits to colleges were out of question due to the pandemic. Colleges were reluctant to allow outsiders, especially researchers, to observe online teaching by student teachers and interview student teachers and mentors. This was due to lack of clarity about how they were supposed to be teaching online. This reduced the number of participants in this study leading to collecting data mainly from two student teachers and their mentors, plus three other student teachers whose participation was restricted to the initial parts of the fieldwork. Following the two student teachers for the whole academic year provided a rich data set although the sample was smaller than what was initially planned. However, this challenge gave me the opportunity to rethink and collect more data from mentors, thus having the 'story' told from different perspectives. The study ended up having two phases.

Collecting data online during the pandemic was challenging. In some lessons, teachers did not hear some students and some students did not hear the teacher and other students, and at times my recordings were not clear; this reduced the accuracy of the data collected. As I conducted data collection during the pandemic but writing the thesis during the post pandemic era, I could see the challenges turning into opportunities. The study has shed light to what was learnt during the pandemic which could be useful during the post pandemic era.

3.9 Conclusion

In Chapter 3, I outlined the research methodological approach of this study as the socio-constructivist perspective of ontology and the interpretivist perspective of epistemology. I also mentioned that data were collected in two phase. During *Phase 1,* which was longitudinal, data were collected in three cycles using mathtasks, lesson observation, mentor meeting observation, interviews with mentors, interviews with student teachers and documents. During *Phase 2,* which was cross section, data were collected from mentors using questionnaire and interviews. Five student teachers and 12 mentors participated in both phases of the study, and the Knowledge Quartet (KQ) and thematic analysis were used as the analysis tools. I also discussed how I attempted to increase trustworthiness of the study, and how I attended to ethical considerations while conducting the study. A discussion on the impact of the pandemic on how I conducted the study and potential methodological limitations followed. I conclude the chapter by presenting a diagrammatic representation of the research process (Figure 3.14).

Chapter 4 is divided into two sections: A and B. In Section A, I give the initial analyses of the data collected during Phase 1 by categorizing episodes using the KQ dimensions: Foundation, Transformation, Connection and Contingency for each of the two main participating student teacher: Job and Cain. I also present flagship episodes manifesting core elements of the student teachers' knowledge and evidence of mentors supporting each of the two main student teachers. A little bit of slightly fragmented, slightly sporadic sets of data from the other three participants: Suzy, Kate and Mary, are presented as complementary data. In Section B, I analyse and discuss the data under four headings: Mathematical and pedagogical knowledge enacted by student teachers in teaching; Student teacher needs; How mentoring addresses the student teacher needs; and Institutional issues that have the potential of influencing mentoring.

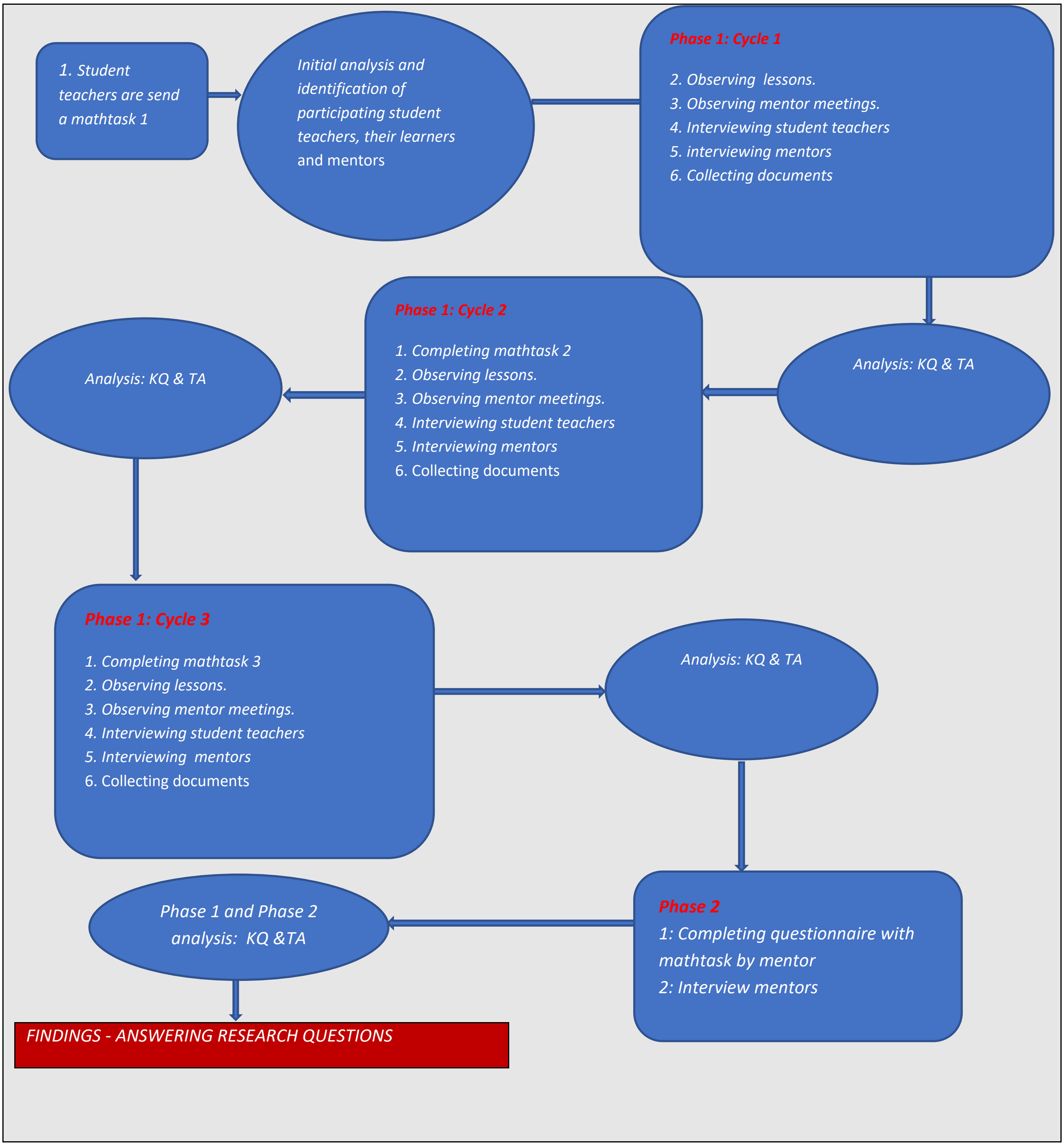

Figure 3. 14 Diagrammatic representation of the research process

4 The mathematical and pedagogical knowledge enacted by student teachers during teaching, student teacher needs and how mentoring addresses the needs

4.0 Introduction

I introduce this chapter by providing background information of the participants, paying special attention to the mathematics-related parts of their qualifications and experience. I then organise the chapter in two sections: A and B. While I recommend reading Section A before Section B, it is also possible to read Section B independently and refer back to Section A as needed, using the coded episodes.

The primary focus of Section A is the initial data analysis, which begins with multiple readings of the data to ensure a deep understanding. I then identify episodes which show aspects of the student teachers' mathematical and pedagogical knowledge enacted during teaching, student teacher needs, and how mentors address (or not) these needs. This is followed by categorising the identified episodes into Knowledge Quartet (KQ) dimensions: *Foundation, Transformation, Connection,* and *Contingency*. Flagship episodes that represent the teaching characteristic of each student teacher are presented. Additionally, episodes showing how mentors assist student teachers' mathematical and pedagogical knowledge development are also presented.

While categorizing the episodes, I recognize that some episodes may align with multiple KQ dimensions. In such cases, I prioritise the dimension where the episode's relevance is most pronounced. The initial analysis in Section A primarily focuses on two student teachers: Job and Cain, but I also include a few complementary episodes from three other participants—Suzy, Kate, and Mary—although the data from these participants are somewhat fragmented and sporadic.

The episodes are selected from nine mathtask responses from five student teachers, 24 lesson observations from two student teachers, six interviews with three student teachers, five interviews with two mentors, three mentor meeting observations of two mentor-student teacher pairs and three documents: two lesson observation reports written by two mentors and one final report. For details of the selection and categorisation of episodes, refer to Stages 1 and 2 in the *Data Analysis* Section 3.5 in *Chapter 3*.

In Section B, I give a detailed analysis of the episodes. With the aim of bringing to surface the mathematical and pedagogical knowledge of the Further Education and Training sector (FE) mathematics student teachers enacted during teaching, student teacher needs (see RQ 1), and how mentoring addresses the needs, and institutional issues that could potentially influence mentoring (see RQ 2), the Knowledge Quartet (KQ) (Rowland et al's, 2003) and the thematic analysis (Braun & Clarke, 2006) are employed as analysis tools. For details of the selection and categorization of episodes, refer to Stages 3 to 8 in the Data Analysis Section 3.5 in *Chapter 3.*

4.1 Background information about the participants

The qualifications and experience of student teachers within FE vary significantly. In Table 4.1, I present the background information of *Phase 1* participants who are five student teachers and two mentors.

Student Teacher	***Mentor***	***Profile outline***
Suzy		*Suzy was between 46 and 55 years old with a master's degree (did not specify discipline). She had worked as an administrator and then English teacher in a secondary school for 5 years before training to be mathematics teacher at a university as an in-service trainee[17]. She was in her second year of training and at her second placement college.*
Kate		*Kate was between 46 and 55 years old. She had A-levels (did not specify subjects). She had worked in a prison[18] as a teacher (did not specify level(s) and subject(s)) for eight years before teaching at a college. She was in her first year of training.*
Job		*Job was less than 25 years old. He had a diploma in Media & Television at Level 3. His highest qualification in mathematics was a Grade C (now Grade 4) at GCSE. Job worked for less than 5 years as a Learning Support Assistant (LSA) before becoming a mathematics teacher. He started training at the same college the year he joined teaching. He was in his first year of training.*
	Alex (Job's mentor)	*Alex was between 36 and 45 years old. He had a Bachelor of Education (Early Years) degree. He joined the college as an LSA and worked for two years before becoming a mathematics teacher. He started training at the same college the year he joined teaching. After qualifying, Alex worked for two years and then promoted to the position of a manager (mathematics & English). Job was his first mentee. Alex's highest qualification in mathematics is a Grade B (now 5/6) at GCSE*
Cain		*Cain was between 36 and 45 years old. He studied mathematics at A-Level and had a Bachelor of Science (Engineering) degree. He worked as an outdoor instructor for six years before joining the college as a library assistant. He was employed as a mathematics teacher at the same college and started training the same year. He was in his second and final year of training.*
	Julie (Cain's mentor)	*Julie was between 46 and 55 years old. She joined the college as a numeracy teacher and moved on to GCSE teaching. Her highest qualification was Level 4 Certificate in Education & Training. Julie did not have a mathematics qualification at GCSE level.*
Mary		*Mary was between 36 and 45 years old. She had a masters' degree (discipline not specified). She had worked at the college as a mathematics teacher for less than five years before training. She was in her first year of training*

Table 4. 1 Background information of Phase 1 participants

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[17] In the United Kingdom, FE teachers are trained following two paths: pre-service student teachers are trained at university and deployed to colleges for teaching practice (also known as placement); in-service student teachers are employed by the colleges and trained by the college on part-time basis.

[18] Prison schools are considered to be FE institutions.

4.2 Section A: Initial data analysis

4.2.1 Student Teacher Job

The data presented in this section is based on episodes from Job's responses to two mathtasks, 15 observed lessons, two interviews with Job, three interviews with Job's mentor Alex, one observed mentor meeting, and a report written by Alex based on a lesson he observed Job teaching. The data is categorised and presented under the KQ dimensions: *Foundation, Transformation, Connection* and *Contingency*, followed by a flagship episode from one of Job's observed lessons, and episodes about how Job is assisted by his mentor, Alex. The section is concluded with a brief summary of Job's teaching characteristics.

Topics taught by Job when observed

1. Percentages, Estimation & Rounding, Lowest Common Multiple (LCM) & Highest Common Factor (HCF),
2. Circles: Area and Perimeter,
3. Ratios: Simplifying and Sharing,
4. Percentages Increase & Decrease and Area & Perimeter,
5. Algebra,
6. Range, Mean & Median (starter) and Century Tech revision,
7. Frequency tress,
8. Venn diagrams,
9. Averages,
10. Solving equations,
11. Forming and Solving equations,
12. Revision – BIDMAS, HCF & LCM,
13. Revision – Number,
14. Revision – Algebra, and
15. Revision – Statistics.

4.2.1.1

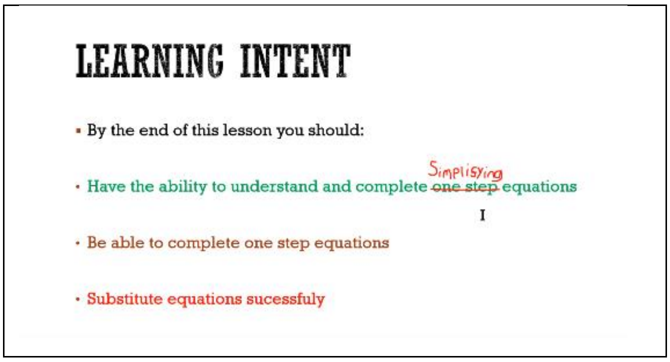
J.1 Foundation

J.1.1 Job completed two mathtasks: *Addition of fractions* (Figure 3.1) and *What is the area of the shaded part?* (Figure 3.3). The first mathtask, among other tasks, invited the student teachers to work out the question: $\frac{5}{6}+\frac{3}{7}$. Job wrote, "Highlight the denominators and begin to write out both sets of times tables the 6s and 7s until you reach 42. Circle this number in both times tables. Then times the numerator by the appropriate number.” Job did not work the question but explained.

The third mathtask asked student teachers to find the area of the ring between two concentric circles of radii 12 cm and 16 cm leaving the answer in terms of π. Job wrote:

> I would first draw the question again showing them the drawing as a whole circle referencing that the entire circle is 16cm radius. I would then write down this information as a step by step. pi x 16 ^2 = 256π. I would then explain this is the area for the whole circle. We then cut out the middle circle which has a radius of 12 cm. π x 12^2 = 144π. So, if we remove the centre circles area what remains is just the frame 256π - 144π = 112π.

J.1.2 Introducing a lesson on *Solving equations*, Job displayed the lesson intent also known as lesson objective (Figure 4.1).



LEARNING INTENT

- By the end of this lesson you should:
- Have the ability to understand and complete Simplisying ~~one step~~ equations
- Be able to complete one step equations
- Substitute equations sucessfuly

Figure 4. 1 Job's lesson intent on Solving equations

While students were copying the lesson intent, Jobs changed ‘one step’ to ‘simplifying.’ Throughout the lesson, Job was mixing up solving and simplifying, and equations and expressions. During interview, I (Researcher) had the following conversation with Job:

> **Researcher:** There is a lesson which you taught expressions and equations. What is the difference between an expression and an equation?
>
> **Job**: An equation has an answer, and an expression has no answer.
>
> **Researcher**: What do you think about the use of mathematical terms in lessons as compared to colloquial terms?

> **Job:** The use mathematical terms is not important as long as students understand the topic taught.

During an interview with Alex, Job's mentor, I raised the issue of the use of mathematical and colloquial terminology:

> **Researcher**: What are your views on the use of mathematical terminology and colloquial terminology in teaching. (long silence). Colloquial terms, I mean terms like top and bottom. By mathematical terms, I mean terms like numerator and denominator.
>
> **Alex**: Yea. The terminology is not important as long as students understand. The use of terminology should be 50 – 50.

J.1.3 In one of his lessons, Job taught *Circles: Area and Perimeter.* Job gave the formula for area and circumference of circle: $A = \pi r^2$ and C = πD. He said:

> The formula for *Area of a circle* is π r squared. You should square radius before you times it by π following rules of BIDMAS. When a question comes up in the examination and it's asking for the area. First thing is to make sure all the lengths are in the same units, so this does happen quite often. For circumference you do π times diameter. For π use 3.14 or if you have a calculate, it's there look for the sign π.

When asked, during interview, about what π is, Job replied, "It is used for area and perimeter of circles."

J.1.4 In another lesson, Job was teaching *Fractions of amounts*. He displayed $\frac{6}{10}$ of 60 and $\frac{2}{21}$ of 84 (Figure 4.2) and asked student to work out the questions.

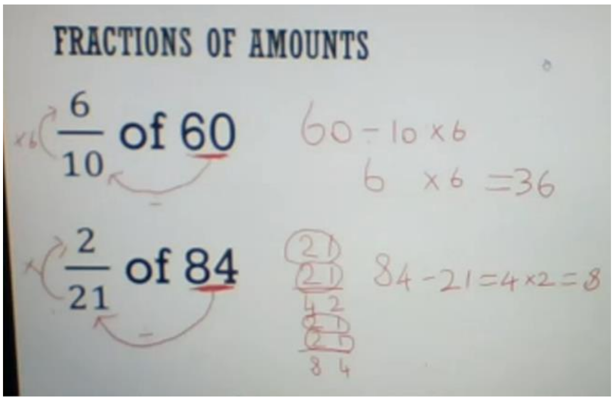
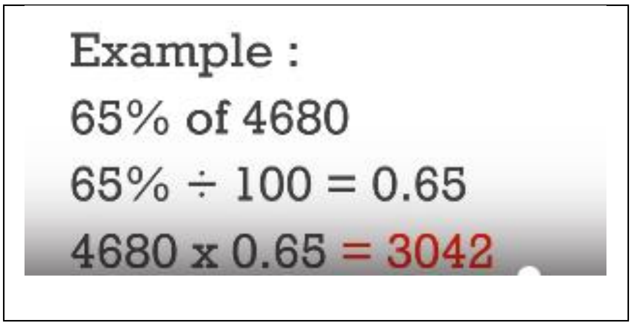


Figure 4. 2 Job's demonstration on Fractions of amounts

He gave students about two minutes to work out the questions. He then explained saying, “You start with the number 60; you divide by 10 then multiply by 6 which is 36,” while writing 60 ÷ 10 x 6, 6 x 6 = 36. He paused for about 30 seconds and continued, “For the second one its 84 divided by 21 which is 4. 4 times by the top 2 which gives as 8. You always divide by the bottom number and multiply by the top number.” Job explained while writing; 84 ÷21 = 4 x 2 = 8.

J.1.5 When teaching *Percentages of amounts* using calculate, Job gave students a question: ‘Find 65% of 4680’ (Figure 4.3). After about two minutes he called for attention and explained while displaying the steps on the PowerPoint. “You always take a percentage and divided by 100. So, if your percentage is 65% divide it by 100, you are going to get some sort of decimal whatever that decimal is just times it by your original number.”


Example :

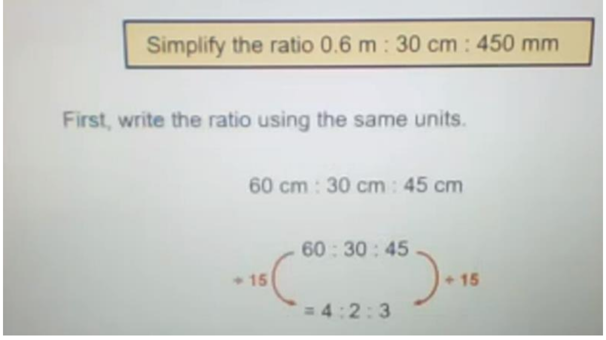
65% of 4680

65% ÷ 100 = 0.65

4680 x 0.65 = 3042

Figure 4. 3 Job's example of question on Percentages

J.1.6 When teaching *Simplifying ratio*, Job asked students to simplify the ratio 0.6 m : 30 cm. He explained, “So when you simplify the ratio change 0.6 metres to centimetres. So, for this is really important to know your conversions.” After students had worked for about two minutes, he gave the answer and a brief explanation, “0.6 m is equal to 60 cm. 60 cm to 30 cm. Which gives 2 to 1. Like fraction we divide both numbers by the highest common factor which is 30." Job gave another question (Figure 4.4) for students to practice.



Simplify the ratio 0.6 m : 30 cm : 450 mm

First, write the ratio using the same units.

60 cm : 30 cm : 45 cm

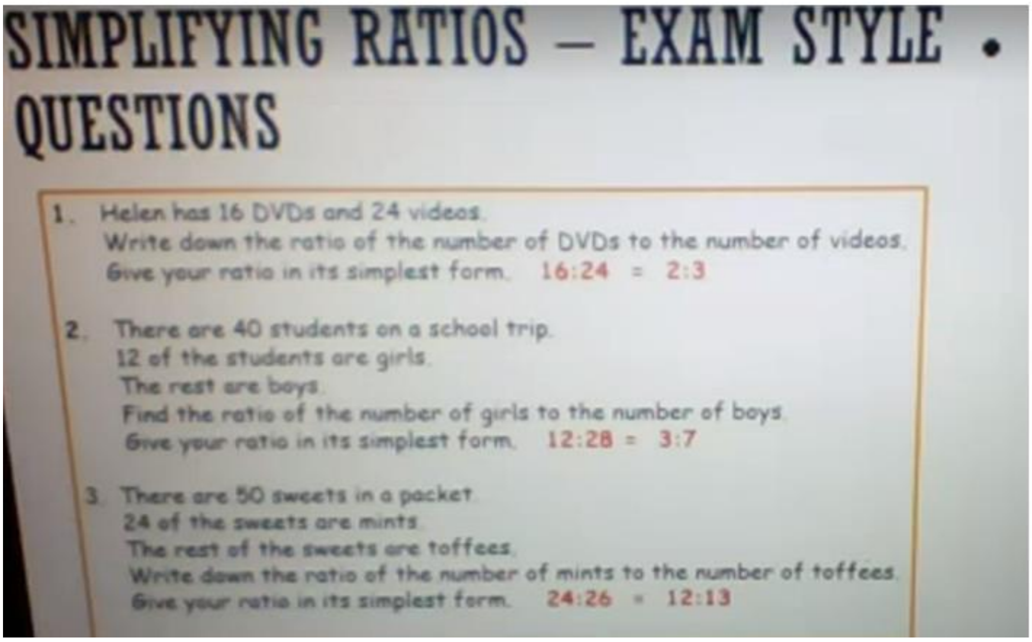
60 : 30 : 45

÷ 15 ÷ 15

= 4 : 2 : 3

Figure 4. 4 Job's example on Simplifying ratio

After about three minutes Job explained, "We first change to the same units cm, then divide each part by the highest common factor which is 15," while displaying the working on the PowerPoint. Then Job gave students examination type questions (Figure 4.5) to practice.



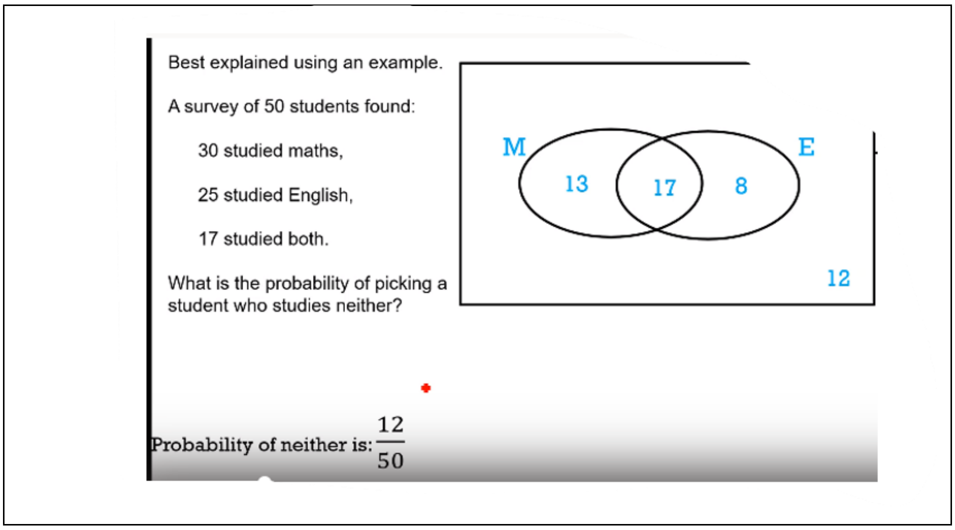
SIMPLIFYING RATIOS – EXAM STYLE QUESTIONS

1. Helen has 16 DVDs and 24 videos.
   Write down the ratio of the number of DVDs to the number of videos.
   Give your ratio in its simplest form. 16:24 = 2:3
2. There are 40 students on a school trip.
   12 of the students are girls.
   The rest are boys.
   Find the ratio of the number of girls to the number of boys.
   Give your ratio in its simplest form. 12:28 = 3:7
3. There are 50 sweets in a packet.
   24 of the sweets are mints.
   The rest of the sweets are toffees.
   Write down the ratio of the number of mints to the number of toffees.
   Give your ratio in its simplest form. 24:26 = 12:13

Figure 4. 5 Job's examination type questions

After about 12 minutes, Job displayed the answers and asked students to mark their work.

J.1.7 When teaching *Venn diagrams and Probability*, Job displayed the question (Figure. 4.6).



Best explained using an example.

A survey of 50 students found:

30 studied maths,

25 studied English,

17 studied both.

What is the probability of picking a student who studies neither?

Probability of neither is: $\frac{12}{50}$

Figure 4. 6 Job's question on Venn diagrams

After about two minutes, he explained:

> There are 50 students. 30 study maths, 25 studied English and 17 studied both. We put 17 in the middle. We subtract; 30 – 17 and we get 13. So 13 studied maths only. 25 studied English. We do 25 – 17 and get 8. If we add 13 + 17 + 8 we get 38. Then 50 – 38 = 12. 12 do not do any. So the probability of neither is 12 over 50.

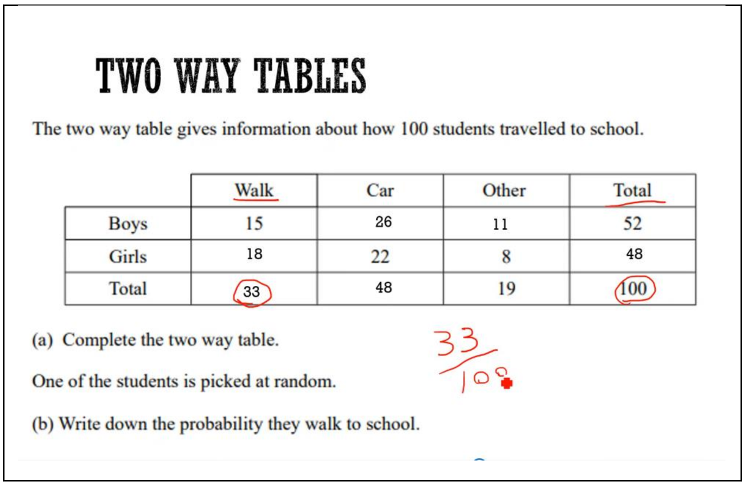
4.2.1.2

J.2 Transformation

J.2.1 In one of his lessons, Job taught *Two-way tables and probability*. He introduced the topic by displaying a question (Figure 4.7).

He explained how to complete the two-way table while typing in the missing values saying:

> There are 8 girls, and the total is 19. We can work out the boys by subtracting 19 – 8 = 11. There are 48 students and 26 boys, so girls are 48 – 26 which is 22. There are 22 girls. I say it's interesting because one unlocks another. There are 33 who walk to school and there are 100 students. So, the probability is 33/100.



TWO WAY TABLES

The two way table gives information about how 100 students travelled to school.

	Walk	Car	Other	Total
Boys	15	26	11	52
Girls	18	22	8	48
Total	33	48	19	100

(a) Complete the two way table.

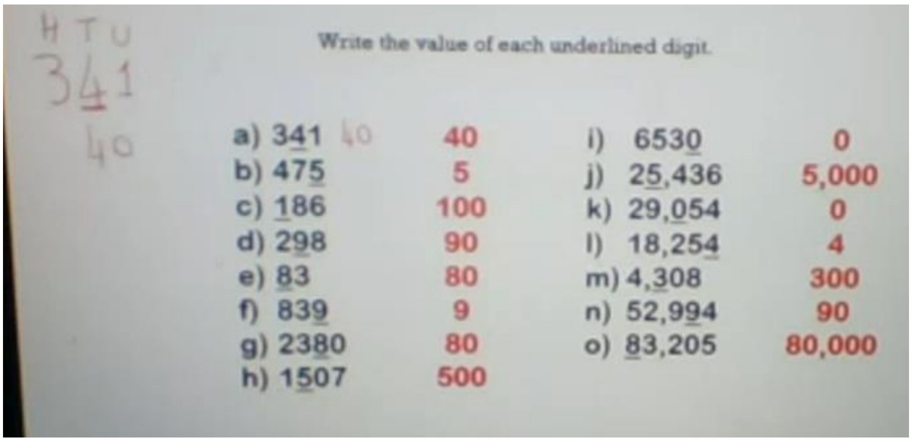
One of the students is picked at random.

(b) Write down the probability they walk to school.

$\frac{33}{100}$

Figure 4. 7 Job's question on Two-way table

J.2.2 When teaching *Place Value*, Job displayed an exercise (Figure 4.8) and asked students to write the place value of the underlined digits. Job explained, "What we mean by place value is the value of the place of each of these numbers, where the number is placed." Job demonstrated using 341. He explained, "1 is units, 4 is tens and 3 is hundreds. So, the value of 4 is tens which is 40." Job gave students ten minutes to complete the exercise (Figure 4.8).



H T U
341
40

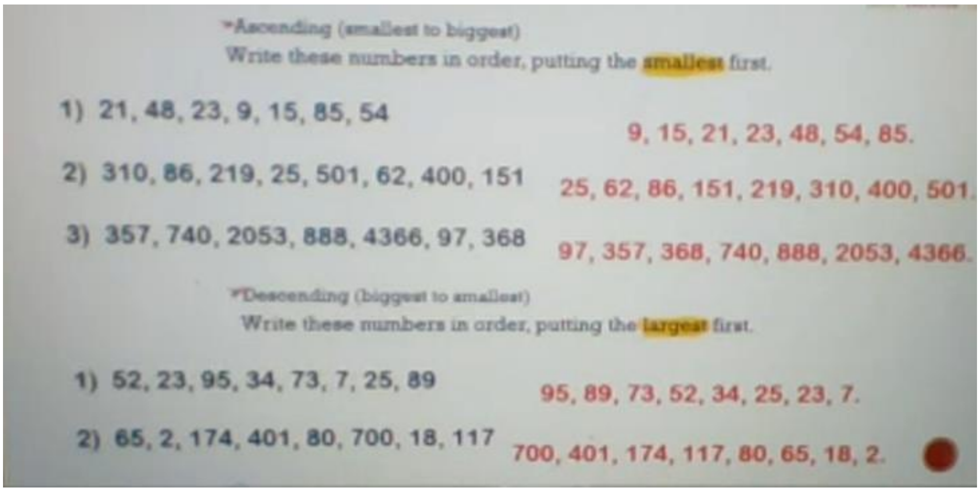
Write the value of each underlined digit.

a) 341 40	40	i) 6530	0
b) 475	5	j) 25,436	5,000
c) 186	100	k) 29,054	0
d) 298	90	l) 18,254	4
e) 83	80	m) 4,308	300
f) 839	9	n) 52,994	90
g) 2380	80	o) 83,205	80,000
h) 1507	500		

Figure 4. 8 Job's exercise on Place value

Job displayed the answers and asked students to mark their work. After that he moved to the next topic.

J.2.3 In one of his revision lessons, Job taught *Ascending and descending order*. He explained the terms using the flying aeroplane saying, "After the plane has taken off it ascends and when it is about to land it descends." He gave an exercise (Figure 4.9) for students to practice, without explaining or showing an example. After about four minutes, he displayed the answers and asked students to mark their work.



*Ascending (smallest to biggest)
Write these numbers in order, putting the smallest first.

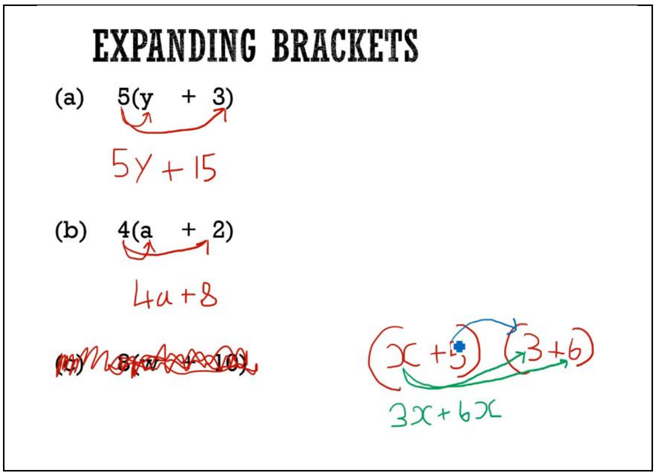
1) 21, 48, 23, 9, 15, 85, 54 9, 15, 21, 23, 48, 54, 85.
2) 310, 86, 219, 25, 501, 62, 400, 151 25, 62, 86, 151, 219, 310, 400, 501.
3) 357, 740, 2053, 888, 4366, 97, 368 97, 357, 368, 740, 888, 2053, 4366.

*Descending (biggest to smallest)
Write these numbers in order, putting the largest first.

1) 52, 23, 95, 34, 73, 7, 25, 89 95, 89, 73, 52, 34, 25, 23, 7.
2) 65, 2, 174, 401, 80, 700, 18, 117 700, 401, 174, 117, 80, 65, 18, 2.

Figure 4. 9 Job's exercise on Arranging numbers in size

J.2.4 While teaching *Expanding brackets*, Job used 5(y + 3) as an example (Figure 4.10). He explained, “This 5 needs to multiply everything in the brackets (pointing at 5). 5 times y is 5y and 5 times 3 is 15. The answer is 5y + 15.” He then explained using 4(a + 2) saying, “This 4 multiplies everything in the bracket. 4 times a is 4a, 4 times 2 is 8. The answer is 4a + 8.” He moved on to double brackets. He wrote (x + 5) (3 + 6) and explained while writing, “x multiplies 3 and 6. 5 multiplies 3 and 6. We get 3x + 6x. You don’t need this for exams. Let’s move on.”



EXPANDING BRACKETS

(a) 5(y + 3)

5y + 15

(b) 4(a + 2)

4a + 8

~~(c) 8(w + 10)~~

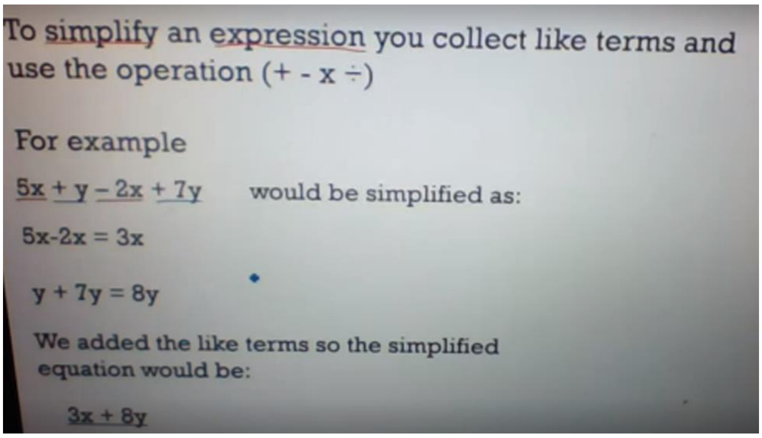
(x + 5) (3 + 6)

3x + 6x

Figure 4. 10 Job's demonstration of Expanding brackets

The working of double brackets is not complete as Job said they do not need it for examinations.

J.2.5 Job introduced *Simplifying expression* by explaining collecting like terms (Figure 4.11). He played the slideshow while reading the text.



To simplify an expression you collect like terms and use the operation (+ - x ÷)

For example

$5x + y - 2x + 7y$ would be simplified as:

$5x-2x = 3x$

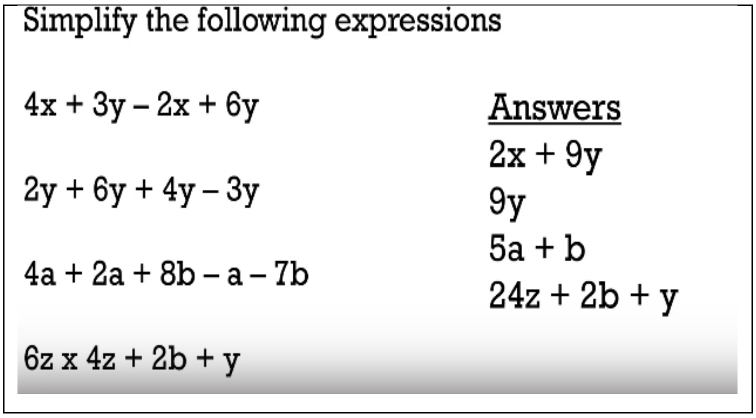
$y + 7y = 8y$

We added the like terms so the simplified equation would be:

$3x + 8y$

Figure 4. 11 Job's demonstration of Simplifying expressions

Job gave students an exercise (Figure 4.12) to practice saying, “Now it’s your turn. Collect your like terms together.” A student asked, “Why does equation 2 have the same letter.” Job replied, “You just work from left so you can do $2y + 6y$ then add $4y$ then minus $3y$.”



Simplify the following expressions

$4x + 3y - 2x + 6y$

$2y + 6y + 4y - 3y$

$4a + 2a + 8b - a - 7b$

$6z \text{ x } 4z + 2b + y$

Answers

$2x + 9y$

$9y$

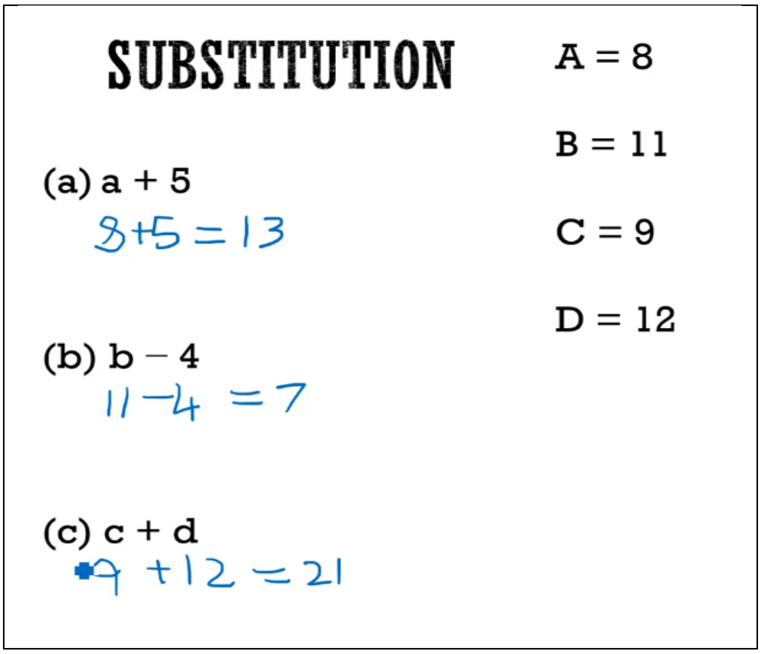
$5a + b$

$24z + 2b + y$

Figure 4. 12 Job's exercise on Simplifying expressions

After about four minutes, Job displayed the answers and asked students to mark their work.

J.2.6 When teaching *Substitution*, Job said, “In substitution, you substitute the letter for the number.” He demonstrated using three examples (Figure 4.13).



SUBSTITUTION

A = 8

B = 11

C = 9

D = 12

(a) a + 5

8+5 = 13

(b) b − 4

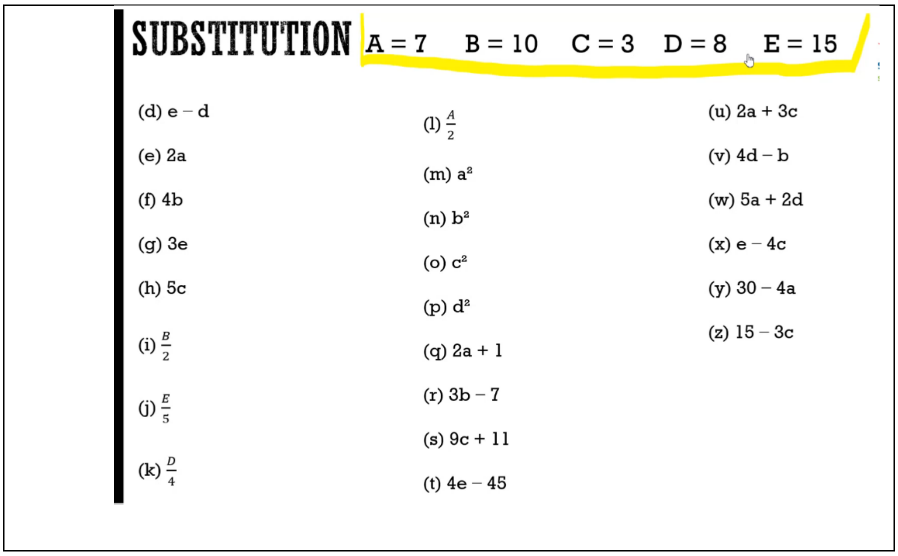
11−4 = 7

(c) c + d

9 + 12 = 21

Figure 4. 13 Job's demonstration on Substitution

He gave the students an exercise (Figure 4.14) to practice. After about ten minutes he dictated the answers while student were marking their work.



SUBSTITUTION A = 7 B = 10 C = 3 D = 8 E = 15

(d) e − d

(e) 2a

(f) 4b

(g) 3e

(h) 5c

(i) $\frac{B}{2}$

(j) $\frac{E}{5}$

(k) $\frac{D}{4}$

(l) $\frac{A}{2}$

(m) a^2

(n) b^2

(o) c^2

(p) d^2

(q) 2a + 1

(r) 3b − 7

(s) 9c + 11

(t) 4e − 45

(u) 2a + 3c

(v) 4d − b

(w) 5a + 2d

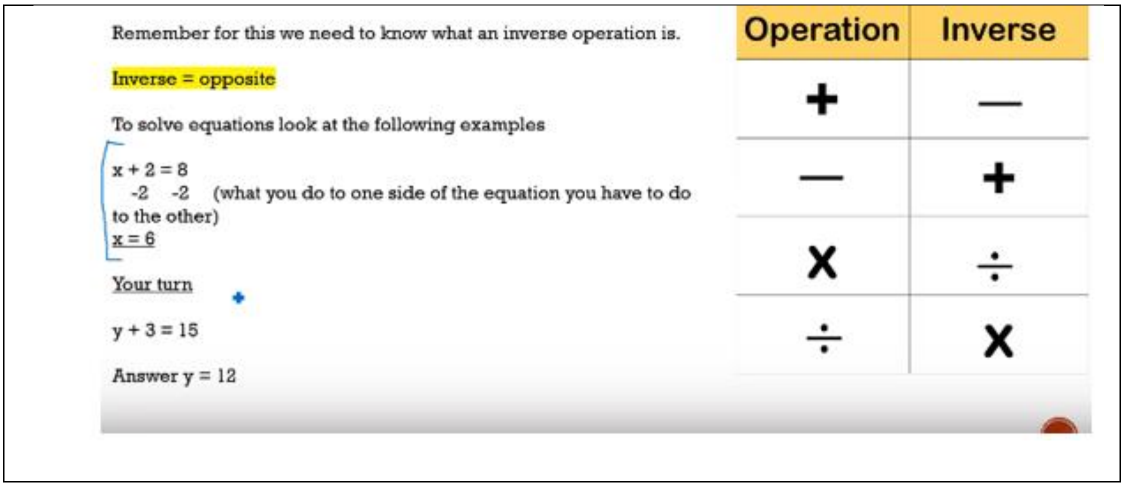
(x) e − 4c

(y) 30 − 4a

(z) 15 − 3c

Figure 4. 14 Job's exercise on Substitution

J.2.7 When teaching *Solving Equations*, Job asked students to copy the information on *Operation and Inverse* (Figure 4.15) and he explained, “Inverse is the same as opposite. So, you do the opposite of an operation like when it is plus you do minus.” He then explained x + 2 = 8 saying, “The



Remember for this we need to know what an inverse operation is.

Inverse = opposite

To solve equations look at the following examples

x + 2 = 8
  -2   -2   (what you do to one side of the equation you have to do to the other)
x = 6

Your turn

y + 3 = 15

Answer y = 12

Operation	Inverse
+	−
−	+
×	÷
÷	×

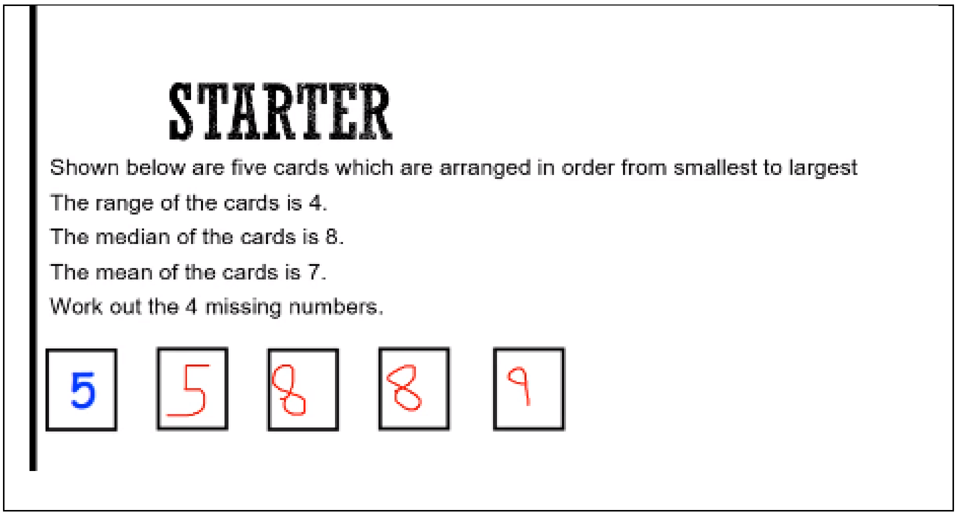
Figure 4. 15 Job's demonstration on Solving equations

opposite of + 2 is – 2 so we subtract 2 from both sides.” He then asked students to try y + 3 = 15. After about two minutes, Job explained, “The opposite of +3 is – 3 so we subtract 3 from both sides and get y = 12.

During an interview, I (Researcher) asked Job follow up questions to the lesson:

Researcher: I want us to solve 2x - 6 = 4. There are many methods which method do you prefer?
Job: To get x on its own. To get rid of – 6 you do the opposite you plus 6. If in person I use the method, I learnt. I will draw an arrow on the – 6 and move it over. It will be 2x = 10. When it moves over the sign changes. To get rid of 2, you divide both sides by 2. You get x = 5
Researcher: Do you have other methods?
Job : No. I haven’t seen other methods.

J.2.8 In one of his revision lessons on *Range, Median and Mean*, Job gave a starter (Figure 4.16) while students were joining the lesson.



STARTER

Shown below are five cards which are arranged in order from smallest to largest

The range of the cards is 4.

The median of the cards is 8.

The mean of the cards is 7.

Work out the 4 missing numbers.

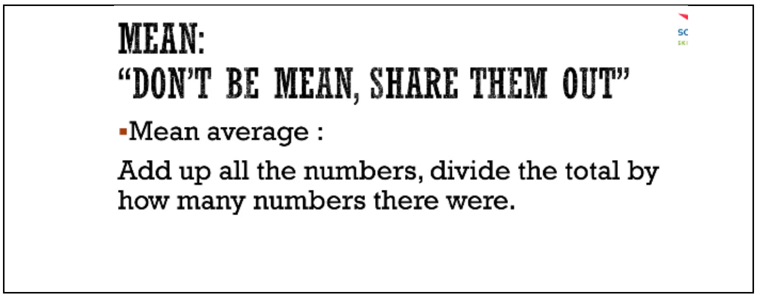
5 5 8 8 9

Figure 4. 16 Job's starter on Averages

After about 10 minutes Job displayed the answer and explained:

> Range is order from smallest to largest and they only gave you the number 5. So, you already knew that five was the smallest number up there. We are told that in the question. And the range is when you take the biggest take away smallest. So, the biggest number takeaway, whatever that five is. To be full. So that's how you can work out by doing reversed at 9 is the biggest number and your median middle is that. And then you just had to work out the mean so you to work out those four missing numbers.

J.2.9 In one of his lessons, Job displayed the title: *AVERAGES: Mean, median & mode*, and said, "Write the title *Averages*. By averages we mean: mean, median, mode and range." It is not clear whether Job took range as an average or not as it is not in the title but it is included in his explanation. He moved on and display a slide about *Mean* (Figure 4.17).



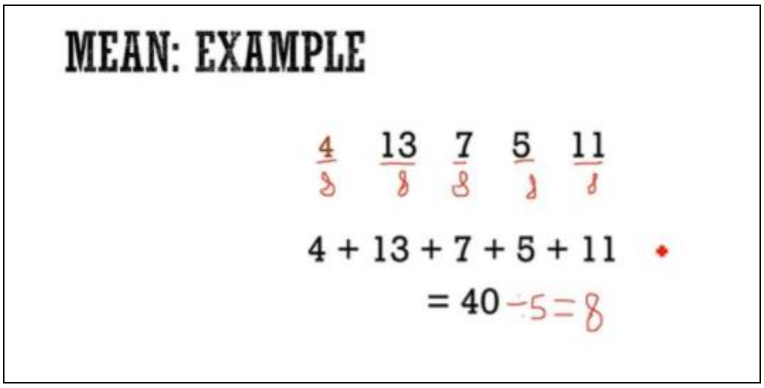
MEAN:
"DON'T BE MEAN, SHARE THEM OUT"

- Mean average :

Add up all the numbers, divide the total by how many numbers there were.

Figure 4. 17 Job's definition of Mean

Job said, “The idea of - Don’t be mean, share them out is - if we have different number of sweets, we put them together, add and divide by how many we are. We share them equally; don’t be mean.” Job gave an example (Figure 4.18).



MEAN: EXAMPLE

$\frac{4}{8}$ $\frac{13}{8}$ $\frac{7}{8}$ $\frac{5}{8}$ $\frac{11}{8}$

4 + 13 + 7 + 5 + 11

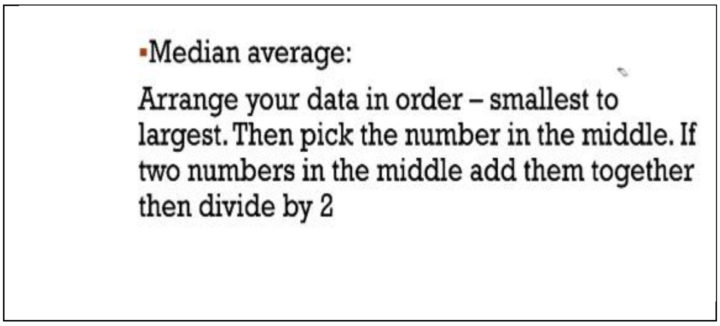
= 40 ÷ 5 = 8

Figure 4. 18 Job's demonstration on Mean

Job worked out the mean explaining:

> We add all these numbers together and we get 40. Once we add them, we look at how many they are, 5. We divide 40 by 5 and get 8. Mean is 8. We can check. If we replace all those numbers by 8 and add we get 40.

Moving on with the lesson, Job asked students to write the title *MEDIAN* and display a slide (Figure 4.19).

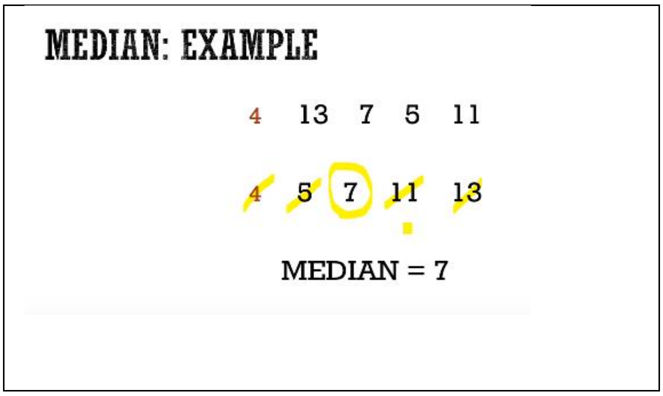


- Median average:

Arrange your data in order – smallest to largest. Then pick the number in the middle. If two numbers in the middle add them together then divide by 2

Figure 4. 19 Job's explanation of Median

He read the slide and added, “When you are given any question on *Averages*, I advise you to put them in order first. It helps you see the numbers clearly.” Job gave an example with an odd number of values (Figure 4.20).



MEDIAN: EXAMPLE

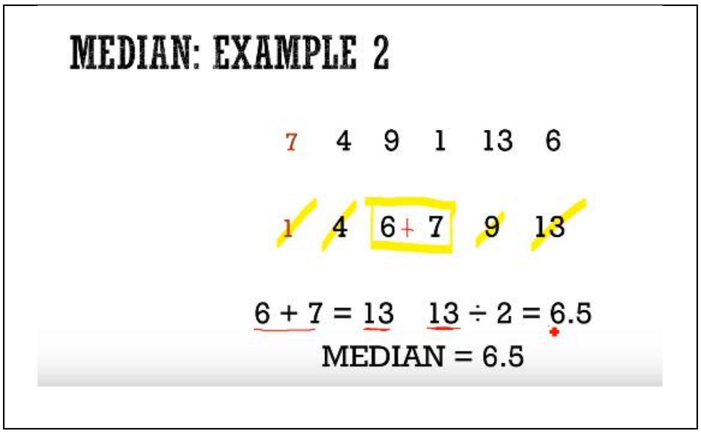
4 13 7 5 11

4 5 7 11 13

MEDIAN = 7

Figure 4. 20 Job's demonstration of Median of odd number of values

Job worked the example explaining arranging in order and then find the middle by cancelling from both ends. Then he explained an example with an even number of values (Figure 4.21).



MEDIAN: EXAMPLE 2

7 4 9 1 13 6

1 4 6 + 7 9 13

6 + 7 = 13 13 ÷ 2 = 6.5

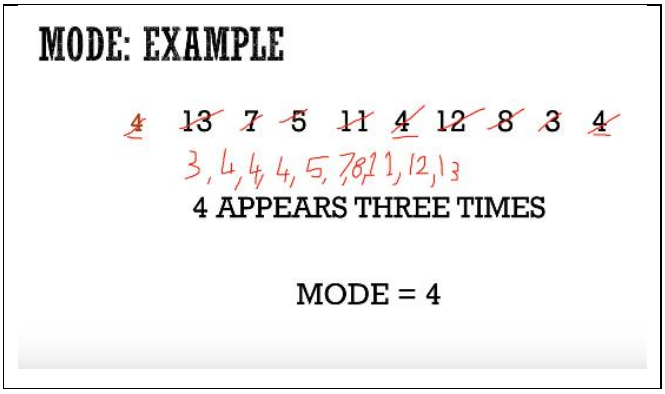
MEDIAN = 6.5

Figure 4. 21 Job's demonstration on Median of even number of values

Job explained the steps for finding the median of an even number of values saying:

> Put the numbers in order from smallest to largest. Cross off the numbers from both ends. You have two numbers in the middle, add them and divide by two. The reason we divide by two, think of the mean we have done.

Job then introduced *Mode* by saying, "*Mode*, which is the most. If there are two or more numbers that have equal amounts, then we call this dual mode." Job gave an example (Figure 4.22) and put the numbers in order and said, "Four is the most common and is the mode."



MODE: EXAMPLE

~~4~~ ~~13~~ ~~7~~ ~~5~~ ~~11~~ ~~4~~ ~~12~~ ~~8~~ ~~3~~ ~~4~~

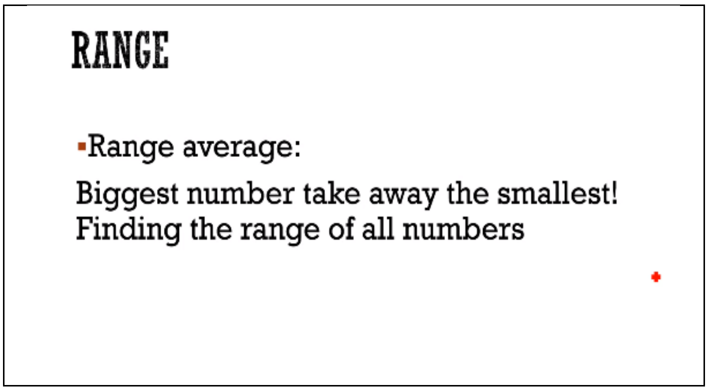
3, 4, 4, 4, 5, 7, 8, 11, 12, 13

4 APPEARS THREE TIMES

MODE = 4

Figure 4. 22 Job's demonstration on Mode

Job moved on to *Range* (Figure 4.23) and explained that "*Range* is the biggest take away the smallest."



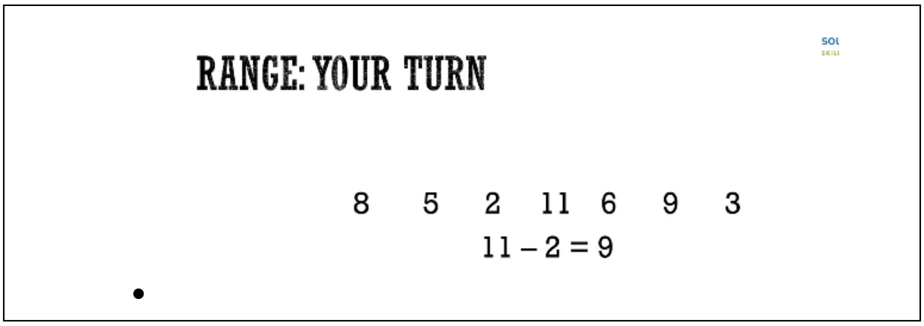
RANGE

- Range average:

Biggest number take away the smallest!
Finding the range of all numbers

Figure 4. 23 Job's definition of Range

He used an example (Figure 4.24) to explain *Range* further.



RANGE: YOUR TURN

8 5 2 11 6 9 3

11 – 2 = 9

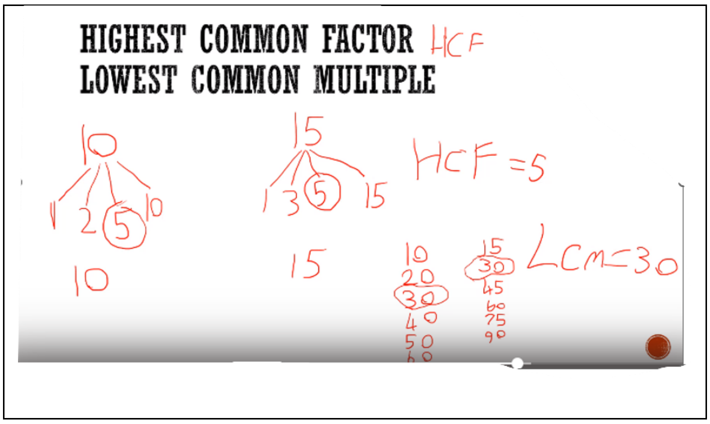
Figure 4. 24 Job's demonstration on Range

J.2.10 During a revision lesson, Job went over *Highest Common Factor (HCF) and Lowest Common Multiple (LCM).* He explained factors, using 10 and 15 as examples (Figure 4.25) saying:

> What can be multiplied together to make 10. Factors of 10 are all the numbers with 10 in their times table: 1, 2, 5 and 10. For number 15, it is 1, 3, 5 and 15. HCF is shared. The highest number they share which is common is 5. The *HCF* is 5. Copy the example down.

He moved on to explain *LCM* saying:

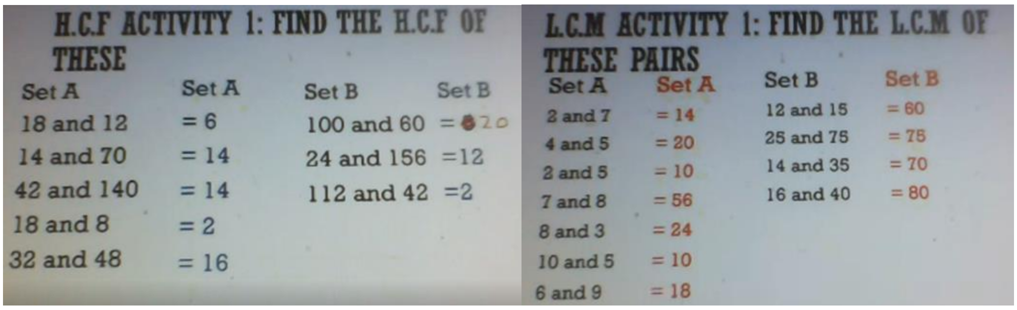
> We focus on lowest and multiple. A multiple is going into sequence. Multiples of 10 are 10, 20, 30. Numbers in the times table. Multiples of 15, you just add 15, they are 15, 30, 45, 60. *LCM* is the lowest number shared which is 30. 60 appears in both but it's not the lowest. The *LCM* is 30.



HIGHEST COMMON FACTOR HCF
LOWEST COMMON MULTIPLE

Figure 4. 25 Job's demonstration on HCF and LCM

Job gave students an exercise on *LCM and HCF* to practice (Figure 4.26), and after about ten minutes he displayed the answers for student to mark their work.



H.C.F ACTIVITY 1: FIND THE H.C.F OF THESE

Set A	Set A	Set B	Set B
18 and 12	= 6	100 and 60	= [illegible]20
14 and 70	= 14	24 and 156	=12
42 and 140	= 14	112 and 42	=2
18 and 8	= 2		
32 and 48	= 16		

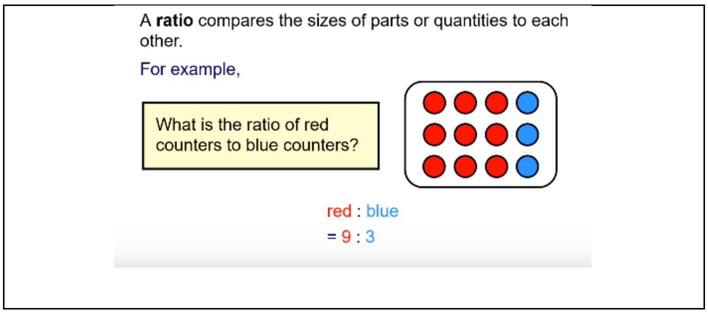
L.C.M ACTIVITY 1: FIND THE L.C.M OF THESE PAIRS

Set A	Set A	Set B	Set B
2 and 7	= 14	12 and 15	= 60
4 and 5	= 20	25 and 75	= 75
2 and 5	= 10	14 and 35	= 70
7 and 8	= 56	16 and 40	= 80
8 and 3	= 24		
10 and 5	= 10		
6 and 9	= 18		

Figure 4. 26 Job's exercises on HCF and LCM

After displaying the answers Job spotted an incorrect answer. The *HCF* of 100 and 60 = 5. He changed it to 20. He did not spot that the *HCF* of 112 and 42 = 2 is incorrect.

J.2.11 When introducing *Ratio*, Job displayed a diagram (Figure 4.27) and explained that the ratio of red to blue counters is 9 to 3.



A **ratio** compares the sizes of parts or quantities to each other.

For example,

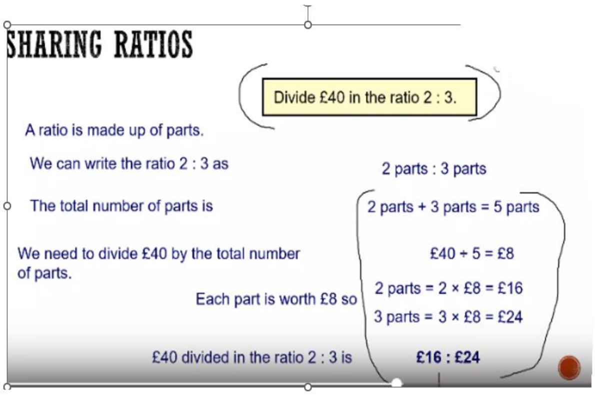
What is the ratio of red counters to blue counters?

red : blue

= 9 : 3

Figure 4. 27 Job's examples of Ratio

Job then explained *Sharing Ratio* using the PowerPoint slide (Figure 4.28). He explained the steps according to the slide show.



SHARING RATIOS

Divide £40 in the ratio 2 : 3.

A ratio is made up of parts.

We can write the ratio 2 : 3 as 2 parts : 3 parts

The total number of parts is 2 parts + 3 parts = 5 parts

We need to divide £40 by the total number of parts. £40 ÷ 5 = £8

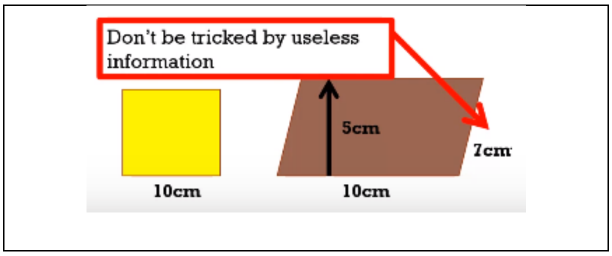
Each part is worth £8 so 2 parts = 2 × £8 = £16

3 parts = 3 × £8 = £24

£40 divided in the ratio 2 : 3 is **£16 : £24**

Figure 4. 28 Job's demonstration on sharing Ratios

J.2.12 When teaching *Area of parallelogram*, Job explained the formula using the diagram (Figure 4.29).

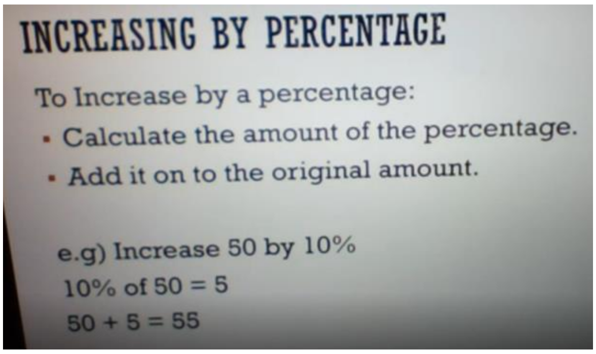


Don't be tricked by useless information

Figure 4. 29 Job's explanation of how to work out Area of a parallelogram

He said, “So don’t be tricked by this outside number (pointing at 7 cm). If they [examiners] have given this inside number (pointing at 5 cm), then you are probably going to use it.”. He explained how to use the formulae saying, “The formula is base times height. So its 10 times 5 which is 50 cm squared.” Job did not explain the reason for 5 cm being the height and not 7 cm.

J.2.13 When explaining *Percentages increase and decrease*, Job used the example: Increase 50 by 10%.



INCREASING BY PERCENTAGE

To Increase by a percentage:

- Calculate the amount of the percentage.
- Add it on to the original amount.

e.g) Increase 50 by 10%
10% of 50 = 5
50 + 5 = 55

Figure 4. 30 Job demonstration of Percentage increase

He explained using the PowerPoint slide (Figure 4.30) saying:

> The first thing we do is to first of all you want to find the percentages. You know, if you are increasing £50 by 10% then you find 10% of it amount and, you then have to add it to the original.

Job did not explain how to calculate the 10% of 50. Probably students knew that from previous lessons. During interview, Job said that in one of his lessons to *Hair & Beauty students*, the students were not paying attention to his explanation on *Percentage increase and decrease*. He gave an example related to their course – buying materials for use in a saloon- and everyone got interested. However, Job did not give the exact example which ‘motivated’ the students.

4.2.1 3

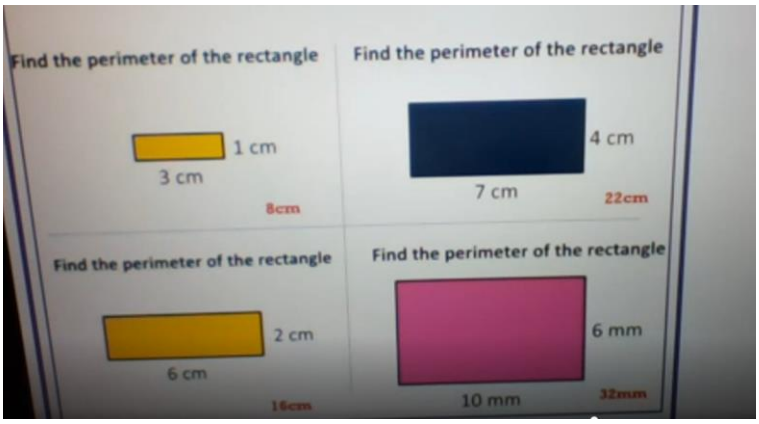
J.3 Connection

J.3.1 When introducing *Area and Perimeter of Shapes,* Job explained:

> We are going to cover *Perimeter*, but we are focusing mainly on *Area* and the reason for this is *Area* can get really confusing and you need to go over it quite a few times because it's the

formulas you need to remember. *Perimeter* you add the entire outside of the shape.[…]. Sometimes you don't get all the sides. A while ago you learnt rules of shapes like square all sides are equal, rectangle opposite sides are equal.

Job gave students four questions to practice finding perimeter (Figure 4.31).


Find the perimeter of the rectangle

Find the perimeter of the rectangle

Find the perimeter of the rectangle

Find the perimeter of the rectangle

Figure 4. 31 An exercise on Perimeter

After about three minutes, Job gave answers explaining each question briefly. Job moved on to *Area* where he explained how to calculate area of rectangle, square, triangle, parallelogram and trapezium, giving the formulae. He then gave an exercise for student to practice (Figure. 4.32).

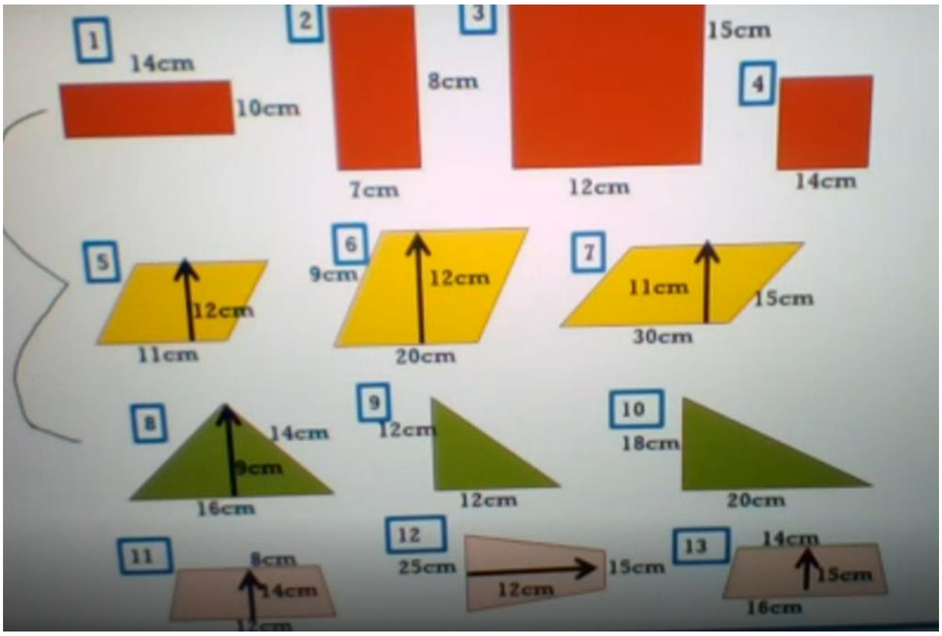


Figure 4. 32 An exercise on Area

J.3.2 When teaching *Simplifying ratio*, Job displayed the ratio (Figure 4.33) and explained:

> Ratios can be simplified just like fractions by dividing each part by the highest common factor. The highest common factor of 14 and 35 is 7. 14 divided by 7 is 2 and 35 divided by 7 is 5. The answer in 2 to 5.

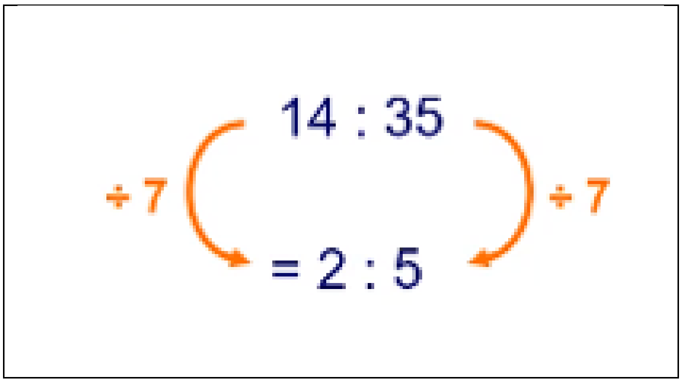


Figure 4. 33 Job's demonstration on Simplifying ratio

J.3.3 The intent/lesson objective of Job's lesson on *Circles: Area and Perimeter* was:

- To calculate *Area and perimeter of circle*
- To recognize parts of the circle.

Job started teaching parts of the circle but according to his intent/lesson objective *Area and perimeter* comes first. During the starter, the parts of the circle: radius, diameter and circumference were taught as separate parts (Figure 4.34).

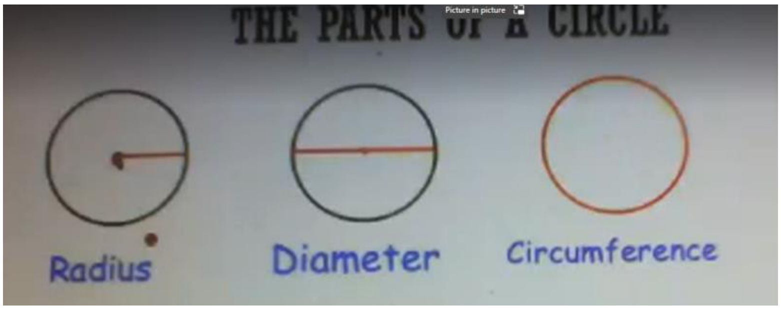


Figure 4. 34 Job's teaching of Parts of the circle

When explaining area of circle formula, as explained during the *Foundation* section (episode J.1.3), Job warned students of the pitfall of multiplying π by radius then square the product. Job concluded the lesson with parts of the circle which were also used as a starter.

J.3.4 a) Job's starter on the lesson on *Ratio* was about *Area and Circumference of Circle,* the topic taught the previous week. Job's starter was connected to previous lesson, but not connected to the main part of the lesson.

b) In another lesson, Jobs' starter to *Percentages* and *Area & Perimeter* lesson was *Target number* which is an exercise where students apply the basic arithmetic operations using given numbers to come up with a target number (Figure 4.35). Students used +, -, x, ÷ and () on 75, 2, 5, 2, and 25 to come up with 175.

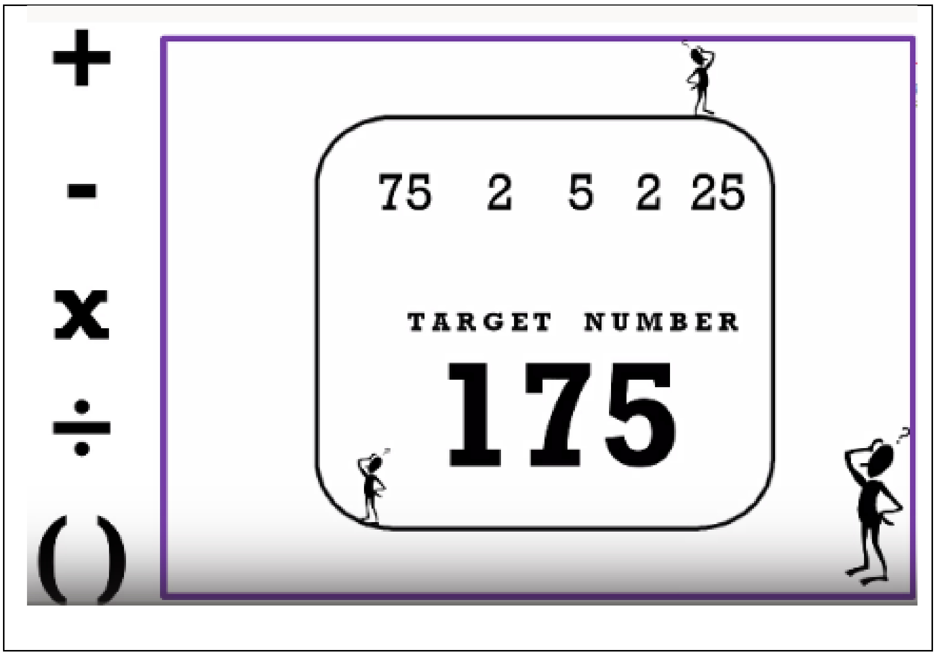
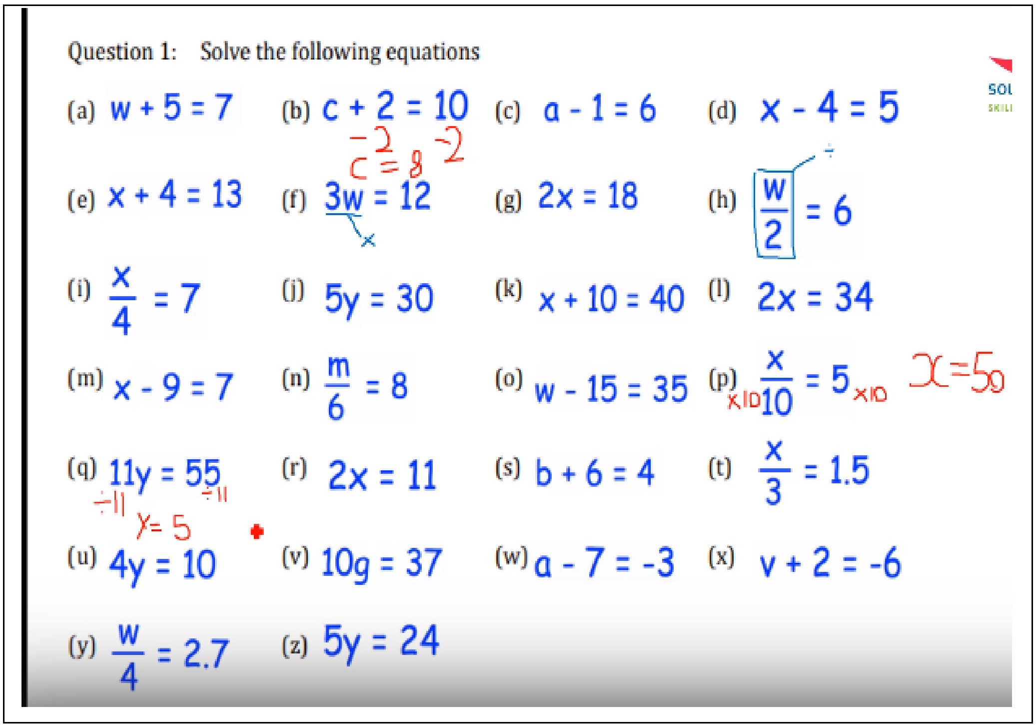


Figure 4. 35 Job's starter to Percentages and Area & perimeter.

4.2.1.4

J.4 Contingency

J.4.1 When teaching *Solving equations*, Job gave an exercise for students to practice Figure (4.36):



Question 1: Solve the following equations

(a) $w + 5 = 7$ (b) $c + 2 = 10$ -2 -2 $c = 8$ (c) $a - 1 = 6$ (d) $x - 4 = 5$

(e) $x + 4 = 13$ (f) $3w = 12$ (g) $2x = 18$ (h) $\boxed{\frac{w}{2}} = 6$ $\div$

(i) $\frac{x}{4} = 7$ (j) $5y = 30$ (k) $x + 10 = 40$ (l) $2x = 34$

(m) $x - 9 = 7$ (n) $\frac{m}{6} = 8$ (o) $w - 15 = 35$ (p) $\times 10 \; \frac{x}{10} = 5 \times 10$ $x = 50$

(q) $11y = 55$ $\div 11$ $\div 11$ $y = 5$ (r) $2x = 11$ (s) $b + 6 = 4$ (t) $\frac{x}{3} = 1.5$

(u) $4y = 10$ (v) $10g = 37$ (w) $a - 7 = -3$ (x) $v + 2 = -6$

(y) $\frac{w}{4} = 2.7$ (z) $5y = 24$

Figure 4. 36 Job's exercise on Solving equations

While students were working, Job stopped them to explain:

> I will pick b which is c + 2 = 10. So how do we get rid of + 2. We would minus 2. We gonna do the complete opposite. We minus 2 from one side and minus it from the other side as well. We now have c = 10 - 2, which is c = 8.

He also explained p and q. It is not clear why Job stopped the students to explain these particular questions. This might be responding to student ideas; probably he saw an idea in the chat; probably it was just teacher insight; probably he thought that students might not get it. As an observer, I was not able to see the chat (problems of online observation) but this looks like a contingency action.

J.4.2 Responding to a mathtask: *Addition of fractions* (Figure 3.1), Job wrote, "Whilst doing this [working a question on *Addition of fractions*], I will gauge students' reactions and decide whether or not they are understanding. If not, I clarify with another example with smaller denominators."

Although Job was responding in writing, this shows that his explanation would be a result of students' understanding which is responding to student ideas and use of opportunities.

4.2.1.5

J.5 Job's flagship episode

Forming and Solving Equations

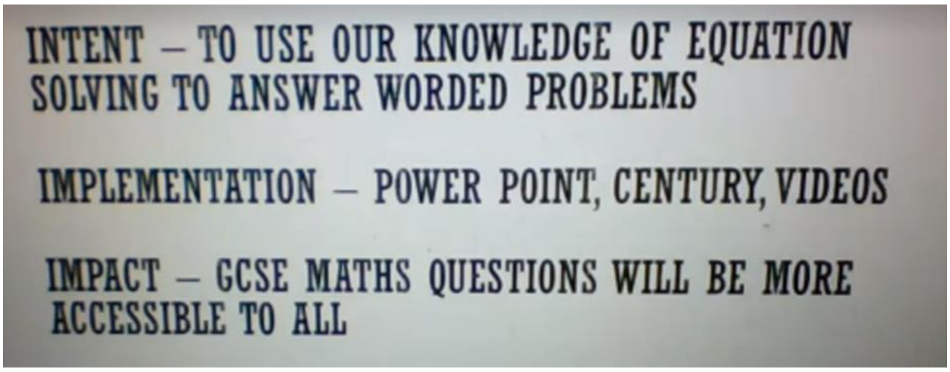
In this section, I present a 22-minute episode (from the 4-minute mark to the 26-minute mark) from a lesson on *Forming and Solving Equations* taught by Job. The episode, which is extracted from one of Job's observed lessons, was selected as it covers most of Job's teaching characteristics as seen through the lenses of the KQ. The episode might be seen as being representative of Job's lessons. As mentioned in the methodology chapter (Section 3.2.3), Job's class had 20 students who were studying for a *Level 2 Diploma in Applied Science*. These students had previously scored below a Grade 4 in GCSE mathematics and were therefore required to retake the subject, aiming to achieve at least a Grade 4, in accordance with the Government directive (Department for Education, 2011).

J.5.1 After going over a starter, Job displayed the title of the lesson (Figure 4.37) and asked students to copy it.

FORMING/SOLVING EQUATIONS

Figure 4. 37 Topic on Forming and solving equations

There was silence for about 2 minutes, then Job displayed the lesson intent, implementation and impact (Figure 4.38) and read it.



INTENT – TO USE OUR KNOWLEDGE OF EQUATION SOLVING TO ANSWER WORDED PROBLEMS

IMPLEMENTATION – POWER POINT, CENTURY, VIDEOS

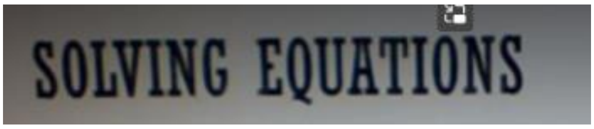
IMPACT – GCSE MATHS QUESTIONS WILL BE MORE ACCESSIBLE TO ALL

Figure 4. 38 Lesson intent, implementation and impact displayed by Job

Then he explained:

> So, the intent of the lesson is to use our knowledge of equation solving to answer worded problems. So, if we think back we're going to use our knowledge that we learn in our last lesson to answer these word problems. Now if anyone missed the lesson, there is still notes in our chat. [....]. Just let me know and I can do some recap with you. I don't mind doing that and just kind of talk me though it’s a little bit more, but I kind of will explain it anyway after lesson. [……]. So just write down that first one for me, so implementation we're going to be doing a PowerPoint. Obviously, I've got video. I'm going to show you in a moment. And also, there is some stuff on century[19] which if we don't get around to do, you can then do it your other time in the century lesson slot. [….]. The impact this is it's going to help us with our exam questions. So, in exams these can range from one to four marks. You'll see that we've got some questions that should be one or two marks.

Job displayed the topic (Figure 4.39).



SOLVING EQUATIONS

Figure 4. 39 Title displayed by Job.

J.5.2 After about 30 seconds Job said, “Solving equations. We are going to skip it for a moment. We are looking at how to form equations. Let me play you a video and I will show you how to do it after.” Job played the video https://corbettmaths.com/2013/04/20/forming-and-solving-equations/
In the video, the video teacher worked out the question step by step: forming the equation and solving it (Figure 4.40).

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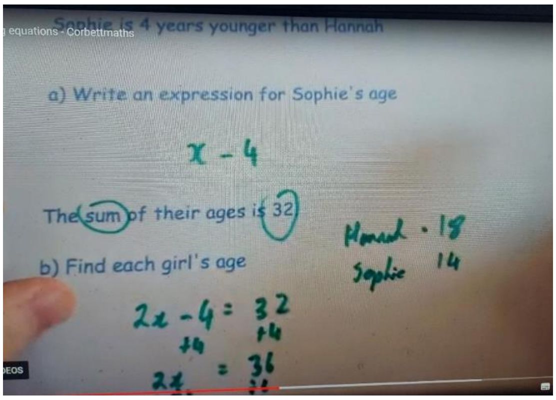
[19] Century is a teaching learning platform that uses digital technology to assess and assign students work due to their understanding. (https://www.century.tech)



Sophie is 4 years younger than Hannah

a) Write an expression for Sophie's age

$x - 4$

The sum of their ages is 32

b) Find each girl's age

$2x - 4 = 32$

$+4 \quad +4$

$2x = 36$

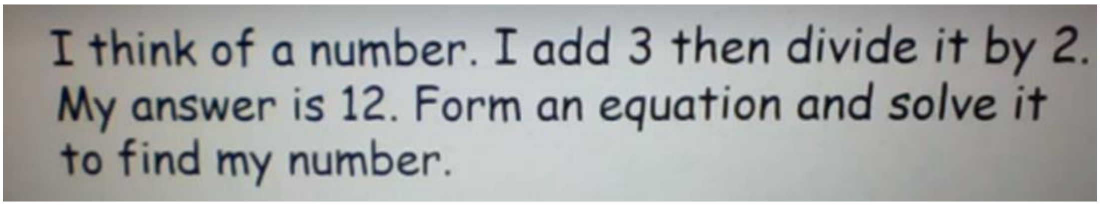
Hannah · 18

Sophie 14

Figure 4. 40 Video teacher example

After the video Job said, “I like the way he [the video teacher] turned a real-life example into an equation and solved it.”

J.5.3 Job displayed a question (Figure 4.41) and said, “I am going to solve this with you.”



I think of a number. I add 3 then divide it by 2. My answer is 12. Form an equation and solve it to find my number.

Figure 4. 41 Job's introduction to Forming and solving equations

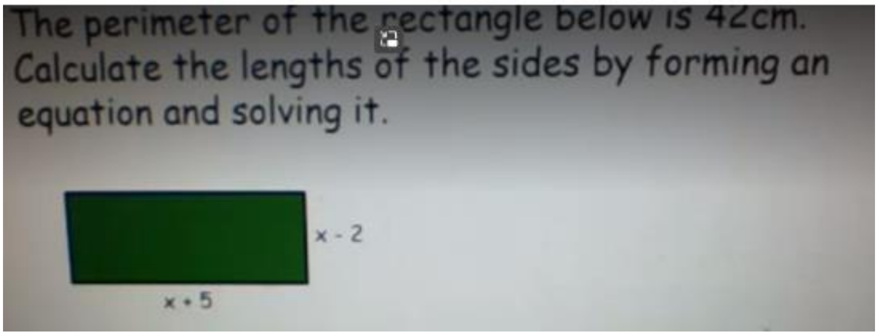
Job read out the question and explained, “Let’s say I think of a number. Let’s say the number is N. We don’t know the number, we add 3 to it, then divide it by 2 and we get 12.” Job explained it again, this time writing. When he got at N + 3 ÷ 2 = 12 (Job did not use brackets), he said, “This gives us an equations. We get the first mark……. We use the same method we used last week to solve the equation.”

After a pause, he continued:

> To get rid of the 2 we times by 2. What we do to one side we do it to the other. Now we have N + 3 = 24. The next step is we have to get rid of the plus 3 it’s on the way. We do the opposite. We do minus 3 from both sides. That leaves us with N = 21. If we put it back into the original we get 21 + 3 = 24 ÷ 2 which is 12. So, we are correct.

Job gave students two minutes to copy the example.

J.5.4 Job then continued, “We are going to another example which is slightly different. There will be some drawing. You need a ruler or some straight-line edge that can be used for drawing. It’s not scale drawing.” There was silence for about two minutes, then Job displayed a question on a slide (Figure 4.42)



The perimeter of the rectangle below is 42cm. Calculate the lengths of the sides by forming an equation and solving it.

Figure 4. 42 Job’s practice question on Forming equations

Then he said, “Draw the rectangle for me please. It doesn’t have to be amazing. It doesn’t have to be to scale.”

After two minutes, Job continued:

> This is a high mark question. The first key thing we know the perimeter. The perimeter of the rectangle is 42 cm. The perimeter is the entire outside of it. The area is the inside that’s why we multiply. We add all sides together for perimeter. Something which is very important. The rule of rectangles. The top and the bottom are parallel and the same value. That’s the same for the other sides.

Job explains while writing x + 5 and x – 2 on the diagram (Figure 4.43). He paused and continued, “We take all this information and put in one equation. It’s very useful to colour code. Before Christmas we did collecting like terms. We cannot add xs and numbers.“ Explaining, Job wrote the equation and started the solving. He stopped explaining at the stage of 4x + 6 = 42 (Figure 4.43) and gave students four minutes to finish off solving the equation and calculate the lengths of the sides. After about three minutes, Job said, “If anyone has a question or doesn’t understand let me know.”

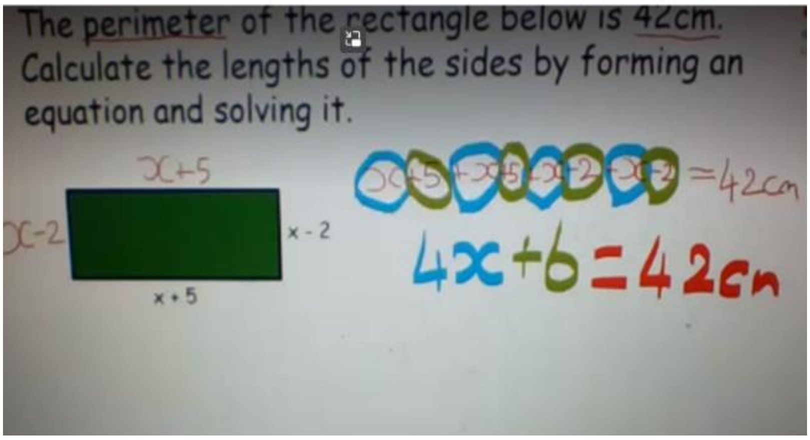

The perimeter of the rectangle below is 42cm. Calculate the lengths of the sides by forming an equation and solving it.

Figure 4. 43 Job's example of Forming and solving equation.

After four minutes, Job solved the equations and calculated the sides while explaining the working step by steps (Figure 4.44).

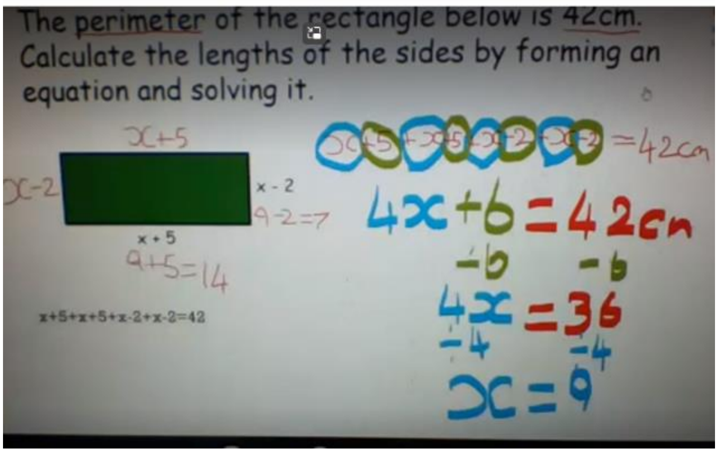

The perimeter of the rectangle below is 42cm. Calculate the lengths of the sides by forming an equation and solving it.

Figure 4. 44 Job Solving the equation

Job gave students a minutes to copy the example. Then he gave student a past examination question to practice.

4.2.1.6

J.6 How Alex (the mentor) assisted Job's (the student teacher) mathematical and pedagogical knowledge development

In this section, I present the episodes from interviews with Job and his mentor Alex, observed mentor meetings and a lesson observation report written by Alex. The episodes are selected if they show Job's needs, and Alex assisting (or not) Job develop mathematical and pedagogical knowledge by addressing the needs.

Job and Alex said they hold formal and informal meetings where in most cases, Job asks for ideas or wanted his resources 'approved' before using them in lesson. Alex is not involved in the assessment of Job, but he submits reports to the *Teacher Training Department* which is responsible for assessing student teachers.

J.6.1 Alex observed Job teaching and gave feedback. In one of the feedback reports (Appendix 7), Alex advised Job on the following issues:

- To practise IT before start of lesson to ensure it is working correctly
- To give feedback more timely using platforms that gives instant feedback such as *Microsoft Forms*
- To improve delivering online sessions by being as enthusiastic as face-to-face sessions

J.6.2 Alex did not discuss teaching specific topics with Job but more general pedagogical issues. Alex said, "So it might be somewhat more general, which would work for all topics. Maybe the pace things like that. But if the student teacher comes with a specific topic like *Venn diagrams*, I can help." According to Alex's report on Job, pacing has been noted. The report read, "He goes too fast and doesn't explain clearly" (Appendix 7). Alex said this was discussed during an informal meeting. During interview, Job confirmed that pacing was one of the targets set and he was working on it.

J.6.3 In an interview, I (Researcher) had the following conversation with Alex:

> **Researche**r: Can you please tell me something you have helped your mentee mathematically and pedagogically. Mathematically, I mean specific mathematics topics and pedagogically the teaching aspect.
> **Alex**: Mathematically, there was not much. It was just a reminder of something he might have forgotten. Pedagogically, it's more of how to apply topics into delivery. I have helped him in making more visual and more interactive PowerPoints. I ask him to change what he had planned to meet the needs of the learners; for example, one question was on quadratic factorisation. He did not just put double brackets. I told him to create questions which work [factorise].

When asked to clarify about the quadratic factorisation, Alex was elusive and sound uneasy, and I did not press him further.

In another interview I had with Alex, I asked him how he had recently assisted Job to improve. Alex said:

> I observed the student teacher and I was impressed with the use of technology; the PowerPoint was good. But his starter was too easy. He should have stretched the learners who finish early. I told him to think on his feet. On the starter, he should have used bigger numbers and include more calculations. He should also have an extension for those who finish early.

J.6.4 What follows is an extract from one of the interviews I (researcher) had with Job:

> **Researcher**: Which teaching style did you adopt from any teacher you observed or from your theory lectures?
> **Job**: The style I adopt is from Alex, who is now my mentor, but I do a lot of creative stuff, yet Alex's lessons are teacher led. Lots of handouts. Lots of examples applying to their courses. More hands-on activities.
> **Researcher**: Which teaching methods? Can you please clarify?
> **Job**: My lessons follow the same structure. I have a starter, explain what we are going to learn showing them an example. Get them to do one example, then some questions, then go through them all. It works the same for in person and online lessons

During lesson observation, it was noticed that most of Job's lessons followed the structure he mentioned.

J.6.5 During the mentor meeting I observed, the following conversation between Alex and Job was captured:

> **Alex**: You missed some of your marking deadlines. In future, plan your marking. If you are going to miss it just let your line manager know and let me know as your mentor. We will support you. Communicate with us.
> **Job**: I had the highest number of students, about 200 students. The teaching was fine. It was marking. First time teaching. In my last role, I did not mark. I had to go through marking reading the marking schemes. I did not understand them. Strange words on the marking scheme.
> **Alex**: But at least you should have told me and your manager.

> **Job**: I had all learners that would miss their assessment. When you want to catch up, missed another one. It was really difficult. It was my first year to do the TAGS [Teacher Assessed Grades]. It was really difficult. If I had a question, it was difficult to get help.

The mentor identified Job's problem as not meeting the deadline for marking and lack of effective communication. Job became defensive saying that he had about 200 students, he also had problems with interpreting the marking scheme and the mentor was not available. It is not clear why the mentor was not available when the teaching was online.

J.6.6 As a follow up to the 'unavailability of the help' I raised the issue during one of the interviews with Job. Job said he also got help from other teachers. I asked Job how he selected the other teachers to help him. He said the following:

> We were in the same team room. Mariam [pseudonym] [an experienced FE mathematics teacher] was very approachable. She put me under her wings. Whenever, I had a question she answered. If I had a resource from the internet, she helped me improve on it t. If I had a gap in knowledge, especially in algebra, I would go to Peter [pseudonym] [an experienced FE mathematics teacher].

J.6.7 In an interview, when asked about advantages and disadvantages of online mentoring, Alex had the following to say:

> Advantage is being able to continue mentoring. The ability to record what you are doing in lessons. You can come back and watch. The use of interactive resources like Century Tech, BKSB[20] and other online programmes. Disadvantages are teachers have to start from zero to learn online teaching. To engage learners has proved to be challenges; they easily disengage. In face-to-face mentoring there is more to talk about than online. The main problem is we don't have answers to problems mentees brings about online teaching. Some of the things in teaching come through experience like driving. I instil the notion of reflection. If a lesson does not go well reflect on what went wrong and improve. Be creative. Don't be afraid to test new waters.

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[20] The Basic and Key Skills Builder (BKSB) tests are designed to assess the competence level of a candidate in the areas of English, maths and information and communication technology (ICT). (https://www.bksb.co.uk)

J.6.8 Alex had the following to say on how to improve mentoring:

> A good framework [structure] should have regular one to one meetings. The mentor should be the mentee's line manager. The one to one will be mentoring. There should be activities put in the calendar so that the student teacher will know what to complete and when. One to one meeting every two weeks and put in calendar. There should be mentoring timetable for mentors and student teachers which is flexible so that it can be put aside if there are 'pressing issues.'

4.2.1.7

J.7 Key features of Job's teaching (and intentions) and mentor assistance

After presenting episodes (categorised under the KQ dimensions, one flagship episode and the mentoring assistance offered) from Job's mathtasks responses, observed lessons, interviews with Job, interviews with his mentor Alex, observed mentor meetings and a mentor's report about an observed lesson, in the next paragraph, I summarise key features of Job's teaching (and intentions). A detailed analysis is provided in Section B.

Job makes some errors in his examples and mentioned that he seeks help from an experienced teacher about certain topics, particularly in algebra. This might be seen as gaps in his subject knowledge. Job is observed using colloquial terms instead of mathematical terms. Jobs relies on procedures in his teaching (and intentions), as shown by mathtask responses and interviews. Good awareness of purpose is observed in Job's teaching. No *Theoretical underpinning of pedagogy* is observed in Job's teaching or interviews. He (over) relies on internet resources. In Job's teaching, he identifies some student errors and missed some. Job employs many instructional materials as visual mediators, though his explanations sometimes contain errors and lack clarity. Examples assigned to students are seen as differentiated to cater for different ability groups in his class. Job's lessons are observed as having limited connections: between concepts; between representations; and between procedures. Job's *Recognition of conceptual appropriateness* and *Anticipation of complexity* are observed to be 'good.' Job's contingency action is observed in his intention to teach as seen by his response to a mathtask. Job receives generic mentoring with some assistance in mathematics.

4.2.2 Student Teacher Cain

The data presented in this section is based on Cain's responses to three mathtasks, nine observed lessons, two interviews with Cain, two interviews with Cain's mentor, Julie, two observed mentor meetings and two reports written by Julie based on a lesson she observed Cain teaching and the final report on Cain's overall performance send to the *Teacher Training Department*. The data is categorised and presented under the KQ dimensions: *Foundation, Transformation, Connection* and *Contingency*, followed by a flagship episode from one of Cain's observed lessons and episodes about how Cain is assisted by his mentor, Julie. The section is concluded with a brief summary of Cain's teaching characteristics.

Topics taught by Cain during observations

1. Addition and subtraction of fractions,
2. Decimals,
3. Percentage increase and decrease,
4. Shapes: polygons,
5. Circle: parts and circumference,
6. Volume of prisms and Volume of cylinders,
7. Types of data and Averages from discrete data,
8. Mean from discrete data, and
9. Working with multipliers.

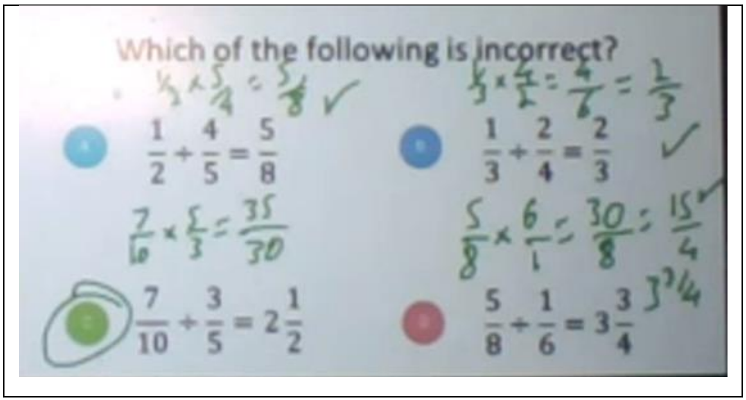
4.2.2.1

C.1 Foundation

C.1.1 Cain completed the three mathtasks: *Addition of fractions* (Figure 3.1)*, What fraction is halfway?* (Figure 3.2) and *What is the area of the shaded part?* (Figure 3.3), which among other questions, asked the student teacher to work out the mathematical problem of the mathtask. Responding to *Addition of fractions* ($\frac{5}{6}$ + $\frac{3}{7}$) mathtask, Cain wrote, "Fraction addition - so find lowest common denominator of 6 and 7 which is 42. $\frac{5}{6}$ + $\frac{3}{7}$ becomes $\frac{35}{42}$ + $\frac{18}{42}$ = $\frac{53}{42}$ = 1$\frac{11}{42}$." For the second mathtask *Fraction halfway between* $\frac{1}{2}$ and 1$\frac{1}{4}$, Cain wrote, "I would find the mean of the two fractions if solving numerically: $\frac{1}{2}$ + 1 $\frac{1}{4}$ = $\frac{2}{4}$ + $\frac{5}{4}$ = $\frac{7}{4}$. Next step divide by 2: $\frac{7}{4}$. divided by 2 becomes $\frac{7}{4}$ x $\frac{1}{2}$ = $\frac{7}{8}$, this is my solution." For the third mathtask *Finding area between two concentric circles of radii 12 cm and 16 cm*, Cain wrote, "Small Circle - π x 12^2 = 144 π. Large (outside) circle - π x (12+4)^2 = π x 16^2 = 256 π (all units cm^2). Shaded area = Large area - small area = (256 - 144) π = 112 π cm^2."

C.1.2 When teaching *Addition of fractions*, Cain gave students the question: $1\frac{1}{2} + 6\frac{1}{3}$. After about three minutes, Cain explained while writing, “We add whole numbers 1 + 6 = 7, then common denominator of 2 and 3 is 6, $\frac{1}{2}$ is $\frac{3}{6}$ and $\frac{1}{3}$ is $\frac{2}{6}$, $\frac{2}{6}$ add $\frac{2}{6}$ is $\frac{5}{6}$, the answer is then $7\frac{5}{6}$.”

C.1.3 During one of his lessons, Cain had starter questions on *Division of fractions*. Cain used the example: $\frac{1}{2} \div \frac{4}{5}$. He used the Keep, Flip, Change (KFC)[21] mnemonic, saying, “Keep $\frac{1}{2}$, flip $\frac{4}{5}$ to $\frac{5}{4}$ and change ÷ to x. It is now $\frac{1}{2} \times \frac{5}{4}$ which is 1 x 5 is 5, 2 x 4 is 8. The answer is $\frac{5}{8}$.” He then gave students the following exercise (Figure 4.45) to practice.



Which of the following is incorrect?

$\frac{1}{2} \times \frac{5}{4} = \frac{5}{8}$ ✓

$\frac{1}{2} + \frac{4}{5} = \frac{5}{8}$

$\frac{1}{3} \times \frac{4}{2} = \frac{4}{6} = \frac{1}{3}$

$\frac{1}{3} + \frac{2}{4} = \frac{2}{3}$ ✓

$\frac{7}{10} \times \frac{5}{3} = \frac{35}{30}$

$\frac{7}{10} + \frac{3}{5} = 2\frac{1}{2}$

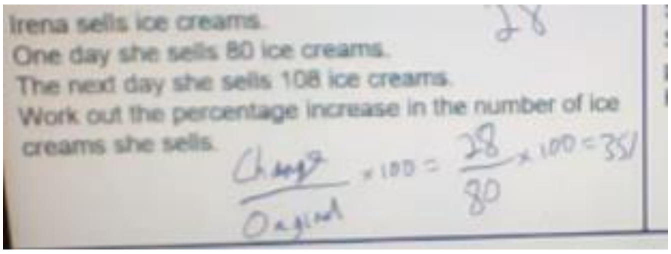
$\frac{5}{8} \times \frac{6}{1} = \frac{30}{8} = \frac{15}{4}$ ✓

$\frac{5}{8} + \frac{1}{6} = 3\frac{3}{4}$ $3\frac{3}{4}$

Figure 4. 45 Cain's Division of fractions exercise

After about five minutes, Cain explained the questions using the KFC mnemonic and displayed the answers. *Question C* had an incorrect answer, and Cain did not notice it. During interview I asked Cain “What is the meaning of the KFC you used when teaching dividing fractions?” He replied, “It is used to divide fractions. I am not sure of the meaning.”

C.1.4 When teaching *Percentage increase and decrease*, Cain gave students a question (Figure 4.46) as an introduction.



Irena sells ice creams.
One day she sells 80 ice creams.
The next day she sells 108 ice creams.
Work out the percentage increase in the number of ice creams she sells.

28

$\frac{\text{Change}}{\text{Original}} \times 100 = \frac{28}{80} \times 100 = 35\%$

Figure 4. 46 Cain's example when introducing Percentage increase and decrease

---

[21] KFC (keep; flip; change) is a mnemonic used to work division of fractions. K – keep the first fraction, F – flip the other fraction: write its inverse and C- change the division sign to multiplication. The division question is now changed to multiplication one.

After five minutes, Cain explained while writing on the screen, “To find percentage change simply divide change by the original and multiply by 100. 28 is the change divided by the original 80 times by 100. We get 35%.” Then Cain gave another question: ‘Decrease £25 by 30%’. He asked students to work and write the answers in the chat. At some point he said, “Sarah [pseudonym], you complicated it.” Cain did not explain how Sarah complicated the question. He then explained, “To get 30% of £25, we divide 30 by 100 then multiply by 25 and get £7.50 then £25 minus £7.50 is £17.50.”

C.1.5 (a) When teaching *Shapes: Polygons*, Cain defined polygon saying:

> A polygon is a closed 2D shape with straight sides. Polygons are named depending on the number of sides. A regular polygon has sides that are equal in length and equal angles. A regular triangle is called equilateral triangle. A regular quadrilateral is called a square. Irregular shapes are all shapes that are not regular.

(b) When teaching *Circles: Parts and Circumference*, Cain explained:

> The tangent is a line that touches the circle once and is at right angle to the radius. π is a number which we multiply by diameter to get circumference. In terms of π means leaving π in the answer.

(c) During an interview, Cain gave a detailed explanation of π including its origin in ancient Greece:

> π is a Greek symbol. It started long ago when they made chariots. It was difficult to measure the circumference but easy to measure diameter and radius. So, they know if they want the circumference, they multiply diameter by something, and it worked for all circles. That’s where π came from. It is the ratio between circumference and diameter.

C.1.6 When teaching *Addition and subtraction of fractions with different denominators*, Cain said, “Think of the lowest common multiple of both the bottom numbers.” In another example, while explaining the formula of volume of prism and cylinder, Cain said, “The volume of a prism is area of front face multiplied by length.” When asked during interview, Cain explained that he used the colloquial terms to make students understand and he later said mathematical terms and colloquial terms should be used interchangeably.

C.1.7 Let us briefly revisit Cain's response to mathtask 1: *Addition of fractions (Figure 3.1)*. When responding to the question: "How would you explain the addition of fraction to a class?" Cain wrote:

> I want to lead by potential *Cognitive conflict* between their understanding that addition makes things get bigger while their workings here do not. [---] Can have Student C explain to Student B what the common denominator is, and then explain why they need it. I want some 'peer learning' to take place, and not 'purely transmit information' to my learners.

When probed during interview, Cain could not explain what 'cognitive conflict' is, but he said that teachers should know what is in 'books.' Cain said at their college the mathematics department produce lessons plans and resources which are used by all mathematics teachers. I (Researcher) had the following conversation with Cain:

> **Researcher:** So, if you get lesson plans and resources from other people, how do you modify them to suit your students?
> **Cain**: In theory, they are meant to be picked up so that anyone can use them and just go for it. It's obviously that requires a certain level of *PCK*.
> **Researcher**: You raised a very important issue of *PCK*. What is *PCK*? What does that actually mean?
> **Cain**: The overlapping of pedagogical principles and mathematical principles, where it overlaps.

I did not go further as I noticed some uneasiness in his voice.

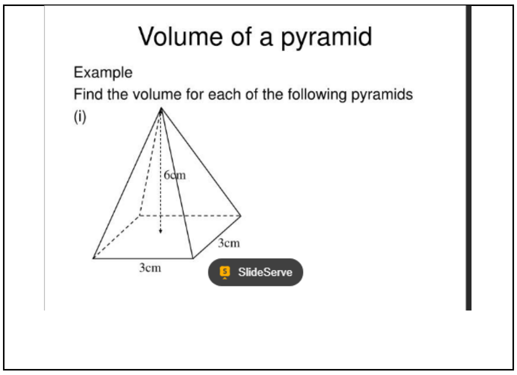
In another example, Cain said he used quizzes in his teaching because it motivates students as he had read it from a book which he could not remember. What follows is an extract from another interview I (Researcher) had with Cain:

> **Researcher**: Can you tell me what you have learnt in your theory courses which you use in teaching?
> **Cain :** Ummmm (takes time to answer).
> **Researcher:** You can include something which you read.
> **Cain**: *Variation theory*.
> **Researcher**: Can you explain please. I don't know about it.

> **Cain**: When you go through a list of questions you see how they change. They talk about *Variation theory* in *Cambridge maths*.

C.1.8 During an interview, I asked Cain a follow-up question to one of his lessons, showing him the diagram captured during that lesson (Figure 4.47).

> **Researcher**: In one of your lessons, you taught *Volume of a pyramid*. How would you explain the formulae?
>
> **Cain**: *Volume of pyramid* is $\frac{1}{3}$ of base area times height. It's rarely come in exams. Normally in exam they give the formula. To introduce the formula, I don't know. I can use a cone. Roughly it would be $\frac{1}{3}$ of that. I don't know.



Volume of a pyramid

Example

Find the volume for each of the following pyramids

(i)

Figure 4. 47 Diagram used by Cain to introduce Volume of Pyramid

4.2.2.2

C.2.Transformation

C.2.1 Responding to a mathtask question which required the student teacher to explain how to help students who would be struggling with *Addition of fractions*, Cain wrote, "In ideal circumstances, I would go for an adapted concrete, pictorial, abstract method and show a correct approach alongside a representation of the incorrect."

C.2.2 In some cases, Cain got mixed up when explaining; for example, he gave the students a question: 'A house has a value of £160 000 to 2 significant figures. Write down the least possible value of the house,' as one of the start questions. Students worked for about ten minutes on this and other questions. Cain stopped the class and explained:

> Remove the 000 that we got 160 OK rounded to two significant figures. So, what I'm going to say is instead let's think of it like this, OK? rounds to nearest 10. What's the lowest value that we could get to 160 pounds if we rounded to the nearest 10 pounds? Lowest amount of money but would round up to 163 around your nearest 10 pounds. I'm not muted, hopefully everyone else can hear me. Thumbs up if you can hear me so greatly from persons saying they cannot hear me. Cool OK. OK, finally because I've spent a little longer on this. Let us move on.

It looks like Cain completely got mixed up. When he ran out of what to say, he talked about his microphone being on mute and finally gave up and moved on. To his own admission, when asked about a lesson that was not very successful, Cain had the following to say:

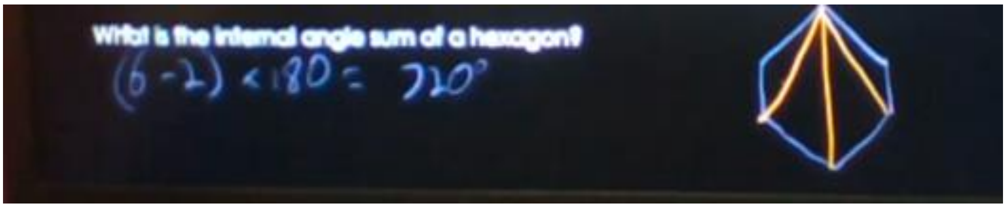
> I don't know what happened on this session. It was so bad. I was trying to teach fractions to *Level 1 Functional Skills* learners. Yeah, so I got a bunch of counters out and everything so I could explain it, and my mind just completely apparently dribbled out as to how I was meant to use them.

C.2.3 Cain used a variety of unrelated examples as starters to most of his lessons. For example, a starter on a lesson on *Addition and subtraction of fraction* had four unrelated questions:

1. Factorise 3m + 12;
2. Change 365 cm to m;
3. Work out 34 x 15; and
4. Write 7.26451 to 3 dec. pl.

In his explanation, he did not connect (or attempt to connect) the examples. When probed during interview, Cain said he picks examples randomly from the internet.

C.2.4 Cain's starter question on *Volume of prisms & Volume of cylinders* was: 'What is the internal angle sum in a hexagon?' Cain asked, "Does anyone remember how to find internal angle sum? What rule was there for that one? (long silence probably, no answer in the chat). Alternatively, how can we think of it? I will draw a hexagon." He drew a hexagon (Figure 4.48).



What is the internal angle sum of a hexagon?

$(6-2) \times 180 = 720^\circ$

Figure 4. 48 Cain's explanation of the formula (n - 2)180˚

Cain explained the formula using the diagrammatic representation:

> Very good well remembered (Implying correct response(s) in the chat). There are 6 sides. Subtract 2. Which is 4. Which will give 4 x 180 which is going to be 720 degrees. If we split the hexagon (splitting the hexagon) we get 4 triangles. So the formula is number of sides take away two times 180 degrees.

He wrote (n-2) x 180°.

C.2.5 When teaching the topic: *Volume of prisms & Volume of cylinders*, which is briefly looked at again during the contingency section, Cain explained the formula for *Volume of prisms* as, "[a]rea of front face times length." He demonstrated using a diagram (Figure 4.49).

Figure 4. 49 Cain's example of Prism

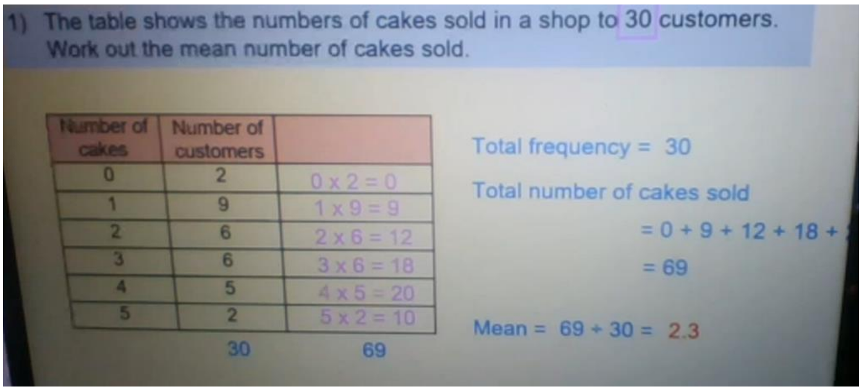
He asked students to give the area of triangle. After one minute, Cain said, "It is base times height divided by two." (Not possible to see if this was student contribution). Cain explained saying:

> Area is gonna be so front area is the triangle…….so triangle gonna be half multiplied by 4 multiplied by 6. So, 4 x 6 is going to be 24. Halfing it is 12. Ruby (pseudonym) so the volume

> is going to be 12 times what?" (I am not sure if Ruby answered). (A long pause) I apparently misread something (seems to be confused because of the two 4s) so 12 times 4 is 48 cm cubed.

A student asked, "Do we half the base times height or we half after multiplying base x height x length?" Cain replied, "…. either way is correct." Cain also explained the volume of a cylinder as face area times length.

C.2.6 When teaching *Mean from the frequency table*, Cain displayed the frequency table (Figure 4.50).



1) The table shows the numbers of cakes sold in a shop to 30 customers.
Work out the mean number of cakes sold.

Number of cakes	Number of customers	
0	2	0 x 2 = 0
1	9	1 x 9 = 9
2	6	2 x 6 = 12
3	6	3 x 6 = 18
4	5	4 x 5 = 20
5	2	5 x 2 = 10
	30	69

Total frequency = 30

Total number of cakes sold

= 0 + 9 + 12 + 18 +

= 69

Mean = 69 ÷ 30 = 2.3

Figure 4. 50 Cain's example on Mean from a frequency table

He then explained displaying slides on his PowerPoint:

> I have got two zeros: 0 0, nine ones 1 1 1 1 1 1 1 1 1, six twos 2 2 2 2 2 2, six threes 3 3 3 3 3 3, five fours, 4 4 4 4 4 and two fives 5 5 ………. To find the mean we have to total our data. We first find the total frequency 2 + 9 + 6 + 6 + 5 + 2 we get 30. Next thing we add a column. We multiply number of cakes by frequency 0 x 2 = 0, 1 x 9 = 9, 2 x 6 = 12, 3 x 6 = 18, 4 x 5 = 20 and 5 x 2 = 10………. next thing total of all that and we get 69. We divide that number by the total frequency: 69 divided by 30 is 2.3. 2.3 would be seating between 2 and 3. That is our mean.

Before moving to *Averages from grouped frequency tables*, Cain taught *Inequalities*. Student were asked about < and > signs. (It seems students understood it according to Cain's comments as answers were coming in through the chat). Cain also explained less than or equal to (≤) and more than or equal (≥) to saying, "If there is a line below it, it is less than or equal to and greater than or equal to." This led to *Averages from grouped frequency tables,* which is not presented here.

C.2.7 As one of the starter questions for the *Volume of prisms* lesson, Cain gave a question: How much is £3000 worth after 2 years of 4% compound interest?' Cain explained using two methods, the 'direct percent' and the 'multiplier,' while writing on the screen:

> *The multiplier method*: For Year 1: 4% = 0.04, 1 + 0.04 = 1.04. £3000 x 1.04 = £3120.
> For Year 2: 1.04 x £3120 = £3244.80.
> *The 'direct percentage' method*: For Year 1: 4% of £3000 = £120; £3000 + £120 = £3120. For Year 2: 4% of £3120 = £124.80; £3120 + £124.80 = £3244.80.

C.2.8 Cain was observed by his mentor Julie teaching the 'correct' presentation of *Solving equations*. Julia said most students' presentation when solving equations is incorrect like 2x – 6 = 8 + 6 = 14 ÷ 2 = 7, and she observed Cain correcting that and teaching the correct presentation like this:

$$2x - 6 = 8$$
$$2x = 6 + 8$$
$$2x = 14$$
$$x = \frac{14}{2}$$
$$x = 7$$

C.2.9 As one of the starter questions, Cain gave *Simplify y x y x y*. Cain explained that y x y x y = y^3. He also explained that y + y + y = 3y. He explained the addition as well, as students often mix up multiplication with addition in algebra.

4.2.2.3

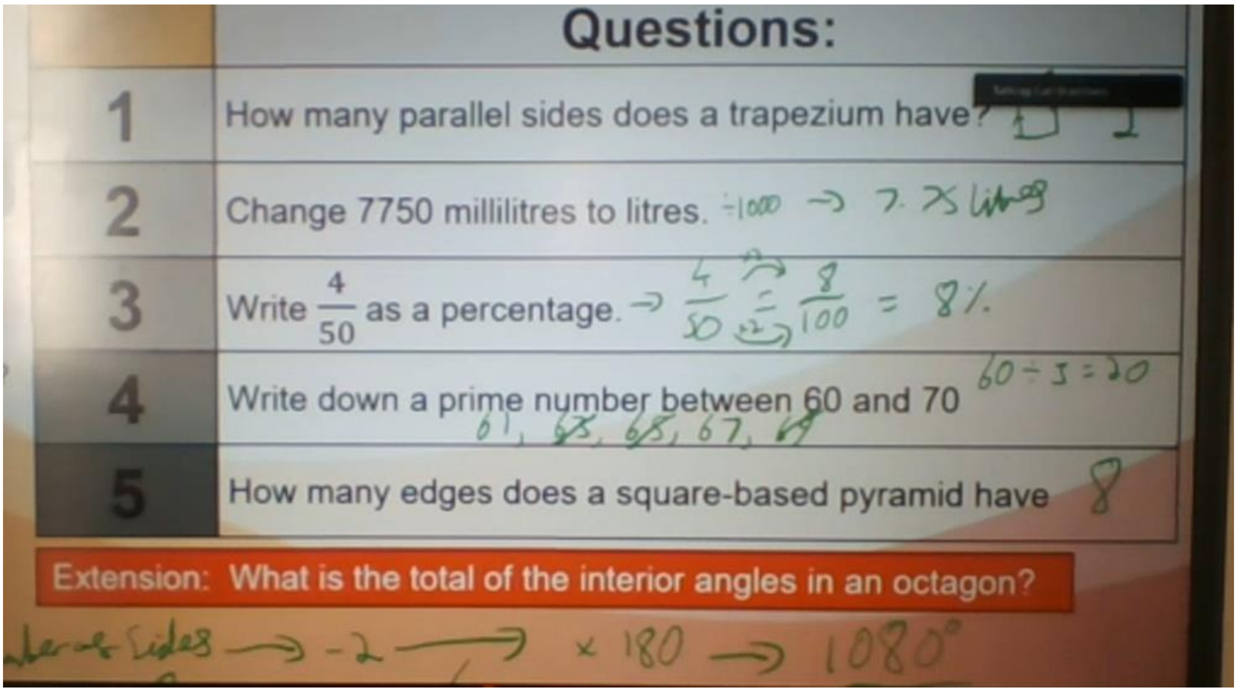
C.3 Connection

C.3.1 When responding to a mathtask which required, among other tasks, student teachers to work out the area of the shaded part between two concentric circles (Figure 3.3) (see also episode C.1.1), Cain worked it out as follows: "Small Circle - π x 12^2 = 144 π. Large (outside) circle - π x (12+4)^2 = π x 16^2 = 256 π (all units cm^2). Shaded area = Large area - small area = (256 - 144) π = 112 π cm^2." Cain wrote that he thought the purpose of the question was to "see how students think and understand the relationships between the dimensions of circles."

When responding to another mathtask: *What fraction is halfway between* $\frac{1}{2}$ *and* $1\frac{1}{4}$*?* (Figure 3.2) question: 'What do you think is the purpose of giving this mathematical problem to the students?' Cain wrote:

While it does prove if the learners can add a fraction and a mixed number, it also investigates their understanding of the mean (and possibly the median) and how to find this. Doing so with fractions is perhaps unusual and may be an issue for cognitive load for less able learners - it is definitely stretch and challenge material for my regular learners.

C.3.2 In one of his lesson, Cain displayed a starter with 6 questions (Figure 5.51).



	Questions:
1	How many parallel sides does a trapezium have? 1
2	Change 7750 millilitres to litres. ÷1000 → 7.75 litres
3	Write $\frac{4}{50}$ as a percentage. → $\frac{4}{50} \xrightarrow{\times 2} \frac{8}{100} = 8\%$
4	Write down a prime number between 60 and 70 $60 \div 3 = 20$ 61, ~~63~~, ~~65~~, 67, ~~69~~
5	How many edges does a square-based pyramid have 8

Extension: What is the total of the interior angles in an octagon?

number of sides → -2 → × 180 → 1080°

Figure 4. 51 Cain's starter to one of his lessons

Students gave answers in the chat. Cain was praising students as he was seeing the answers. Then he called for attention and gave the answers briefly explaining. Cain stopped at *Question 4*, and wrote 61, 63, 65, 67 and 69 and asked, “Which number is not in the times table?” Cain cancelled 63, 65 and 69 saying, “Think of 60 divided by 3 is what? (a long pause) 20. 63 divided by 3 is 21, 65 can be divided by 5 is 13 and 69 divided 3 is 23. The answers are 61 and 67.” He also explained the extension question. He said, “An octagon has how many sides? 8. (a student wrote 8 in the chat according to Cain). So, 8 take away 2 is 6. 6 times 180 is 1080 degrees.” It is not clear why Cain selected the two questions.

C.3.3 Cain introduced *Percentage increase and decrease* by asking students to write words which mean the same as increase on a software mentimeter[22]. The students came up with the different words (Figure 4.52):

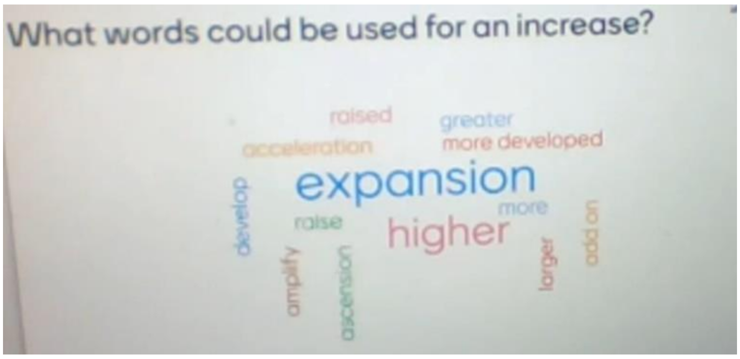


Figure 4. 52 Cain's students contributions on mentimeter to meaning of increase

C.3.4 Cain's starter on *Addition and subtraction of fractions* was 20 minutes long and on *Decimals* it was 36 minutes long. The starters were made up of unrelated questions and there was no attempt to connect the questions. In an interview, Cain gave reasons for long and uncoordinated starter questions:

> Cool, OK so I don't know how much you know about the *5 Rs project* as it was originally told or even as it is now. So, we've got *5 Rs* you got they are**,** recall, routine, revise, repeat and ready so those are the main starters for the session and the main body of a session, and the last R is exam ready. So that is something that we've pulled over from that. Um, so the plenary for most of our sessions is some exam type.

At Cain's college, the teachers follow a teaching project called *5 Rs.* This was the possible reason for examples and activities which are unconnected. In another interview, I (Researcher) followed up on the *5 Rs:*

> **Researcher**: Last time you talked about the 5Rs. Can you please explain what that mean?
> **Cain**: We attended a course on delivering GCSE [General Certificate of Secondary Education] maths resit. This is a lesson structure. We start with *Recall*: class starts with 5 questions learners should always get. Then *Routine* section: 4 questions from the previous lessons: one from last lesson, one from last week, one from last month or so on. *Revise & Repeat*: This is

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[22] Mentimeter is a software application where students can write and what they write is shared with other students without their names Available at Interactive presentation software - Mentimeter .

when we do the teaching of maths; that is teaching a specific topic. *Repeat* and *Revise* can be alternated. They should finish on exam *Ready*.

Researcher: How do you plan your lesson that is putting together the resources and the questions?

Cain: *Routine* questions are from *Edexcel. Recall* part, I use *Diagnostic questions*. *Repeat/Revise*, I give them an example following what we would have done. I use *variation theory* set of questions. If there are no variation theory questions, I set one myself which I did for compound interest. *Exam Ready* we use past exam questions.

C.3.5 When explaining how to change $5\frac{1}{3}$ into improper fraction, Cain said:

> You could see $5\frac{1}{3}$ as being 5 lots of three thirds, and then another third and get 16 thirds. But the easier or quicker way of doing it is to do 5 times 3, so that is going to be 15 and add one that's 16 thirds.

`4.2.2.4`

C.4 Contingency

C.4.1 During an interview, I asked Cain to give an example of how he had assisted a student who did not understand a topic or a question he was teaching. Cain had the following to say:

> One of the quizzes I gave was on fractions. One of the examples was $\frac{1}{2}+\frac{1}{2}$. One person said oh $\frac{1}{2}+\frac{1}{2}$ is $\frac{2}{4}$ and then asking him is this correct or not? He said, yes, it is because 1 + 1 is 2 and 2 + 2 is 4. Which is a classic misconception when it comes to adding fractions? In fractions I identified that was a big problem, so I thought right? How can I tackle this? Well, I'm going to tell him how to add fractions. But also, I want to make him think of something first. I explained that $\frac{1}{2}+\frac{1}{2}$ make a whole thing. So, $\frac{2}{4}$ can't possibly be right. And I've been pondering how I might do it in the future, and probably, I'm thinking of drawing them out on a number lines.

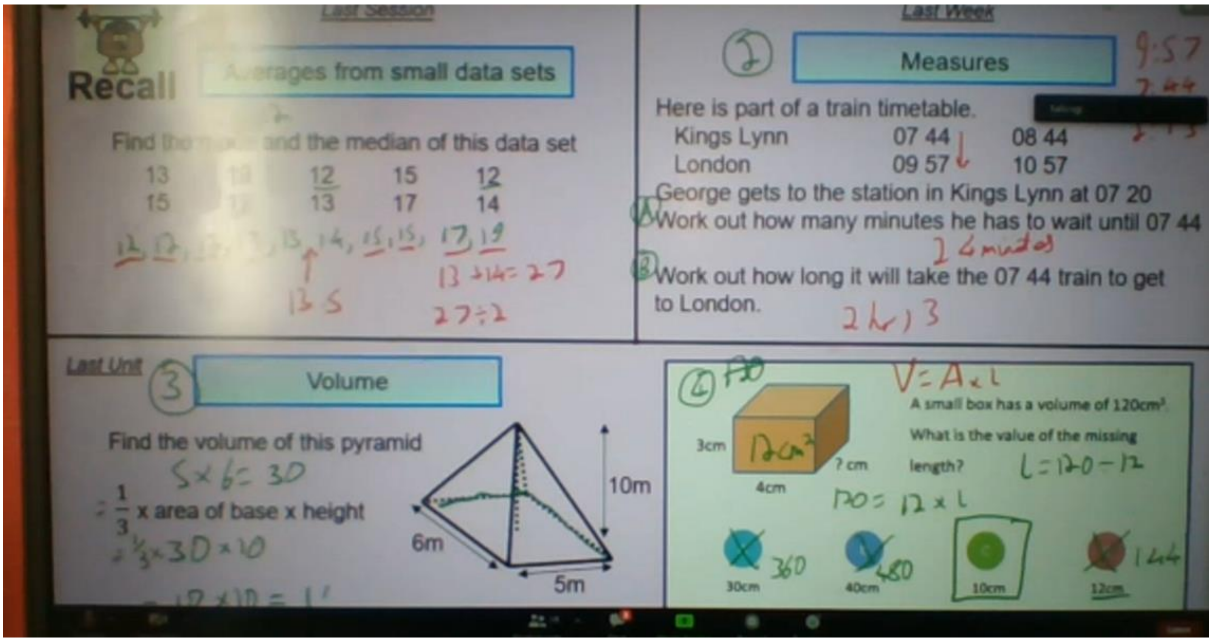
C.4.2 When asked to explain one of his most successful lesson, Cain had the following to say:

> I was teaching straight lines and everything like y = mx + c. I gave them a question where they had to find out the gradient of a line going between two points. And they totally didn't get it

at all. And I was drawing it out on the PowerPoint and everything like I would've done normally. They still weren't really quite getting it and I just stopped. Paused for a moment. I said to myself I've got a learning tool that will work for this. I've got autograph[23] on that computer, so I opened up autograph on that computer. I explained using autograph and they all got it.

C.4.3 On one of the starters, after working for about 5 minutes, Cain noticed that students had not answered one of the questions (answers were written in the chat) and he said, "Has anyone answered question 3 yet? I haven't seen any answer." (*Question 3* was: A map has a scale of 1: 10 000. How far away in reality are two points 4 cm apart on the map?). After seeing that no one answered the questions, Cain explained saying, "4 cm on paper is equal to 40 000 cm on the ground. Changing it to metres we divide by 100 so we get 400 m."

C.4.4 Cain gave a starter (Figure 4.53) and said, "The starter is on what we have recently done."


Last Session

Recall

Averages from small data sets

Find the mode and the median of this data set

Last Week

Measures

Here is part of a train timetable.

Kings Lynn	07 44	08 44
London	09 57	10 57

George gets to the station in Kings Lynn at 07 20

Work out how many minutes he has to wait until 07 44

Work out how long it will take the 07 44 train to get to London.

Last Unit

Volume

Find the volume of this pyramid

$\frac{1}{3}$ x area of base x height

A small box has a volume of 120cm³.

What is the value of the missing length?

Figure 4. 53 Cain's starter to one of his lessons

Cain said, "If you have any answer, let me know." After about 4 minutes, Cain said, "I have not seen any answer yet. Can anyone tell me how to find mode and median?" Student gave answers (Cain was saying, well done, good, ---). After about 2 minutes, he explained Question 1 saying, "12 is the mode,

---

[23] Autograph is a graph plotter that comes with a broad variety of features ranging from the simple plotting of functions to the creation and analysis of statistical figures. (https://risekasap.weebly.com/autograph-maths-software.html)

most common. Median let us put them in order." He writes the numbers in order and explained, "The middle one is between 13 and 14. The answer is 13.5. Add 13 and 14 that is 27 divided by 2 is 13.5." He then gave answers to Question 2 with a brief explanation. He moved to Question 4 saying "What is the answer to Question 4?" After waiting for student responses which did not come, Cain explained:

> Cuboid has cross section area. Volume is area times length. Area is 3 times 4 is 12 cm squared. Volume 120 cm cubed. 120 is equal to 12 times length. 120 divided by 12 which is 10. We can check our answer 12 times 10 is 120.

Cain moved back to Question 3 and explained, "Volume of a pyramid is 1/3 area of base times length. 5 times 6 is 30. A third of 30 times is 10. 300 divided by 3 is 100 cm cubed."

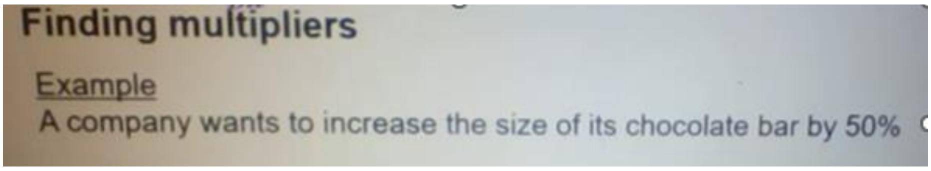
4.2.2.5

C.5 Cain's flagship episode

Percentage increase/decrease using the multiplier

In this section, I present a 23-minute episode (from 37-minute mark to 60-minute mark) on *Percentage increase/decrease using the multiplier*, taught by Cain. The episode, which was extracted from one of Cain's observed lessons, is selected as it covers most of Cain's teaching 'characteristics' as seen through the lenses of the KQ. The episode might be seen as being representative of all Cain's observed lessons. As a reminder, Cain's class had 15 students who were studying for a *Level 2 Diploma in Business Studies,* and GCSE mathematics. The students had obtained lower than Grade 4 in mathematics at GCSE at school; therefore, they were studying mathematics again, as per Government directive with the aim of getting at least a Grade 4 (Department for Education, 2011).

C.5.1 After going over the starter questions on *Angles*, Cain displayed an example (Figure 4.54) and said:



Finding multipliers

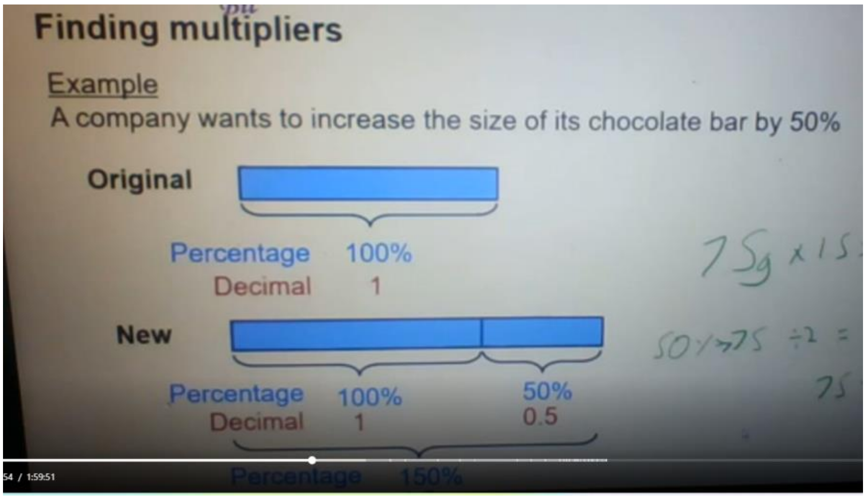
Example

A company wants to increase the size of its chocolate bar by 50%

Figure 4. 54 Title on Finding multipliers

> A multiplier is a quick way of finding percentage increase and decrease. A company wants to increase the size of the chocolate bar by 50%. The original bar is 100% (displaying: percentage

> 100%) (Figure 4.55). As a decimal we divide by 100 and is 1 (displaying: decimal 1). The new bar will be 100% and 50%. In terms of decimals, it will be 1 + 0.5 which is 1.5 (displaying the new bar with Percentages 100%, 50% and 150% (partly obscured) and decimals 1 and 0.5 and 1.5 (partly obscured).



Finding multipliers

Example

A company wants to increase the size of its chocolate bar by 50%

Original

Percentage 100%

Decimal 1

New

Percentage 100% 50%

Decimal 1 0.5

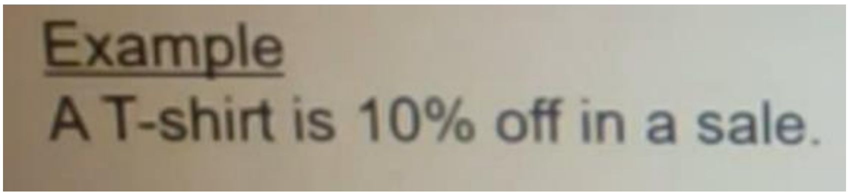
Percentage 150%

Figure 4. 55 Multiplier example

Cain then worked out a question, explaining and writing saying;

> If a chocolate bar is 75g. The new bar is 75g x 1.5 which is 112.5g. We can also find 50% by dividing 75 by 2 and get 37.5g then add to 75g and get 112.5g. We get the same answer.

C.5.2 Cain moved on to decrease. He said, “Let’s have a look at another example,” while displaying a question (Figure 4.56).

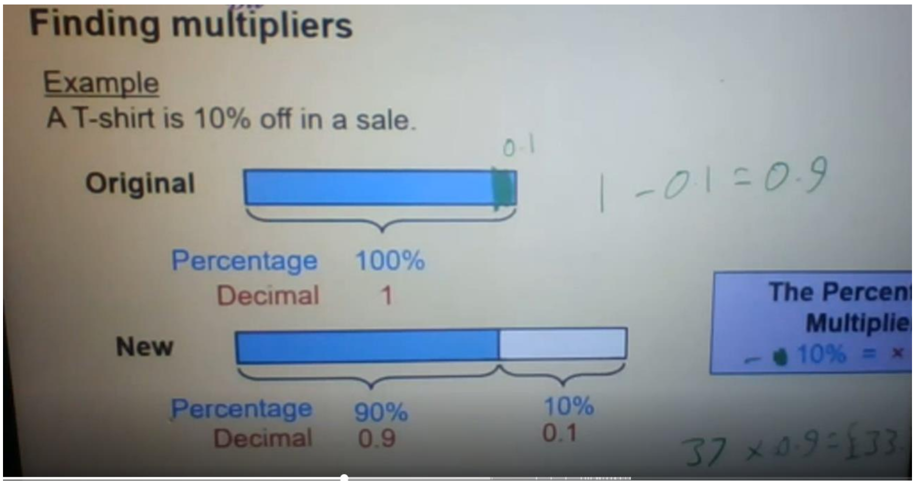


Example

A T-shirt is 10% off in a sale.

Figure 4. 56 Cain’s question on Decrease

Cain explained finding the multiplier and worked out the question while writing (Figure 4.57) saying, “The original is 100% and the decimal is 1. 10% off we have 90% left (he displayed 90% and 10%) decimals 0.9 and 0.1 (displaying 0.9 and 0.1).” He paused and continued, “Alternatively, we can say 1 – 0.1 which is 0.9. The shirt was (pausing; thinking) say £37, then 37 x 0.9 which is £33.30.”



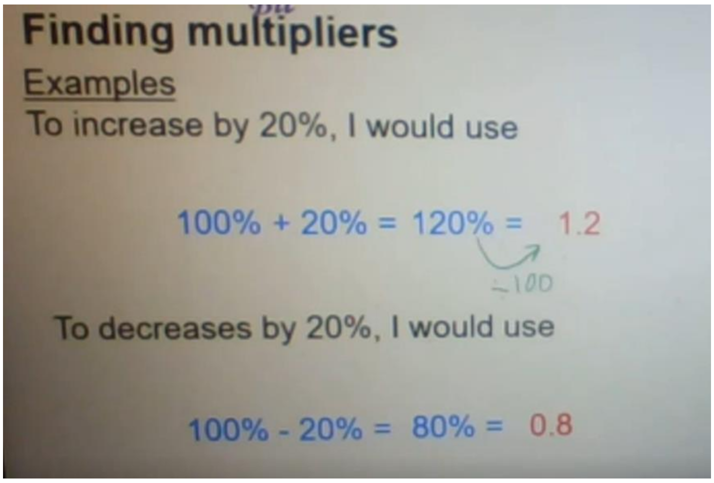
Finding multipliers

Example

A T-shirt is 10% off in a sale.

Figure 4. 57 Cain's working Decrease question

C.5.3 Cain displayed two examples and explained how to get the multipliers while writing and talking (Figure 4.58).



Finding multipliers

Examples

To increase by 20%, I would use

100% + 20% = 120% = 1.2

To decreases by 20%, I would use

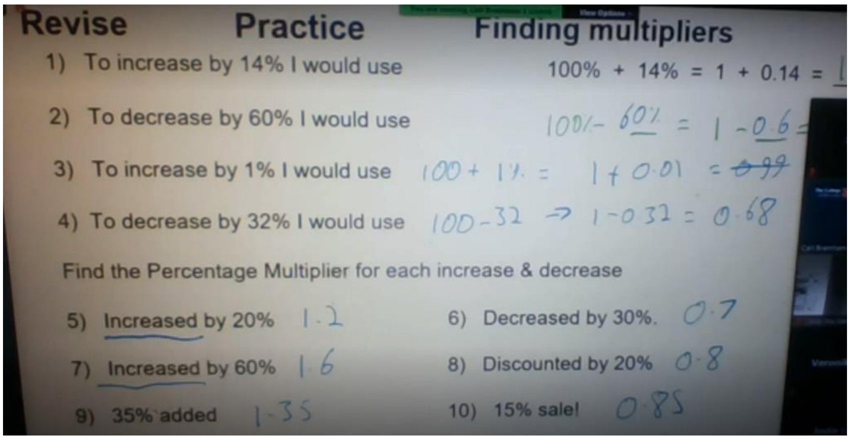
100% - 20% = 80% = 0.8

Figure 4. 58 Cain's Increase and decrease examples using multiplier

"Increase something by 20% , we have 100% we add 20% and get 120%, we divide that by 100 and get 1.2. Decrease we subtract; 100% - 20% is 80% divided by 100 is 0.8."

C.5.4 After the explanation, Cain gave an exercise for students to practice (Figure 4.59). He briefly explained Questions 1 and 2. He asked students to give answers through the chat. He was praising students as they gave answers. He was also commenting as answers were coming in and saying the answers. When it seems no more answers were coming, Cain gave answers explaining briefly. When Cain was giving the answer for Question 8, a student interjected saying, "Number 3. It should be plus."

Before the student could finish Cain quickly said, “Sorry number 3. You are right. I did not read the question” and changed minuses to pluses and cancelled 0.99 and wrote 1.01 (obscured).



Revise Practice Finding multipliers

1) To increase by 14% I would use 100% + 14% = 1 + 0.14 =

2) To decrease by 60% I would use 100% − 60% = 1 − 0.6 =

3) To increase by 1% I would use 100 + 1% = 1 + 0.01 = ~~0.99~~

4) To decrease by 32% I would use 100 − 32 → 1 − 0.32 = 0.68

Find the Percentage Multiplier for each increase & decrease

5) Increased by 20% 1.2

6) Decreased by 30%. 0.7

7) Increased by 60% 1.6

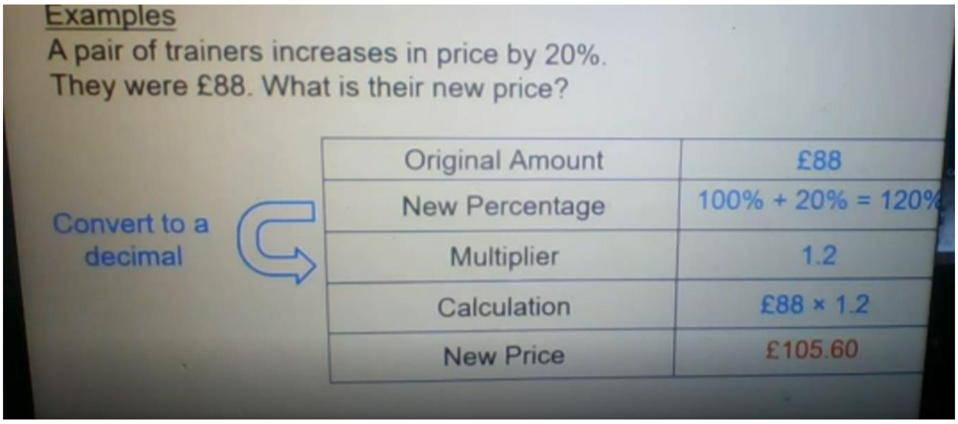
8) Discounted by 20% 0.8

9) 35% added 1.35

10) 15% sale! 0.85

Figure 4. 59 Cain’s exercise on Increase and decrease

Cain said, “Now we know how to find the multiplier, let’s use it. Let us see how it works.” He displayed an example with steps (Figure 4.60). He worked out the question completing the table. He explained that the original is £88. The new percentage in 100% + 20% = 120%. Divide by 100 to convert to decimal and get 1.2, multiply it by the original, the new price is £105.60.



Examples

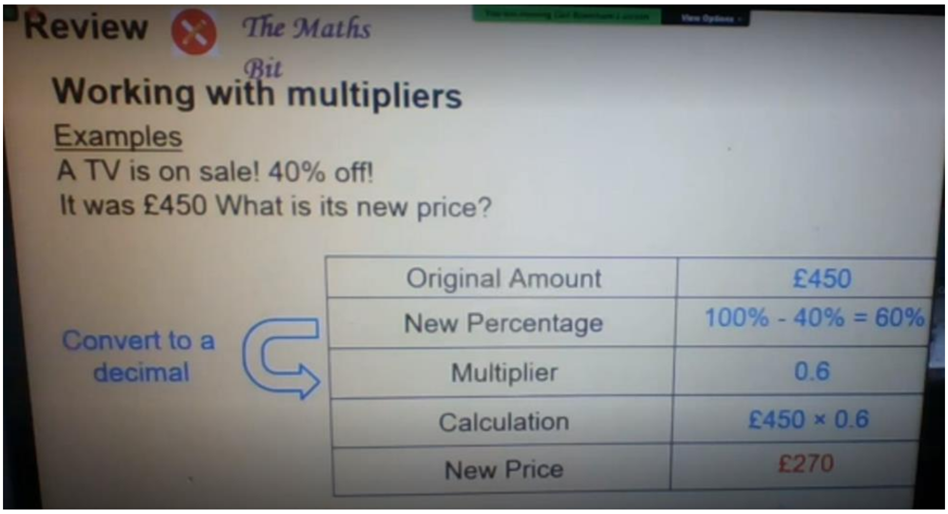
A pair of trainers increases in price by 20%.
They were £88. What is their new price?

Convert to a decimal

Original Amount	£88
New Percentage	100% + 20% = 120%
Multiplier	1.2
Calculation	£88 × 1.2
New Price	£105.60

Figure 4. 60 Cain’s question on Increase

After a few seconds, Cain said, “If you get it give me thumbs up.” After about 20 seconds, Cain said, “I have 8 thumbs ups. Good.” Cain then gave a decrease question and displayed the working while explaining (Figure 4.61).



Review

The Maths Bit

Working with multipliers

Examples

A TV is on sale! 40% off!
It was £450 What is its new price?

Convert to a decimal

Original Amount	£450
New Percentage	100% - 40% = 60%
Multiplier	0.6
Calculation	£450 × 0.6
New Price	£270

Figure 4. 61 Cain's example on Decrease

Cain said, "These question are up to 3 marks in the examination." Cain then gave some questions for students to practice.

4.2.2.6

C.6 How Julie (the mentor) assisted Cain's (the student teacher) mathematical and pedagogical knowledge development

In this section, I present the episodes from interviews with Cain, interviews with his mentor Julie, observed mentor meetings, and reports written by Julie. The episodes are selected if they show Cain's needs and Julie assisting (or not) Cain develop mathematical and pedagogical knowledge by addressing the needs.

Cain and Julie do not hold meetings systematically. Their meetings are haphazard and happens wherever both have time. Julie is not involved in the assessment of Cain, but she submits reports to the *Teacher Training Department* which is responsible for assessing student teachers.

C.6.1 During an interview, while discussing teaching different ability groups, Cain said, "My mentor knows a lot more about ability groups than I do. I do not know about all the other groups that we have and everything." Julie, in an interview, also said she had knowledge of learners. She said, "I understand the lower-level learners and what they need as well as the higher-level learners." Cain was learning about how to teach different ability groups. However, there is no evidence to suggest Cain was differentiating work for his students in the class I observed. Even though Cain was observed as not differentiating work for his students, the knowledge about students he was 'learning' from Julie might be linked to good teacher-student rapport he had developed with his students as shown by the mentor report (Appendix 6) which reads:

> He made good progress in motivating his students and a student said that he has made maths seem interesting. Cain has a great relationship with his *Dash*[24] GCSE students and from the videos of his live sessions you can see as they feel comfortable in asking questions

Another part of the report reads, “Learners clearly happy to unmute – good rapport especially given online only.”

C.6.2 Cain said he was advised on how to involve all learners in answering questions during class discussions, and he had improved on this according to mentor report which reads, “Cain made excellent progress with this and was seen adapting questioning techniques to help engage all his students” (Appendix 6). Another part of the same report reads:

> Cain responds to feedback that he has been given, he adapted different questioning techniques and using [mini] whiteboards to get the answer. Cain is open to suggestions as to how he can get better in what he is doing. He is happy to get the opinions of teachers that have been doing this longer than him…. .

The use of mini whiteboard is not applicable during online teaching and learning, and due to his own initiative, Cain was observed using a lot of resources like mentimeter (a software application where students can write on and what they write is shared with other students without their names) which encourage student participation in online lessons.

C.6.3 During an interview, Julie talked about Cain’s enthusiasm to learn:

> Cain has taken on lots of extra activities this year to help aid his teaching. He regularly participates in the team meetings that we have weekly. Cain attended a maths conference back in October and come away with ideas that he uses in the classroom and has demonstrated using them in his sessions.

---

[24] At Cain and Julie’s college, some students take less than one year to cover the resit GCSE mathematics course. The students are called Dash students because they dash to the examination by taking less than a year to prepare for the examinations.

During one of the interviews, Cain said that he learnt about mathbox[25] from a colleague. Cain said, “The teachers at our college observe each other’s lessons and share ideas.”

C.6.4 In a conversation captured during the mentor meeting, Julie is seen encouraging Cain about reflecting and applying ideas from other teachers into his lessons; that is encouraging learning from peers.

C.6.5 During an observed mentor meeting, the following conversation was captured:

> **Julie**: You are just about to finish your subject specialist paper. Are you?
> **Cain**: I am to finish today because tomorrow is the conference day at university.
> **Julie**: Do you go into rooms and talk to people and make connections?
> **Cain**: Yes. We discuss our papers in groups of eight.
> **Julie**: It’s good to make connections and learn from others.

Again, Julie is seen encouraging Cain to learn from fellow student teachers.

C.6.6 Julie also encouraged Cain to be innovative. During interview, I asked Cain, “Can you tell me anything which you have learnt from your mentor, you can pinpoint and say I did not know this now I know, and I am using it in my teaching.” Cain, after a long pause, replied saying his mentor told him to try something new. In one of the mentor meetings, Julie explained to Cain how to be innovative in online teaching. She said she uses different things like kitchen utensils and sweets to demonstrate topics like *Perimeter* and *Averages*.

C.6.7 During one of the observed mentor meetings, Cain said that he was using *Diagnostic Questions*[26] for starters, and he was running out of them. Julie said, “Since you are running out of starters, you can use *Level 2 Functional Skills* questions for your GCSE maths classes.” This led to Cain and Julie working through past examination questions which is reported in detail in Chapter 5 (Section 5.1.1: Episode 1).

C.6.8 Cain and Julie shared resources and ideas. Julie got Cain’s resources and use them. Julie said, “Um, he's really good with IT so lovely quizzes he's developing, and I will try them with my groups.” At

---

[25] A collection of resources including skills checks and the popular topic-based starter/plenary 3 questions to project resources (https://www.mathsbox.org.uk/index1.php)

[26] Diagnostic questions is an assessment tool that provides detailed insights into student understanding https://diagnosticquestions.com

one point in a mentor meeting, Julie said "You use a lot of technology in your lessons to make them better. It is difficult to use technology teaching online. How can you help students working on the phone? Something to do with equality." Cain did not understand the question, so Julie explained, "How do you treat your students equally. We are in a deprived area." Again, Cain did not understand it. He went on to talk about using his tablet, and Julie did not pursue that further.

C.6.9 What follows is an extract from a mentor meeting where Cain and Julie were discussing Cain's observed lesson by the *Teacher Education Department*:

> **Julie:** Do you want to do the feedback on your observation first?
>
> **Cain**: I gave them [students] a QR code which they failed to scan, and I gave them on learners' page. There were nine questions: six on the topic [taught that day] and three on *Pythagoras [Theorem]*. They should be able to do *Pythagoras [Theorem]* on *3D*. The observer was zooming. I had an issue with pacing and questioning because I forgot what I wanted to do.
>
> **Julie**: Were these your first thoughts when you came out of the observation?
>
> **Cain**: I thought straight aware that it was like *Level 2*. The observer could not hear the students but could hear me.
>
> **Julie**: Pacing is different from class to class. I can't take it as negative. What you did not do you can take it to the next lesson.

C.6.10 During a mentor meeting observed, without being asked, Cain enthusiastically explained one of his lessons. Cain said he taught interest using excel. Julie said she was not confident with excel and want to learn more about it. Cain demonstrated how he used the excel in one of his lessons. Julie said, "You have given them life skills." Cain moved on to do the *Right Move mortgage calculation*. (This is reported in detail in Chapter 5 Section 5.1.1: Episode 2).

C.6.11 During interview, when discussing improving mentoring, Julie said:

> I need time allocated for mentoring. When we are really busy, we make our own slots, but it needs to be allocated for both mentee and mentor. There should be a structure. Training offered. Time allocated. A flexible framework**.** Mentor must have time to attend to mentee needs even outside the allocated time. The mentor needs to be there for general day-to-day support. I am on a different campus with Cain, that's why we arrange Fridays. There should be guidelines. The [training] university may produce some mentor handbooks. They gave us some paperwork. It was just about Cain.

4.2.2.7

C.7 Key features of Cain’s teaching (and intentions) and mentor assistance

After presenting episodes (categorised under the KQ dimensions, one flagship episode and the mentoring assistance offered) from Cain’s mathtasks responses, observed lessons, interviews with Cain, interviews with his mentor, Julie, observed mentor meetings and mentor’s reports, in the following paragraph, I summarise key features of Cain’s teaching (and intentions). A detailed analysis is provided in Section B.

Cain’s subject knowledge is considered strong, as evidenced by the minimal errors observed in his teaching and the comments from his mentor. Similar to Job, Cain tends to use colloquial language rather than precise mathematical terminology and relies heavily on procedural methods. Examples from Cain's lessons indicate a ‘good’ *Awareness of purpose*. There is evidence of *Theoretical underpinning of pedagogy* in Cain’s mathtask and interview responses. There is also evidence of reliance on resources from the internet in Cain’s lessons (and Job’s lessons as well). Cain is observed identifying students errors, but does not take advantage of the errors/misconceptions to move the lessons forward. Although Cain uses a lot of representations in form of visual mediators and software like mentimeter, his explanation is observed to be long and winding (and at times confusing). Unlike Job’s lessons which show differentiation, Cain’s choice of examples does not include differentiation to cater for different ability groups in his class. Like Job’s lessons, most of Cain’s lessons are not properly sequenced and there is limited connection between concepts, between representations, and between procedures. Observing contingency actions in online lessons without access to the chat is challenging, but Cain shows some contingence action; for example, when he changed his plan and used *Autograph,* which is *Deviation from the agenda*. The mentoring Cain receives is generic but includes mathematics specific assistance.

4.2.3 Student Teacher Suzy

Knowledge of fractions and mentor assistance

The data presented in this section is based on episodes from Suzy’s responses to two mathtasks: *Addition of fractions* (Figure 3.1) and *What fraction is halfway*? (Figure 3.2) and two interviews. As a reminder, Suzy was a pre-service student teacher, and her mentor did not consent to participate in the study.

S.1 When responding to the mathtask 1 on *Addition of fractions*: $\frac{5}{6} + \frac{3}{7}$, Suzy wrote: “$\frac{5}{6} + \frac{3}{7} = \frac{(7\times5)+(6\times3)}{6\times7} = \frac{35+18}{42} = \frac{53}{42} = 1\frac{11}{42}$.” Responding to how she would explain to the class, Suzy wrote, “I may put this question to the class discussion and say my point that this is the method we follow to add fractions as methods like long divisions help us to find solutions easily and quickly.” When responding to mathtask 2: *Fraction halfway between* $\frac{1}{2}$ *and* $1\frac{1}{4}$, which required, among other tasks to work out a fraction that is halfway between $\frac{1}{2}$ and $1\frac{1}{4}$, Suzy wrote, “As half of each gap is $\frac{1}{8}$, I will add $\frac{1}{8}$ to $\frac{3}{4}$ which will give $\frac{7}{8}$.”

S.2 During interview, I asked Suzy to explain her method on the *Addition of fractions* mathtask. She said:

> OK, that's one $\frac{5}{6}$ plus $\frac{3}{7}$. We need to multiply these two denominators. I don't know they don't have common factor firstly. Yeah yeah. So, in that situation we can straightaway multiply together to get the common denominator. Which is 42, so yeah. In fraction yeah of $\frac{5}{6}$. I need to times denominator by 7. So, you multiply 5 times 7 and get 35. Also, times 6 times 3 and get 18. 18 plus 35 is 53 divide by 42 and get $1\frac{11}{42}$.

I asked, “Why do you cross multiply the denominator of one fraction by the numerator of another fraction,” and she explained:

> Yeah, actually I'm trying to get the equal in fraction. Actually, it is for example $\frac{3}{7}$. I have to get a fraction equal in fraction that should have a denominator for 42. So, to get that 42, I have to times this 7 by 6. So, I need to do the same thing to the numerator which is 3 times 6. OK yeah, I get it. I actually used this method to my students, and it went well better than the method which I went with.

I asked Suzy about other ways of finding the common denominator besides multiplying denominators and she explained:

> I would make sure that they know how to find factors, common multiples, and lowest common multiples. Then I would encourage them to use the lowest common multiples as common denominators. I would explain how to use the *Venn diagram* to find the common denominator. I would say that finding the common denominator is good and help them to revisit the method of finding the common denominator such as using the *Venn diagram.*

S.3 I asked Suzy about a topic she taught and was successful. She explained:

> I taught shapes like parallelogram, rhombus and trapezium. I did not like it at first because I thought students would be put off by these long words. I put the word parallelogram on the board and asked what it means. The students did not know, and I explained. I put a rectangle and explained the parallelogram saying it's like rectangle pushed over. I linked rhombus to square. They struggled when learning area and I thought it's a good opportunity. They started to connect things.

S.4 During interview, Suzy, said she was observed by her mentor teaching *Drawing bar charts*. She said her scale was not uniform and the gaps between bars were not equal. She said during the feedback meeting, her mentor explained the correct way of scaling bar chart and to have gaps which are uniform (This is explained in detail in Chapter 5: Section 5.1.3.3, Episode 10). She also said her PowerPoint had a lot of animation and she was advised to reduce the animations.

Suzy's responses to mathtasks and interviews indicate that her subject knowledge is 'secure,' as evidenced by her correct solutions to fraction questions. However, she demonstrated limited knowledge in drawing bar charts, requiring her mentor's assistance to do so correctly. Despite responding to only two mathtasks and being interviewed twice, Suzy exhibits procedural tendencies. Unlike Job and Cain, Suzy's responses reflect the intentions to use of various teaching methods.

4.2.4 Student Teacher Kate

Knowledge of addition of fractions

Kate responded to one mathtask: *Addition of fractions* (Figure 3.1). She withdrew from the study but had consented to have her data analysed and reported.

K.1 Kate did not work out the question. She wrote, "Work out using different methods." She did not explain the methods. She added, "Students would self-mark. [---]. I would as a class teacher go through how to find the correct answer."

Kate's response to the mathtask does not demonstrate mathematical knowledge, but it does reflect general pedagogical knowledge.

4.2.5 Student Teacher: Mary

Knowledge of addition of fractions

Mary responded to mathtask 1: *Addition of fractions* (Figure 3. 1) before withdrawing from the study, but had consented to have her data analysed and reported.

M.1 Responding to the mathtask, Mary worked the *Addition of fractions* question. She wrote: $\frac{5}{6}+\frac{3}{7}=\frac{5\times7}{6\times7}+\frac{3\times6}{7\times6}=\frac{35}{42}+\frac{18}{42}=\frac{52}{42}$ = 1 whole and $\frac{10}{42}$ that can be simplified by dividing by 2 to $\frac{5}{21}$. The final answer is 1 whole and $\frac{5}{21}$. Mary wrote, "A common denominator is a common multiple of the denominators, in our case a number that is in both 6- and 7- times table." Mary made a mistake in her calculation; 35 + 18 = 53 and not 52. Mary wrote, "I would use visual representations of fractions or manipulatives. I would mention the common misconceptions about adding fractions of adding the tops and adding the bottoms." Responding to the question: If you were working with a different class, how would you teach 'Addition of fractions with different denominators' and why would you use this approach?, Mary explained adding fractions by converting the fraction to decimals. She wrote, "$\frac{5}{6}$ = 0.83 and $\frac{3}{7}$ = 0.43, 0.83 + 0.43 = 1.26." Mary also connected fraction to algebra. She wrote "We can think of any fraction $\frac{a}{b}$ as a x $\frac{1}{b}$. The unit fraction $\frac{1}{b}$ is a unit, and it only makes sense to add units that are of the same type."

Mary's response to the mathtask shows 'secure' subject knowledge, though she made a mistake when working out a question. Mary's response to the mathtask shows the use of different methods in teaching (or intention).

The presentation of the data in Section A is taken as the initial analysis as data were categorised by student teachers' names using the KQ dimensions. In Section B the data is aggregated and discussed using the KQ dimensions, and student teachers' names are of less significance.

4.3 Section B: Data analysis and discussion

In this section, I give a detailed analysis of the data presented in Section A. In an attempt to answer the research questions (RQs), the section is organised into four sub-topics: *Mathematical and pedagogical knowledge enacted by FE student teachers in teaching; Student teacher needs* (RQ 1); *How mentoring addresses the student teacher needs,* and *Institutional issues that have the potential to influence mentoring practices* (RQ 2).

4.3.1 Mathematical and pedagogical knowledge enacted by further education student teachers in teaching

In this section, I give a detailed analysis of the mathematical and pedagogical knowledge enacted by student teachers in teaching as seen through the lens of the Knowledge Quartet (KQ); therefore, I organise the section under the KQ dimensions: *Foundation, Transformation, Connection* and *Contingency*. Unlike in Section A where data were organised under the student teachers, in this section student teacher names are of less importance as the data were aggregated and reported under the KQ dimensions. While Turner and Rowland (2010) emphasise that the practical application of the KQ relies more on understanding the broader characteristics of the four dimensions than on recalling specific contributory codes, this analysis is structured around these codes for clarity. Preliminary results of the analysis of *Mathematical and pedagogical knowledge enacted by further education student teachers in teaching* were presented at the British Society for Research into Learning Mathematics (BSRLM) conference and published in Machino (2021).

4.3.1.1 Foundation

Overt subject knowledge

While defining *Overt subject knowledge*, Rowland et al. (2012) say, “Of course, teachers display ‘overt knowledge’ all the time when they demonstrate that they know themselves the subject matter that has been selected for the class to learn” (p. 1).

Looking at the two observed student teachers: Job and Cain, it is seen that both worked questions correctly in most cases during their teaching and responding to mathtasks. To give examples, both Job and Cain correctly worked the questions on *Addition of fractions (Figure 3.1)* (episodes J.1.1, C.1.1 & C.1.2). Looking at another example from Job, he worked a question on *Venn diagrams* (episode J.1.7) correctly explaining step by step. However, in some instances Job was seen to be making errors in his calculations; for example, he miscalculated the HCF of 112 and 42; he gave the answer as 2 (as presented in episode J.2.10) when it is 14. Job also admitted to having gaps in subject knowledge, especially algebra (episode J.6.6). Job did not show conceptual understanding of the meaning of π, which he explained as a number 3.14 or a button on the calculator (episode J.1.3). Turning to examples from Cain, he worked questions on *Percentage increase and decrease correctly* (flagship episode C.5). Cain showed ‘good’ understanding of formulas; for example, the formula of interior angles of a polygon (episode C.2.4) and the conceptual meaning of π (episode C.1.5). Cain, on rare occasions, showed gaps in subject knowledge; for example, when he admitted to not knowing the conceptual meaning of the formula for volume of a pyramid which is $\frac{1}{3}$ of length x width x height (episode C.1.8), and the meaning of the mnemonic KFC (Keep, Flip and Change) used when dividing fraction (episode C.1.3).

Turning to the three student teachers whose participation was partial, Suzy worked out mathtask 1 question correctly: *Addition of fraction* $\frac{5}{6} + \frac{3}{7}$ and mathtask 2 question: *What fraction is halfway between* $\frac{1}{2}$ *and* $1\,\frac{1}{4}$ correctly (episode S.1). Mary’s working of mathtask 1, presented in episode M.1, made an error of addition 35 + 18 which she gave as 52 when it should be 53. This error cannot be taken to mean Mary could not add fractions correctly as she wrote about introducing decimals and algebra (writing fraction $\frac{a}{b}$ as a x $\frac{1}{b}$) to help students understand addition of fraction which is ‘complicated’ and this could be taken to mean Mary’s knowledge is higher than GCSE level. The error could be a result of not paying attention to detail. Unlike other student teachers, Kate’s response did not show any subject knowledge. Her response reported in episode K.1 mentioned three issues: working out the question using different methods, self-marking, and teacher going through how to find the correct answer. This does not show mathematical subject knowledge; however, it shows some pedagogical knowledge.

The qualifications of the student teachers especially the two main participating ones Job and Cain, and their teaching seem to agree with Stevenson’s (2020) observation that it is generally agreed that good subject knowledge is an important prerequisite for successful teaching. Cain had higher qualifications in mathematics than Job (see Table 4.1), and Job was observed to be making more errors when working through questions than Cain. As mentioned earlier, teachers display ‘overt knowledge’ all the time when they demonstrate that they know themselves the subject matter that has been selected for the class to learn (Rowland et al., 2012), and in this case Job and Kate were observed not having the subject matter well enough; therefore, *Gaps in subject knowledge* is a potential student teacher need which could be addressed by mentoring.

The qualifications of student teachers entering Further Education (FE) Initial Teacher Education (ITE) programs, such as those observed by Job and Cain, are diverse. This aligns with Greatbatch and Tate's (2018) findings, which highlight the varied experience and qualifications of student teachers in FE teacher education courses. This study explores differences in the mathematical backgrounds of FE teachers, encompassing both their educational and professional experiences. These variations are reflected in the diverse teaching approaches of student teachers, which is discussed in the transformation section later. The study confirms existing literature on the varying qualifications of FE student teachers entering ITE (Thompson, 2014) and further identifies a positive correlation between their qualifications and the mathematical and pedagogical knowledge they apply in teaching.

In the context of FE, the requirements for obtaining a Postgraduate Certificate in Education (PGCE) differ from those for secondary schools. While a degree is typically required for secondary PGCE programs, individuals with a GCSE Grade C (now Grade 4) in mathematics can pursue training to become GCSE mathematics teachers in FE. However, the pathways and qualifications for student teachers without degrees differ from those of degreed counterparts. The diversity in qualifications and backgrounds among those entering ITE is significant, with individuals pursuing a range of teaching qualifications (Greatbatch & Tate, 2018; Thompson, 2014) (see Section 1.2.6).

Use of terminology

Use of terminology is demonstrating knowledge of the correct mathematical terms and their precise meanings, and precise use of mathematical symbols; mistakes could be based on an incorrect use of symbols, or a misunderstanding of technical mathematical vocabulary (Campton & Stevenson, 2014). The use of terminology was observed in terms of mathematical (in)accuracies which could be seen by how student teachers used words (colloquial and mathematical), presented examples, used diagrammatic representations, and mathematical notations.

The student teachers who were observed teaching were seen to be using colloquial terminology instead of the mathematical terminology. For example, in episode J.1.4, when Job was explaining *Fractions of amounts*, he taught students to divide by the 'bottom number' and multiply by the 'top number' which are colloquial terms. During interview reported in episode J.1.2, Job said, "The use of terminology is not particularly important as long as students understand what is taught." I discussed the issue of using colloquial and mathematical terminology during an interview with Alex, Job's mentor (episode J.1.2). Alex also did not see the use of terminology as an issue, but said, "The use of terminology should be 50 – 50" meaning colloquial and mathematical terminology should be used equally. Besides the use of terminology, mathematical presentation of examples was observed to be incorrect. Job wrote 84 ÷ 21 = 4 x 2 = 8 when explaining an example on *Fractions of amounts*: $\frac{2}{21}$ of 84 (episode J.1.4). While the final outcome is correct, it is the presentation which is not mathematically correct. In a lesson on *Solving equations* (episode J.2.7), Job explained that "Inverse is the same as opposite. So, you do the opposite of an operation like when it is plus you do minus," with reference to operations meaning + is the opposite of –, and x is the opposite of ÷. Referring inverse as opposite could be seen as mathematically incorrect use of notations. When Cain was teaching *Percentage increase and decrease using the multiplier* (Figure 4.57 in Flagship episode C.5), the diagram is seen to be incorrect as the bar representing 90%, after 10% decrease, is longer than the bar representing the original 100%. In episode C.1.6, Cain is seen explaining volume of a prism as area of front face multiplied by length. This could be seen as mathematically incorrect use of diagrammatic representation as front face depends on the position of the viewer.

However, there were instances when the use of terminology was observed to be correct ; for example, in episode C.1.5b, Cain is seen defining 'tangent' correctly. Cain was also seen giving an explanation which shows conceptual understanding of π saying, "It is the ratio between circumference and diameter" (episode C.1.5c). In another incident, Cain was observed by his mentor Julie teaching the correct presentation when solving equations. In episode C.2.8, Julie said a lot of students presented solving equations in mathematically incorrect way, but she observed Cain correcting that and teaching the correct presentation.

According to the participating student teachers and their mentors, the use of mathematical terminology is not of any significance as long as students understand, but Rowland et al., (2012) advise teachers to demonstrate knowledge of the correct mathematical terms and their precise meaning. Campton and Stevenson (2014) say teachers should be demonstrating knowledge of the correct mathematical terms and their precise meanings, and precise use of mathematical symbols. While researchers (for example, Campton & Stevenson, 2014; Rowland et al., 2009; Ball et al., 2008) emphasize the importance of use of accurate mathematical terms, in this study it has been observed that the use of terminology is of lesser importance as long as students understand what is taught.

An explanation for the lesser importance of the use of terminology in FE mathematics teaching could be that teachers are constrained by the time (Noyes & Dalby, 2020) and also the examination orientation culture of the resit course; therefore, the use of correct mathematical terminology might not be all that important. However, Use of terminology could be taken as a student teacher need which should be addressed by mentoring.

Reliance on procedures

Reliance on procedures is rule-bound, with a reliance on memorising rather than conceptual understanding; teachers who are more procedural believe that mathematics is about rules which have to be remembered (Goulding et al., 2002).

When teaching *Area and circumference of a circle*, Job explained π as a number 3.14 or a button on the calculator (episode J.1.3). In another incident when Job was teaching *Mean*, he used of the mnemonic: 'Don't be mean, share them out' (episode J.2.9), and explained range as " …. order from smallest to largest" (episode J.2.8). Visiting episode J.1.4 again, Job was seen teaching 6/10 of 60 and $\frac{2}{21}$ of 84, using the rule: divide by the bottom number and multiple by the top number. Again, when he was teaching *Percentages of amounts* (episode J.1.5): 30% of £25, Job explained that "We divide 30 by 100 then multiply by 25," without any explanation to make students understand beyond just getting the correct answer. These examples show that Job was emphasizing procedures in his teaching.

When Cain was teaching *Percentage change* (episode C.1.4), he gave an example of increase in sales and explained percentage increase as: change ÷ original x 100. There was no explanation about the meaning, and this was just given as a formula or rule. When Cain used π during teaching *Area and circumference of a circle;* there was no explanation about what it means, but during interview he explained it in detail talking about its origin from ancient Greece (episode C.1.5). There were some instances where Cain's teaching (or intention) was not procedural; for example, responding to a mathtask, Cain wrote, "I want some peer learning to take place, and not purely transmit information to the learners" (episode C.1.7). Although Cain did not explain what he meant by 'purely transmit information to the learners,' this showed his intention to move away from procedural teaching to teaching that aims at conceptual understanding. Also, Cain explained finding percentage increase and decrease using the multiplier in detail giving reasons behind each step (flagship episode C.5). Cain expressed his interest in more student-centred approaches. However, he does not take the opportunity to materialize those approaches in his teaching.

Suzy also showed some procedural intentions when responding to the mathtask 1: *Addition of fractions* (Figure 3.1). She wrote, "I may put this question to the class and say my point that this is the method we follow to add fractions” (episode S.1). The ‘methods we follow’ might be seen as procedural explanation.

Although there were some instances of explanations aiming at conceptional understanding especially from Cain, all the student teachers were observed to be more procedural as evidenced by their examples in lessons and responses to mathtasks; therefore, this is potentially a student teacher need that could be addressed through mentoring.

The findings of this study agree with Ball’s (1990a) investigation of elementary and secondary pre-service teachers’ understanding of division of fractions where the pre-service teachers had significant difficulties with the meaning of division by fractions. Most could do the calculations, but their explanations were rule-bound, with a reliance on memorizing rather than explanations that aims at conceptual understanding: that is knowing the meaning of the procedures. While Ball (1990a) refers to division of fractions only, this study discovers this to be true for division of fraction (remember KFC in episode C.1.3) and also other topics; for example, explaining percentage increase as change ÷ original x 100. Goulding et al., (2002) argue that if teachers believe that mathematics is principally a subject of rules and routines which have to be remembered, then their own approach to unfamiliar problems would be constrained and this may have an impact on their teaching. Fennema and Franke (1992) do not see procedural approach as showing some weaknesses when they argue that if a teacher has a conceptual understanding of mathematics, this influences classroom instruction in a positive way; however, procedural rules are also important.

FE mathematics student teachers’ procedural approaches could be explained in two ways. It might be gaps in subject knowledge as Ball et al., (2008) see it or it might be the pressure faced by mathematics teachers in FE who have to cover a two-year curriculum in one year to students who appear to have no intrinsic motivation to study mathematics (Noyes & Dalby, 2020). The first explanation might be seen in Job’s teaching as he had gaps in subject knowledge as per his qualifications in mathematics (Grade C at GCSE) and he said he struggled with some topics, especially algebra (episode J.6.6). The second reason might be visible in Cain who used π procedurally in teaching, most likely due to time pressure, but his explanation during an interview shows conceptual understanding (episode C.1.5).

While researchers in mathematics education (for example, Ball et al., 2008; Rowland et al., 2012) seem to emphasise directly or indirectly the importance of teaching that aims at conceptual understanding, the results of this study show that these FE student teachers rely on procedural teaching. This is an area which could be taken as a student teacher need.

Awareness of purpose

Awareness of purpose refers to the use of realistic contexts for mathematical problems that help to give purpose to the teaching and learning of mathematics as well as helping to support pupils in carrying out tasks with understanding (Rowland et al., 2012).

While introducing *Ratio*, Job gave the students a question: Simplify 0.6 m : 30 cm.’ Job told the students to first convert 0.6 m to cm before simplifying the ratio (episode J.1.6). In another lesson, Cain taught inequality signs: <, >, ≤ and ≥, before introducing *Averages from grouped data* (episode C.2.6). At Cain’s college, the mathematics department followed the lesson structure which is known as the 5R: *Recall, Routine, Revise, Repeat* and *Ready* (see episode C.3.4 for detailed discussion of the 5Rs). The last R is *Ready for examination* when students practice examination type questions. Job and Cain referred to examinations and used examination type questions in almost every lesson because they were focusing on making the student pass the examination. The three examples above: changing to the same units before simplifying ratio, teaching inequalities before averages from grouped data, and referring to examination show that the student teachers were aware of the purpose of teaching different topics and the need to practice for examinations. Job was aware that for students to correctly simplify ratio, they should have an understanding of converting to the same units: centimetres to metres in this case, while Cain is aware that for students to learn averages from grouped data, they need to know inequalities first. Giving examination type questions is also awareness of purpose as FE mathematics students are preparing for resit examination. The student teachers were aware of the institutional expectations of having as many students as possible getting a Grade 4 or higher. Besides examination type questions, the two student teachers showed awareness of purpose by connecting mathematics topics to real life and vocational courses in some of the observed lessons (episode J.2.13). This aligns with what Noyes and Dalby (2020) mean when saying connecting mathematics to students’ vocational study programmes highlights the ‘user value’ of mathematics, and this could improve how students view mathematics.

Awareness of purpose could be observed in what Ball et al., (2008) call vertical curriculum which is the knowledge of the mathematics taught at current grade-level and what will follow in the next grades. In the FE context, this could be taken to mean knowledge of the current topic(s) or lesson(s) and what will follow during the next topic(s) or lesson(s).

Awareness of purpose is key to FE mathematics teaching as the teachers have to know the reasons for teaching a particular topic and what needs to be known before teaching the topic. The FE mathematics curriculum is a revision course as students are preparing to retake the GCSE examination, and the students are mostly demotivated to study mathematics 'again' (Noyes & Dalby, 2020). Students could see the purpose of studying mathematics 'again' if teachers focus on examinations (the students just want to pass) and relate the mathematics to their vocational courses (students are in college to study vocational courses and are 'forced' to study mathematics). This study confirms what is in literature (for example, Noyes & Dalby, 2020) about the importance of connecting mathematics teaching to vocational courses.

Theoretical underpinning of pedagogy

Theoretical underpinning of pedagogy is the teacher's use of a theoretical foundation to guide instructional decisions, rather than relying on imitation of another teacher or trial and error; therefore, it is important for teachers to know factors that are significant in the teaching and learning of mathematics (Rowland et al., 2009).

In episode C.1.7, during interview, Cain was seen constantly referring to theories of teaching; for example, *Cognitive conflict* and *Pedagogical Content Knowledge (PCK).* When responding to a mathtask about *Addition of fractions* (Figure 3.1)*:* $\frac{3}{5} + \frac{3}{7}$, Cain wrote "I want to lead to potential cognitive conflict." Cain also mentioned the common misconception in adding and subtraction of fraction when discussing how he assisted a student who had said $\frac{1}{2} + \frac{1}{2} = \frac{2}{4}$ (episode C.4.1). This was also mentioned by Mary who wrote that she would tell her students about this common misconception in fractions of 'add/subtract numerators and add/subtract denominators' (episode M.1).

Cain and Mary, who were in their second year of training, showed understanding of *Theoretical underpinning of pedagogy* by referring to theories and misconceptions. The explanation might be that, at the time data were collected, second year student teachers might have attended some theoretical lectures. There is no evidence of *Theoretical underpinning of pedagogy* in Job's teaching, during interviews or responding to mathtasks. Also, Suzy and Kate's responses to mathtask shows no *Theoretical underpinning of pedagogy*. An explanation for Kate, Suzy and Job's limited understanding of the theories in mathematics teaching and learning might be that during data collection there were in their first year of training and they might have attended few or no theory lectures due to the COVID-19 pandemic. ITE in FE is generic and the theories taught are generic as well; therefore, it might be argued that first year student teachers might not have developed the ability to relate the generic theories to mathematics teaching.

This study has shown that student teachers seem not to have developed the understanding of theoretical foundation to guide instructional decisions at an early stage of their training; they seem to rely on other teachers. It seems there is no (or very little) literature on relationship between *Theoretical underpinning of pedagogy* and the stage of teacher education of mathematics student teachers in FE, and this study might be the first (or add literature) on the issue.

Adherence to textbooks (and internet resources)

Adherence to textbooks (and internet resources) is about how the teacher "[m]ake use of his/her own resources and teaching strategies rather than adhering to textbook [and internet resources] or *National Numeracy Strategy* unit plans" (Rowland et al., 2009. p. 35).

Job and Cain were observed to be mostly relying on internet resources in their teaching. Most of the PowerPoint presentations they used were made up of internet resources which showed no signs of having been edited. Most of the PowerPoint presentations were composed of portable document format (pdf) worksheets snipped from the internet and copied into slides. For example, in episode J.2.10, Job had a worksheets on HCF and LCM with two incorrect answers of which he spotted one and missed the other. Job's resources from the internet were 'improved' by a senior colleague, Mariam (episode J.6.6). Cain used a diagram on *Volume of a prism* which had two 4s (Figure 4.49 in episode C.2.5) which caused some confusion. The errors could have been spotted had the resources been carefully looked at. During an interview, Cain said he picked up questions, especially for starters, randomly from the internet (episode C.2.3), and in episode C.3.4, he said he got questions from Edexcel[27], Diagnostic questions[28] and Variation theory[29]. This shows that Cain used 'ready-made' questions from the internet.

The internet is loaded with resources (obviously useful and not so useful); therefore, there is need for teachers to carefully select resources and student teachers might not have that skill in abundance. As

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[27] An examination body which sets, administer and accesses examinations. https://qualifications.pearson.com/en/about-us/qualification-brands/edexcel.html

[28] Diagnostic Questions is an assessment tool that provides detailed insights into student understanding. https://diagnosticquestions.com/ https://diagnosticquestions.com

[29] Variation Theory is based on an attempt to assemble a collection of high-quality, sequences of questions and examples using key principles . https://variationtheory.com/

a result, student teachers were observed to be relying on the internet for resources without carefully checking the resources for suitability and accuracy.

Ball and Cohen (1996) say teachers interpret textbooks (and internet resources) in different ways, and that their interpretation influences the ways they use them in their teaching. While curricular materials, such as textbooks (and internet resources), can serve as a starting point and a guide for teaching, rigid adherence to them may indicate gaps in *Specialized Content Knowledge (SCK)* on the part of the teacher (Stein et al., 2007). One aspect of *SCK* is the ability to critically use the curriculum and modifying it in order to meet the needs of students (Ball et al., 2008; Rowland et al., 2009). The student teachers, most likely due to lack of experience, tend to rely on internet resources and it seems they have limited knowledge to interpret and edit them to suit students of different abilities.

While literature points to the different skill shortages among student teachers; for example, inability to anticipate student mistakes or misconceptions, and shortage of 'professional noticing of students' mathematical thinking' skills (Jacobs et al., 2010), there is no (or very little) literature pointing to gaps in knowledge of selecting or developing resources among student teachers as pointed out by this study. Therefore, the issue of *Adherence to textbooks (and internet resources)* could be taken as a student teacher need which has to be addressed by mentoring.

Identifying errors

Identifying errors is about how teachers identify errors and correct them without causing confusion and promote misconceptions (Rowland et al., 2009).

Student teachers had some instances where they identified errors and some instances where they failed to identify errors. Looking at episode J.2.10 again where Job displayed answers to a HCF and LCM exercise. Job spotted an incorrect answer that gave 'the HCF of 100 and 60 as 5', and he changed it to 20. One of the examples gave the HCF of 112 and 42 as 2. Job did not spot that error. Another example is seen in episode C.1.4 where Cain gave students a question: 'Decrease £25 by 30%.' Students were required to work it out and post the answers in the chat. At some point Cain said, "Sarah (pseudonym) you complicated it." However, Cain did not explain how Sarah 'complicated' the question. Even though I did not see the chat, the statement made to Sarah implies that Cain had identified an error. It is not clear why Cain did not explain Sarah's 'complicating it.'

Teachers who have secure foundation knowledge can identify errors and correct them without causing confusion and promote misconceptions (Rowland et al., 2009). The statement by Rowland and his colleagues has two parts: identifying the error and addressing it. In some instances, Job and Cain identified the errors but the ‘correcting/addressing’ of the error was missing; for example, ‘the Sarah you complicated it’ incident.

FE mathematics teachers might be faced with more instances of identifying error than their secondary school counterparts. The FE mathematics students have negative attitudes towards learning mathematics which can be caused by multiple factors, including negative prior experiences with learning, peer pressure and lack of confidence (Greatbatch & Tate, 2018). Noyes and Dalby (2020) say teaching mathematics in FE primarily involves working with low-attaining students who consider themselves ‘failures’, and this might result in the students making a lot of errors. This study has found that student teachers can identify errors but the ability to use the errors to move the lesson forward needs to be developed further. Studies on student teachers’ ability to use errors to move lessons further seems to be scarce (or unavailable) in FE. However, I have to acknowledge that due to observing online lessons and not having access to the chat, there were few instances observed on teachers identifying errors. Therefore, there is no strong argument to justify taking *Identifying errors* as a student teacher need.

4.3.1.2 Transformation

Teacher demonstration and choice of representation

Teacher’s demonstration refers to the way the teacher makes procedure/concept understandable to students and should relate to what the students already know, and *Choice of representation* refers to the selection of resources to use in teaching (Rowland & Turner, 2017). The resources may be used in different ways; one of which might be as a representation to bridge the gap between the physical world and the abstract world of mathematics (Rowland et al., 2009). The two codes are so interlocked that it is difficult to discuss then separately; teacher demonstrates using representations which are the resources.

The observed student teachers: Job and Cain, used a lot of diagrammatic representations. In episode J.2.11, Job used the diagrammatic representation – blue and red counters - to demonstrate what ratio is. In other examples, in episode J.2.3, Job explained ascending and descending order using an example of the aeroplane going up after taking off (ascending) and going down when it is about to land (descending). He also used the two-way table which had modes of transport: walk, car and other, and students gender: boys and girls (episode J.2.1), which applies to students' daily lives when travelling to college. In flagship episode C.5, Cain is seen using a marked rectangle to demonstrate the multiplier when teaching *Percentage increase and decrease*. Students could clearly see the increase and decrease. Besides the diagrammatic representations and real-life examples, responding to a mathtask (Figure 3.1) about *Addition of fractions* reported in episode C.2.1, Cain wrote, "I would go for an adapted concrete, pictorial, abstract methods," meaning he would use concrete objects and pictures as well as abstract methods.

Unlike Cain, Job's explanation seems to be affected by the mode of teaching: online or face-to-face. In episode J.2.7, when explaining how he would teach solving an equation: *2x - 6 = 4*, Job explained, " [If online] To get rid of – 6 you do the opposite you plus 6. If in person [---] I will draw an arrow on the – 6 and move it over." It is not clear why Job would use different methods. I suspect it might be due to the technology involved when teaching online. Looking at solving *2x – 6 = 4*, I think Job did not know how to draw an arrow showing -6 moving to the other side while teaching online; therefore, he decided to use a method of adding 6 to both sides. Job treated teaching face-to-face differently from teaching online, hence his mentor advised him to be as enthusiastic when teaching online as when teaching face-to-face (episode J.6.1).

There are some areas where the student teachers need help with regard to teacher demonstration; for example, both student teachers: Job and Cain explanation was, at times, observed to be long, winding and often confusing. In episode C.2.2, Cain was seen explaining a question: 'A house has a value of £160 000 to 2 significant figures. Write down the least possible value of the house.' Cain got so mixed up that he gave up without an answer. During an interview reported in episode J.6.2, Job's mentor Alex said Job's students complained that he did not explain properly and was too fast. This was also noticed during lesson observations, I conducted. This area of development might be a result of problems of e-teaching as the observations were carried out when classrooms had shifted from physical to virtual.

Another area which needs development for the two student teachers observed was that their explanation was restricted to a single method in most cases. Looking at episode J.2.10 again, Job taught *HCF and LCM* using 'listing of factors and multiples' method when 'the factor tree' method could have been better, or he could have explained using the two methods and connected them. Cain was observed, on rare occasions using different methods but he did not connect them; for example, in flagship episode C.5, when teaching *Percentage increase and decrease*, he used the methods of finding the multiplier, and finding percentage increase or decrease then add to or subtract from the original. These two method were not connected.

The problem of ‘unclear explanation’ and ‘not connecting methods’ could be explained by the fact that student teachers in FE colleges (even qualified and experienced teachers) might not worry about using different methods and connecting them as the teaching time is limited (Noyes & Dalby, 2020) and there are institutional expectations of achieving a high pass rate.

Both Cain and Job used a lot of diagrammatic representations and examples about real-life and vocational areas of study to aid their explanations as most students studying mathematics in FE colleges have negative attitudes towards learning mathematics (Greatbatch & Tate, 2018). Rowland et al. (2009) and Barmby et al. (2013) are seen justifying the use of diagrammatic representations explaining that they are used to bridge the gap between the physical world and the abstract world of mathematics. Literature (for example, Rowland et al., 2009) says a lot about teacher demonstration and choice of representation, and a lot of examples of good practice are given. However, what is missing in literature (probably few sources are found) but mentioned in this study is FE mathematics student teachers’ inability to employ different methods of teacher demonstration and representations, and connect them.

Choice of examples

“Examples play an essential role in the teaching of concepts, in the teaching of procedures, and as exercises through which children [students in the FE context] become familiar with new ideas and fluent in the use and application of procedures” (Rowland et al., 2009, p. 99).

During an interview, Alex said when he was observing Job, he noticed that Job was not differentiating work for his students and this was set as a target (episode J.6.2). Job’ lessons I observed had evidence of differentiation; for example, in episode J.2.6 on *Substitution*. The questions Job gave his students were observed to be from easy to difficult; well differentiated to cater for different ability groups in his class. Giving differentiated examples for students shows a good *Choice of examples* as it ensures that each student is appropriately challenged. It should be mentioned that the interest in differentiation in FE might have come from results of the 2014 Office of Standards in Education (Ofsted) survey carried out in 20 FE colleges which reports that, “In weaker provision, areas for improvement were largely the reverse of the pedagogical strengths noted in stronger providers, with lessons poorly differentiated,” (Greatbatch & Tate, 2018, p. 35). FE colleges (and other educational institutions) have to always be prepared for Ofsted inspection, given the very serious consequences of an unfavourable Ofsted grade; therefore, Alex had to mentor Job on differentiation.

Apart from differentiation, Job's examples were also appropriate; for example, in episode J.1.4, Job gave his students questions on *Fractions of amounts*: $\frac{6}{10}$ of 60 and $\frac{2}{21}$ of 84. Using Job's method of 'divide by the denominator then multiply by the numerator,' student could understand the concepts without being overwhelmed by large numbers. On not so good *Choice of examples*, Job demonstrated place values using $3\underline{4}1$ (episode J.2.2). Job demonstrated using an example without decimals but he went on to give students an exercise with numbers with decimals; for example, $\underline{8}3.205$ (Figure 4.8). Another example of not so good *Choice of examples* was seen when Job was teaching expanding brackets (episode J.2.4), he wrote (x + 5) (3 + 6). This example might not be what Job intended to give as it is not a 'good' double bracket example. He might have used an example like (x + 5) (x – 3). When Job was teaching *Simplifying expressions* (episode J.2.5), he gave students an exercise to practice. The level of difficulty of the questions is not increasing progressively. Question 1: 4x + 3y -2x +6y has two letters: x and y which makes it more difficult than Question 2: 2y + 6y + 4y – 3y which has one letter. A student asked, "Why does equation 2 have the same letter?" Job answered, "You just work from left…." Job's answer was not relevant to the student comment and the question itself was not well thought of given that all other questions had two letters. As discussed in the *Foundation* section about terminology, Job mixed up expressions and equations and the student who asked used the term 'equation' instead of 'expression.'

On the other hand, Cain used a mixture of easy and difficult questions and there is no evidence of differentiation. He talked about using *Variation theory* during an interview (episode C.3.4) but examples used in the teaching seem not to show the 'variation.' Looking at episode C.1.3, it can be seen that the questions on *Division of fractions* were a mixture of easy and challenging ones. Also, Cain's questions were mostly unrelated and from different topics especially starters; for example, the starter in episode C.3.2 had six questions which were on *Parallel lines of a trapezium, Changing millilitres to litres, Changing fractions to percentages, Prime numbers, Edges of a pyramid* and *Interior angles of an octagon.* The starter in episode C.2.3 had four unrelated questions which were on *Fractions, Changing centimetres to metres, Multiplication* and *Decimals.*

Carefully looking at the student teachers' *Choice of examples*, it is worth getting some advice from Rowland et al., (2009) who say:

> Through consideration and careful examination of lessons taught by beginning teachers, we saw that it is not the case that any one example is as good as another. Indeed, the examples used in mathematics teaching should be chosen with care, keeping in mind their intended purpose, and the possible dimensions of variation within a particular example (p. 99).

The selection of examples in the teaching of mathematics in FE is not as straight forward as in schools. The time of teaching FE mathematics revision course is too short to cover all the GCSE topics in one year (Noyes & Dalby, 2020); this 'forces' teachers to give examples without careful thoughts as one has to cover as much ground as possible. The institutional expectations to have as many students as possible pass with a Grade 4 or above, justifying Job and Cain's use examination questions in all their lessons. Also, it might be expected that trainee teachers in a generic training environment might have limited exposure to 'good' mathematics examples. Another reason for lack of clarity in the selection of examples is that "…this crucial topic has been under-researched" (Rowland et al., 2009, p. 83).

While agreeing with literature on *Choice of examples* being affected by limited time for teaching the GCSE course in one year (Noyes & Dalby, 2020), this study goes further to point at institutional expectations as a major contributing factor to selection of examples.

(Mis)use of instructional materials

The instructional materials like posters are used to explain the reason for a concept/procedure; for example, to demonstrate why one tenth equals ten hundredths. Used correctly, instructional materials may help students understand the general principles of concepts (Weston et al., 2013); for example, equivalent fractions.

During e-teaching and e-learning, the student teachers used a lot of instructional materials in form of visual mediators. For example, in key episode J.5 when Job was teaching *Forming and solving equations*, he used a rectangle to demonstrate how to find the perimeter. Teaching the same topic, Job used a video to aid explaining forming and solving equations. In another example seen in episode J.2.11, while teaching *Ratio,* Job used pictorial representations of counters. When the students understood the concept of ratio, Job withdrew the pictorial representation (the scaffolds) and displayed a question: *Divide £40 in the ratio 2:3*. When Cain was teaching *Percentage increase and decrease*, he used mentimeter which is a software application where students can contribute, and the contributions are shared with other students without their names appearing (episode C.3.3). Cain's use of visual mediators while e-teaching was also mentioned by his mentor Julie in a report (Appendix

5) on a lesson she observed; part of the report reads, “Mentimeter worked well for the large numbers of learners involved in the group.”

Visual mediators in case of e-teaching and e-learning, are of greater importance when developing student basic skills in mathematics especially in FE where students have negative learning experiences of mathematics in the past, resulting in not having some of the ‘basic’ mathematics knowledge and skills that would be expected (Noyes & Dalby, 2020). Therefore, there is need to teach basic concepts and processes before progressing to other work to avoid over-reliance on memorisation of routines by students.

There is little research on COVID-19 triggered e-teaching and e-mentoring; therefore, studies on the use of visual mediators during online teaching and mentoring are still scarce, and this study could be credited for taking a step into studying this area.

4.3.1.3 Connection

Decision to sequence

Rowland, et al., (2009) explain *Decision to sequence* as to “[i]ntroduce ideas and strategies in an appropriately progressive order” (p. 37).

The observed student teachers’ lessons were not smooth flowing in most cases. The starters were not always related to the main components of the lessons, and the main components had unrelated parts. For example, in one of his lessons, Job’s starter was on *Area and circumference of a circle*, yet the lesson was on *Ratio* (episode J.3.4). In episode J.3.1, Job taught how to calculate area of rectangle, square, triangle, parallelogram and trapezium, giving the formulae without making any connections (or attempting to). In flagship episode C.5, Cain’s starter was on *Angles* but the lesson was on *Finding multipliers*. Besides concepts in a lesson not sequenced, Cain and Job’s lessons ended without recapping what would have been learnt; there were no conclusions or plenaries.

Rowland et al. (2009) give an example of good sequencing where a student teacher having taught the column method introduced the grid method by saying she would show the students a “[s]lightly different way of writing it down” (p. 121). The decision to sequence requires knowledge of the logical structure of mathematical content and how student learn (Rowland et al., 2009), and these skills might not have fully developed in student teachers. Another explanation might be that in FE it seems topics are introduced and taught in an unsystematic way as there are too many topics to teach in a short space of time to students who comes from different schools and with varied levels of mathematical knowledge. In this study, student teachers were observed not introducing concepts in an appropriately progressive order; therefore, it is recommended that student teachers be assisted in making connections. I consider *limited connections* as a need for student teacher.

Connection between concepts

When describing *Connection between concepts*, Weston et al., (2013) say this code is about whether a teacher makes instructional decisions with an awareness of connections across the domain of mathematics; mathematics is not, after all, a subject that contains discrete topics. This involves the teacher's ability to sequence experiences for pupils, anticipate what pupils will likely find 'hard' or 'easy' and understand typical misconceptions in a given topic (Weston et al., 2013). The teachers are advised to show relationships between parts (concepts) of a lesson when teaching.

In many instances, the student teachers were observed not connecting concepts; for example, in episode J.1.6, Job was seen teaching *Ratio* and *Fractions* with no connection made between the two concepts. Cain was observed teaching a lot of topics (concepts) in a single lesson without connecting them. In episode C.1.6, Cain was observed teaching *Volume of prisms* and *Volume of cylinders*, as unrelated topics. However, there were instances when the student teachers were observed connecting topics they were teaching. In flagship episode J.5, Job taught *Area and perimeter of shapes* and he connected what he called 'rules' of shapes to perimeter. He said, "A while ago you learnt rules of shapes like square all sides are equal, rectangle opposite sides are equal." In this instance, Job was seen connecting what students already know: 'rules' of shapes to the 'unknown': *Area and perimeter of shapes*. When Cain was teaching *Volume of prisms* (episode C.2.5), he reminded students about the formula for *Area of a triangle*. He then connected the *Area of triangle* (what students already knew) to *Volume of the prism* which he gave as *Volume of a prism = front area x length* (the unknown). Cain showed the importance of connecting concepts when he wrote that the purpose of the question about *Area of a circle* was to "[s]ee how students think and understand about the relationships between the dimensions of circles" (episode C.3.1).

The connection observed in the student teachers' lessons is what Rowland et al. (2009) mean by saying connection is the decisions about sequencing subjects or lessons, associating lessons with previous lessons and with students' knowledge. However, the connection of what students already know to 'new knowledge' might not be straight forward in FE as the mathematics course is a revision of what students would have been taught at school; therefore, they might know what would be taught. In terms of FE, it might be better explained as connecting what the teacher would have taught in previous lesson(s) to what s/he would be teaching.

There were some instances where student teachers showed no connection between concepts and some instances where the connection was visible but on the whole student teachers need support with *Connection between concepts*. Like this study, there are studies (for example, Campton & Stevenson, 2014) which report that student teachers have limited knowledge about sequencing and connectivity.

Connection between representations

As already mentioned earlier, representation may be described as a resource used to bridge the gap between the physical world and the abstract world of mathematics (Rowland et al., 2009). Rowland et al. (2009) suggest two questions that might be considered when selecting 'good' representations: Does this representation helpfully illustrate the concepts or procedures being taught? Do the students have the prerequisite knowledge and understanding to make use of this representation?

When Job introduced *Area and perimeter of the circle* in episode J.3.3, he explained parts of the circle separately using different diagrams (Figure 4.34). No connection was made between the parts of the circle, which were shown on different diagrams. It could have been more understandable had Job drawn all the parts of the circle on a single diagram and show connection between the parts; for example, radius and diameter, arc and circumference, chord and diameter, etc. However, the connection between radius and diameter was made later in the lesson when explaining the formula for *Area of a circle*, where he said, "You should half diameter to get radius," (episode J.1.3). In episode C.2.5, Cain was also seen not connecting representations; for example, when he taught *Volume of prisms* and *Volume of cylinders* no connection was made between the diagrams of prisms and cylinders.

Representations used in a lesson are expected to be connected; for example, symbols, images (pictures), language and contexts (concrete experiences) (Haylock, 1982). Job and Cain's limited ability to make connections between representations supports what is observed by Campton and Stevenson (2014) who say student teachers lack the knowledge to connect. The limited ability to make connections by mathematics student teachers in FE might be a result of shortage of time to teach all GCSE topics in one year as observed by Noyes and Dalby's (2020) or lack of experience as observed by Campton and Stevenson (2014).

Connection between procedures

When defining *Connection between procedures,* Rowland et al. (2009) explain that teacher's demonstration of procedures should not be disjoined when teaching the same concept.

Job connected the procedures of simplifying ratio and fractions by explaining that ratios can be simplified just like fractions by dividing each part by the highest common factor (episode J.3.2), but the concepts *Ratio* and *Fractions* were not connected as discussed during the *Connection between concepts* section. However, he could have made the connection more visible by writing the ratio and the fraction side by side and show the simplifying. Cain showed connection between procedures in episode C.3.5 where he was seen explaining how to change $5\frac{1}{3}$ into improper fraction. He explained $5\frac{1}{3}$ as being five lots of three thirds, and then add another third and get 16 thirds. He then explained the "[e]asier or quicker way of doing it, which is to do 5 times 3, so that is going to be 15 and add one that's 16 thirds." Cain could have made the connection more visible to the students by explaining how the two methods relate to each other. In episode C.2.5, when teaching *Volume of prisms*, a student asked Cain, "Do we half the base times height or we half after multiplying base x height x length?" Cain replied, "…. either way is correct." However, he could have gone further to explain the meaning of the two procedures: base x height x length divided by 2: $\frac{b\times h \times l}{2}$and base x height divided by 2 times length: $\frac{b \times h}{2}\text{x } l$. It seemed Cain did not see that base x height x length and divide by 2 gives the correct answer, but it is not consistent with the given formula, which is *Volume of a prism = area of front face x length*. He could have explained the two procedures showing the connections. There are some instances when the connections were clearly visible; for example, when Cain was teaching compound interest. He taught the multiplier method and the 'direct' methods by explaining and showing how the two methods are related (episode C.2.7).

In this study, student teachers were observed to be struggling with connection between concepts, connection between representation and connection between procedures. This was also observed by Campton and Stevenson (2014) who view being able to draw upon knowledge about sequencing and connectivity as something that student teachers may not easily do as they may have limited knowledge in these areas. Campton and Stevenson (2014) explain that an important part of mentoring involves mentors drawing student teachers' attention to links and encouraging them to make connections within their planning and teaching of mathematics. It seems connection is not something FE mathematics student teachers consider important as long as the syllabus is covered. The situation in FE seems to be summarised by Cain who said, "I am teaching a GCSE resit classes. I have to cover a lot of ground in one lesson."

Recognition of conceptual appropriateness and Anticipation of complexity

Recognition of conceptual appropriateness and *Anticipation of complexity* are where decisions will typically follow from a teacher's ability to anticipate what is complex and what is conceptually appropriate for an individual or group of pupils (Rowland et al., 2009).

Both student teachers observed teaching: Job and Cain were aware of the conceptual appropriateness of different topics. They taught parts of the circle before introducing *Area and circumference* as understanding of parts of the circle, especially radius and diameter, is a prerequisite for understanding area and circumference (episode C.1.5 b for Cain & episode J.1.3 for Job). The teaching of inequalities before *Averages from grouped data* (episode C.2.6) by Cain shows good recognition of conceptual appropriateness as the understanding of inequalities help students understand the concept of grouped data.

The student teachers, in most lessons, kept on warning students about difficulties they might face when answering certain questions; for example, in episode J.1.3, Job warned his students of the mistakes commonly made when calculating area of the circle using the formulae: $A = \pi r^2$, of squaring πr, instead of squaring r then multiply by π. In one of his lesson, Cain had a starter with 6 questions on different topics (Figure 4.51 in episode C.3.2), and students were working and giving answers in the chat. Then Cain called for attention and gave the answers briefly explaining. He explained two questions in detail. It is not clear why Cain selected the two questions; it might be taken as *Insight during instruction and/or Anticipation of complexity*. Another example of *Anticipation of complexity* is seen in episode C.2.9 when Cain gave a question: Simplify y x y x y and gave y^3 as the answer. He also explained that y + y + y = 3y. Students often confuse and mix up multiplication and addition in algebra. Cain and Job, kept on reminding students of the common pitfalls as the students would have failed to achieve a Grade 4 or above previously most likely by making the same errors.

Rowland et al. (2009) advise teachers to anticipate the complexities that can arise when introducing new topics; for example, a teacher should anticipate that students might add numerators and add denominators when teaching *Addition of fractions*, and this usually comes with experience. In this study, it appears that student teachers heeded this advice, as both recognition of conceptual appropriateness and anticipation of complexity were evident in their practice.

4.3.1.4 Contingency

Unlike *Foundation*, *Transformation* and *Connection*, there were some few instances observed which show the student teachers' contingency actions; therefore, this section is not organised into codes. It was difficult to see the student teacher's contingency actions during online teaching without access to the chat and students' contributions; this makes this section relatively shorter than the other sections.

As mentioned in the *Conceptual framework* chapter, *Contingency* is about the ability to 'think on one's feet.' It is about contingent action (Rowland & Turner, 2017); this involves the teacher's ability to make cogent, reasoned and well-informed responses to unanticipated and unplanned events (Rowland, 2013).

There is evidence from mathtasks responses that student teachers had some knowledge of deviating from the agenda in response to students' ideas and understanding. For example, in episode J.4.2, while responding to mathtask on *Addition of fraction* (Figure 3.1), Job said, "I will gauge students' reactions and decide whether or not they are understanding. If not, I clarify with another example with smaller denominators." Even though Job was responding to the mathtask his idea shows contingency action. In episode J.4.1, Job was teaching *Solving equation,* and he gave students an exercise to practice. He stopped the class to explain c + 2 = 10. It is not clear why he picked up this equation; probably it is teacher insight during instruction.

During interview (episode C.4.1) Cain explained that one of his students gave the answer to $\frac{1}{2}+\frac{1}{2}$ as $\frac{2}{4}$. Cain said he took time to explain that $\frac{1}{2}$ and $\frac{1}{2}$ cannot make $\frac{2}{4}$. Cain added that this was a 'classic' misconception. He said that he contemplated using a number line. This is an example of contingency where a student gave an incorrect answer, and the teacher took time to explain using different methods. Although, this was an interview question, it shows that Cain had an awareness of responding to student ideas. In another instance that can be seen as contingency action reported in episode C.4.2, Cain said that he had to use *autograph* when his students failed to understand finding the gradient of straight-line graphs: y = mx + c. Although this was during an interview, it shows responding to the availability of resources. Cain proved to have insight during instructions as he stopped to reflect-in-action and changed his method in response to students not understanding.

One of the codes of the *Contingency* dimension of the KQ is *Use of opportunities*. There were some cases where the student teachers missed the opportunities. In episode C.4.3, when students gave no answer to the question: ‘A map has a scale of 1: 10 000. How far away in reality are two points 4 cm apart on the map?’ Cain explained saying, “Multiply 100 000 by 4 and get 40 000 cm, then divide 40 000 by 100 and get 400 m.” While Cain explained the question correctly, he missed the opportunity of explaining the reason for dividing by 100. In another case, Cain missed an opportunity when he gave a question on subtraction of time (episode C.4.4, Figure 4.53, Question 2). Subtracting time is difficult as there are 60 minutes in one hour but most measurements like length are measured in multiples of 10, 100 and 1000; for example, 1 cm = 10mm; 1 m = 100 cm and 1 kg = 1000g. This was a missed opportunity to explain that unlike other measurements 1 hour = 60 minutes.

There were few instances of contingency action revealed by student teachers in teaching, during interview and responding to mathtasks; this can be explained using two reasons. Firstly, taking contingency action especially responding to student ideas, just like noticing (Jacobs et al., 2010) is acquired though experience. Flexibility of responses to learners is often cited as a mark of an experienced teacher, and student teachers are more likely to adhere to pre-planned lesson plans (Campton & Stevenson, 2014). The second reason which relates specifically to this study is that it was difficult to see the student teachers’ contingency action during online teaching especially when one has no access to the chat as was the case during the observed lessons.

In an attempt to bring the *Mathematical and pedagogical knowledge enacted by further education mathematics student teachers in teaching* to surface, student teacher needs, discussed in the next section, are identified. This is followed by discussing the role of mentoring in the student teachers’ mathematical and pedagogical knowledge development as seen by how mentors address the student teachers’ needs.

4.3.2 Student teacher needs

While discussing the student teacher needs, there is referring back to the *Mathematical and pedagogical knowledge enacted by further education student teachers in teaching* section. It is important to mention that data for this study were collected while teaching was online. However, it is likely that the needs identified during online teaching will still be relevant in face-to-face teaching.

The following student teacher needs are identified:

- gaps in subject knowledge
- relying on procedural explanations

- sticking to a single method
- unclear explanations
- limited connections between examples, between procedures and between representations
- limited theoretical underpinning of pedagogy
- *Improper use of terminology (and mathematical errors)*
- (over) relying on internet resources

Gaps in subject knowledge

It was observed that four (Job, Suzy, Mary and Kate) out of the five student teachers who participated in this study had gaps in mathematical subject knowledge at GCSE. It seems only Cain had strong subject knowledge, as few gaps were identified. During interview (episode J.6.6), Job said that he struggled with some topics especially algebra, and he sought help from Peter, who had more than 20 years experienced of teaching mathematics in FE. The lessons observed also show that Job struggled with working out mathematics questions; for example, he failed to work out 'expanding (x + 5) (3 + 6)' (episode J.2.4), and the question was not well thought of as well. In episode J.2.10, Job is seen failing to correctly calculate highest common factor (HCF) of 112 and 42, which he gave as 2 instead of 14. In one of his lessons, Job was observed mixing up 'equation' and 'expression' (episode J.1.2). While mixing up equations and expressions might be seen as improper use of terminology, it might also be seen as a gap in subject knowledge. Job's gaps in mathematics subject knowledge might be related to his mathematics studies; his highest qualification in mathematics was a Grade C (now Grade 4) at GCSE at the time of data collection.

When invited to work out a mathtask question: $\frac{5}{6}+\frac{3}{7}$ (Appendix 1), Kate's response did not show any mathematical subject knowledge but some general pedagogical knowledge (episode K.1). In fact, she did not work out the question; this brings some doubts into her ability to work out the question. To her own admission, Suzy said she had gaps in mathematical knowledge. During interview she explained that she drew bar charts with uneven gaps and the scale was not uniform (episode S.4). Mary made an error when working out a question on addition of fractions $\frac{5}{6}+\frac{3}{7}$ (episode M.1). While the error might be taken simply as carelessness or lack of attention to detail, it could also be taken as a gap in subject knowledge.

It might be assumed that mathematics student teachers (and qualified teachers as well) in secondary schools and FE colleges have the 'adequate' mathematical subject knowledge to teach at GCSE level. Rowland et al. (2005) observe an uninformed perspective that secondary (and FE) teachers already have mathematical knowledge needed for teaching, and elementary teachers need very little of it. However, the perspective happens to be untrue. The claim that mathematics teachers might not be having ‘adequate’ mathematical knowledge can be evidenced by the Government initiatives to enhance the mathematics subject knowledge of prospective and serving teachers under the funded scheme: *Subject Knowledge Enhancement (SKE)* courses (Department for Education, 2018). Greatbatch and Tate (2018) discover that “Education and Training Foundation (ETF) offers over 20 different courses to support effective teaching of English and mathematics for [FE] teachers of GCSE, functional skills….” (p. 36). Boli (2020) observes that training courses and educational projects to enhance subject knowledge for teachers and improve pedagogical approaches targeting FE students have been offered to FE institutions all over the country; this is an essential effort as a large proportion of the FE mathematics workforce is non-specialist (Noyes et al., 2018).

This study confirms what is in literature about student teachers’ gaps in mathematical subject knowledge but it seems the situation is different between secondary schools and FE colleges. Universities recruit candidates with mathematics degrees or degrees with a ‘strong’ mathematics component to train as secondary school mathematics teachers while in colleges not all mathematics teachers have degrees in mathematics or mathematics related fields or just a degree. In secondary schools mathematics student teachers achieve Postgraduate Certificate in Education (PGCE) while in FE the qualifications are many, different and often confusing (see Section 1.2.6). Looking at the qualifications on entry into ITE of the student teachers in FE, gaps in subject knowledge are expected. To make matters worse, the training is generic. How are these gaps addressed? It seems researchers and Government bodies give a blind eye to these problems which I try to address in this study.

Relying on procedural explanations

The student teachers were observed to be relying on procedures in their explanation in lessons and when responding to the mathtasks. In fact, all the five student teachers who participated in this study showed less explanation that aims at conceptual understanding: the explanations were mostly procedural. For example, in episode J.1.4, Job taught students to follow particular steps saying, “You always divide by the bottom number and multiply by the top number when working out fractions of amounts” (Figure 4.2). Also, in episode J.2.12, when explaining how to calculate area of a parallelogram (Figure 4.29), Job gave the formulae saying, “The formula is base times height.” He did not give any explanation that aims at conceptual understanding, which is making students understand the meaning or reason behind the formulae. In episode C.1.3, Cain explained dividing fractions using the mnemonic *Keep, Flip, Change (KFC),* without explaining the reason behind the mnemonic or justifying the procedure. When asked for the meaning of KFC during an interview, Cain admitted to not knowing the meaning. When responding to mathtask 1: *Addition of fractions* (Figure 3.1), Suzy explained how to work out the addition of fraction using clearly laid down steps – cross multiplying[30] (episode S.1). Responding to the same mathtask on *Addition of fractions*, Mary used the cross-multiplying method which is explained in episode M.1. Kate who also responded to the *Addition of fractions* mathtask did not work out the question but simply said she would work it out using different methods. It is not clear what Kate meant but the 'methods' might imply procedures.

Using procedural explanation without explanation that aims at conceptual understanding which was observed in this study is also discussed in literature. Ball (1990a) finds that student teachers had significant difficulties with the meaning of division by fractions; most could do the calculations, but their explanations were rule-bound with a reliance on memorizing rather than conceptual understanding. Livy (2012) says, "… studies suggest pre-service teachers rely on procedural methods" p. 479.

Literature and data show that student teachers in FE mostly rely on procedures when explaining. The procedural tendencies of FE mathematics student teachers could be explained using Noyes and Dalby's (2020) observation that FE mathematics teachers understand the need to develop students' mathematical skills, but they are constrained by the time as the one-year course is not enough to cover all the GCSE topics. It might also be explained using Rowland et al.'s, (2012) view that clinging to procedural approach shows insecurity about using more conceptually oriented approaches which shows some limitations in foundation knowledge. FE mathematics teachers, due to institutional expectations of high pass rate seems to follow Boli (2020) who says, "Memorizing mathematical facts and learning basic mathematical procedures seem to be considered the key tools [in FE] for passing the examination" (p. 2).

Sticking to one procedure/method

The two observed student teachers, Job and Cain were seen to be relying on one method or procedure to explain concepts in most instances in their lessons. When teaching *Solving equations*, Job used the 'what you do to the left do it to the right' method (episode J.2.7). During interview Job admitted to not knowing any other methods. Looking at episode J.2.10 when Job was teaching *HCF and LCM*, he used the listing of factors and multiples method only, yet other methods like writing a number as a

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[30] Cross-multiplying method is used to add and subtract fraction where the denominators multiply the numerators of the other fractions and denominators are multiplied; for example, $\frac{5}{6}+\frac{3}{7}=\frac{5X7}{6X7}+\frac{3X6}{7X6}=\frac{35}{42}+\frac{18}{42}=\frac{53}{42}=1\,\frac{11}{42}$

product of its prime factors using the factor trees could have been more effective as the numbers were too large for the method used; for examples, factors of 156 and multiples of 16. Also, Cain used one method in most of his lessons; for example, in episode C.1.4, when teaching *Percentage increase and decrease*, he used only one method which he taught using the procedure: change/original x 100. On rare occasions Cain and Job were observed using more than one method but without connecting them.

A study in a primary school by Livy (2010), also reported later during the *(Over) Relying on internet resources* section below, shows that student teachers do not use a range of strategies when completing mathematics problems. Recent research indicates that student teachers often restrict their explanations to a single method when teaching mathematics. These results seem to agree with results of this study which was conducted in FE where student teachers were observed to be restricting their explanation to a single method.

However, literature emphasise the importance of using various methods. The use of a single method is problematic because it limits students' opportunities to explore various problem-solving strategies, and can impede students' understanding and ability to apply mathematical concepts flexibly. Star (2021) emphases that teaching should involve multiple problem-solving paths rather than focusing solely on memorization or a single method. Star (2021) argues that comparing different methods side by side enhances students' understanding and engagement with the material. Similarly, Charalambous and Praetorius (2018) highlight that high-quality mathematics instruction involves the use of multiple strategies, as this approach supports deeper comprehension and critical thinking skills (Charalambous & Praetorius, 2018).

Studies about explanations using a variate of methods when teaching mathematics in FE seem to be elusive, and this study might be the first (or at least one of the first) to look into the issue. There might be many explanations for student teachers in FE sticking to one procedure; it seems the most obvious one is lack of enough time to explain using different methods as teachers in FE have to teach all (or most) of the GCSE topics within one year of at most 36 weeks. This might be the reason for being procedural, sticking to one method, and lack of connection.

Unclear explanation

The observed lessons show that Job and Cain were at time not clear in their explanations. In case of Job, the 'unclear explanation' was also observed by Alex, his mentor (episode J.6.2), who said that Job was going too fast in his explanation and his students complained that they did not understand him properly. In episode C.2.2, Cain was also observed going too fast and having long and winding explanations and he got mixed up. During one of the mentor meetings, Cain said, “I had an issue with pacing and questioning because I forgot what I wanted to do” (episode C.6.9).

The mathematics student teachers (and other mathematics teachers) in FE are overwhelmed by the amount of content they have to cover in just one year (which is 36 weeks with one lesson a week) (Noyes & Dalby, 2020) as mentioned several times in this section and elsewhere; this could be the cause of fast pacing which results in unclear explanation. The institutional expectations of high pass rate and the departmental prescribed lesson structure (remember the 5Rs in episode C.3.4) might be other reasons for fast explanations as the student teachers would not want to be blamed for ‘not doing enough’ which might carry the consequence of unfavourable mentor report send to the *Teacher Training Department.*

Limited connections

The area student teachers were struggling with mostly was connection between concepts, between procedures and between representations. Their lessons were not properly sequenced. While teaching *Simplifying ratios* (episode J.1.6), Job made reference to *Simplifying fractions* but the connection was not clear. He just mentioned that ratios can be simplified like fractions by dividing each part by the highest common factor. He could have juxtapositioned the ratio and fraction examples and work them showing the connection. Cain taught *Volume of prisms* and *Volume of cylinders*, as unrelated topics and no connection was made (episode C.1.6). Job and Cain taught a lot of unrelated topics in a single lesson without connecting them (or attempting to). In one lesson Job taught *Percentages, Rounding & Estimation* and *LCM & HCF* (see Section 4.2.1). In a single lesson, including the starter questions, Cain taught *Simplifying algebraic expressions, Percentages, Scale, Angles, Probability, Perimeter, Rounding, Angles on parallel lines,* and *Parts of a circle & Circumference*.

Studies in mathematics education (for example, Campton & Stevenson, 2014) report that student teachers have limited knowledge about sequencing and connectivity, and this is also reported in this study. It might be reasonable to suggest that student teachers in this study did not have the knowledge of structural connections within mathematics itself, and an awareness of the relative cognitive demands of different topics and tasks (Rowland et al., 2012), hence they taught unrelated topics and relied on procedures. In FE student teachers (in fact all teachers) are under pressure to make as many students as possible cross the pass line: getting a Grade 4 or above; therefore, there are institutional expectations and prescribed way of teaching which ‘force’ teachers to teach many unrelated topics in one lesson.

Limited theoretical underpinning of pedagogy

In an interview (episode J.6.4), I asked Job about what he learnt from other teachers and from theory lectures. Job seemed not to understand the second part of the question besides rephrasing it several times. He talked about copying his mentor Alex’s teaching styles. In his lessons and interviews there is no evidence to show any theory applied to his teaching. There is also no evidence to suggest that Suzy and Kate, according to their responses to mathtasks, had any idea about *Theoretical underpinning of pedagogy*. Cain had ideas of how to connect theory to his teaching as seen in interviews and mathtask response. He talked about theories like *Pedagogical Content Knowledge (PCK)* (episode C.1.7). Cain and Mary mentioned the common misconception of ‘add the tops, add the bottoms’ when adding fractions (episodes C.4.1 and M1 respectively). One explanation for Suzy, Kate and Job’s limited use of the *Theoretical underpinning of pedagog*y might be that during data collection there were in their first year of training; therefore, they might not have attended many theory lectures. Cain and Mary were in the second year of teacher education and were observed to be aware of *Theoretical underpinning of pedagogy.*

Rowland et al. (2009) say, “…it has been apparent that having the theoretical knowledge … influence classroom practice” (p. 57). Rowland et al. (2009) explain that among three teachers observed by one of their research colleagues, Fay Turner, one had started planning from her knowledge of *Gelman and Gallistel’s principle*[31] for counting, and this was apparent in her teaching. In this study, there is no evidence from Cain to suggest that theory influenced planning and teaching, but in his responses to mathtasks and interview questions (episode C.3.4), Cain mentioned *Cognitive conflict* and *PCK* (episode C.1.7).

Improper use of terminology (and mathematical errors)

Student teachers were observed using colloquial terms instead of mathematical terms; for example, in episode J.1.7, when teaching *Venn diagrams*, Job did not use any mathematical terms; he used terms like ‘in the middle’ instead of ‘intersection.’ Both Job and Cain used top and bottom instead of using numerator and denominator when teaching fractions (episode J.1.4 for Job; C.1.6 for Cain).

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[31] Gelman and Gallistel’s ‘how-to-count’ principles are a set of five principles that govern and define counting. These principles were first introduced in their 1978 paper, “The Child’s Understanding of Number.” https://www.bing.com/search?pglt=41&q=Gelman+and+Gallistel%E2%80%99s+prerequisites+for+counting&cvid=687dc0f5de2646b49b4e071d9a86ee36&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIFCAEQ6wfSAQgxNDMxajBqMagCALACAA&FORM=ANNTA1&PC=ACTS&showconv=1

Another issues, closely related to *Improper use of terminology*, which might be taken as a student teacher need is *Mathematical errors*. Job wrote 65% ÷ 100 = 0.65 (episode J.1.5). This is an incorrect way of presentation as 65% = 0.65, and 65% ÷ 100 = 0.0065.

One aspect of mathematical knowledge in teaching is a teacher's knowledge of mathematically correct terminology and notation (Ball et al., 2008; Rowland et al., 2009). This includes verbally using mathematically correct language as well as writing correct mathematical expressions (Weston, 2013). Besides the encouragement to use correct terminology from mathematics education researchers, the use of terminology is not seen as important by mentors and student teachers. The use of colloquial terms is acceptable and not challenged as long as students understand. The student teachers in FE are under pressure to teach a two-year syllabus in one year to unmotivated students; therefore, emphasising the use of correct terminology might be seen as an unnecessary burden. However, this is a need which has to be addressed by the mentors.

(Over) Relying on internet resources

Both Job and Cain were observed to be relying on internet resources, without checking the suitability and accuracy of the resources for their classes. Job had a worksheets on *HCF and LCM* with errors (episode J.2.10) while Cain used a diagram on *Volume of a prism* which had two 4s (Figure 62) which caused some confusion (episode C.2.5). Had the student teachers checked the internet resources, they could have spotted the errors. Most of the worksheets used during the lessons were pdf files snipped and pasted into PowerPoint presentations.

A study by Livy (2010), also reported earlier during the *Sticking to one procedure/method* section on *Pre-service Teacher's Primary Mathematical Content Knowledge*, concludes that student teachers rely on textbooks. Recent research by Morris and Hiebert (2017) supports Livy's findings, showing that despite efforts to broaden content knowledge through teacher preparation programs, many pre-service teachers still depend primarily on textbooks, which can limit their instructional adaptability. Although Livy's (2010) study, Morris and Hiebert's (2017) study, and my study were conducted in different contexts and years apart, their results are strikingly similar.

My study also shows that student teachers in FE, most likely due to lack of experience, tend to rely on internet resources and they have limited knowledge of interpreting the resources. The internet is full of resources and selecting the appropriate resources to use needs *Knowledge of Content and Students*

(KCS), Knowledge of Content and Teaching (KCT) and *Knowledge of Content and Curriculum (KCC)* (Ball et al., 2008) which might not have been fully developed in student teachers.

After identifying mathematical and pedagogical knowledge enacted by student teachers in teaching and the student teacher needs (RQ 1), the question which comes to mind is: How does mentoring assist in addressing the needs? (RQ 2). In the next section, I try to address the question.

4.3.3 How mentoring addresses student teacher needs

In this section, I report finding of how mentoring assists in the development of mathematical and pedagogical knowledge of mathematics student teachers as seen by how mentors address student teacher needs. I give an overview of the findings of the data collected during *Phase 1*. This section is a precursor to what follows in Chapter 5 (see Section 5.1).

According to this study, mentors take the role of formative support; they are not involved in the assessment of student teachers; however, their involvement is indirect as they submit reports to the *Teacher Training Departments* (see Appendix 6) who assess the student teachers based on the mentor reports, their own lesson observations and assignments. This is contrary to claims by Lawy and Tedder (2011) that there is a lack of clarity about the purpose and role of mentoring of student teachers in ITE in FE, either as a source of formative support or as a tool for the assessment of competence.

According to Alex, mentoring is restricted to generic issues like lesson pacing and differentiation, and not subject specific. However, Alex said he would discuss teaching specific topics if approached by the student teacher (episode J.6.2). During interview, Alex said his mentee Job's students complained that his explanation was not clear. Alex said he was working with Job on how to improve the explanation. He did not explain how; he evaded the question during interview. Alex also advised Job to be contingent: to 'think on his feet' instead of following his lesson plans and PowerPoint presentations even if things need to be changed (episode J.6.3). There were few instances when Alex was observed assisting Job on specific mathematical issues; for example, in (episode J.6.3) he advised Job to give students quadratic expressions which can be factorised.

Cain's mentor, Julie's mentoring was also generic but some mathematics specific issues were discussed. During one of the observed mentor meetings, Cain and Julie worked through mathematics questions and discussed how to teach specific topics; for example, *Perimeter of semi-circle* (episode

C.6.7). Julie also advised Cain on generic issues like questioning techniques and how to teach different ability groups.

Literature (for example, Maxwell, 2014; Lucas, et al., 2012), agrees with the findings of this study when saying ITE in FE is mostly generic; meaning it focuses on the application of generalised pedagogies which can operate across subject boundaries. The subject specialism relies on trainees' ability to contextualise their learning to their own specialism with the support of subject mentors (Lucas et al., 2012).

Use of technology in the classroom was also discussed during mentor meetings. Alex advised Job to practice technology before lessons, to give timely feedback using *Microsoft Forms* and to be as enthusiastic during online teaching as during face-to-face teaching. Suzy and Job said they were advised by their mentors on how to develop 'effective' PowerPoints with reduced animations and content. Cain's mentor did not offer any technological assistance; in fact, she praised Cain for his technological skills. The problem faced by mentors in trying to address student teachers' concerns about e-teaching was summed up by Alex who said, "The main problem is we [mentors] don't have answers to problems mentees bring about online teaching" (episode J.6.7). For some mentors, mentoring student teachers in the effective use of digital technologies in teaching and learning was quite challenging, particularly if the mentor feels under pressure 'to be the expert' but the mentee is more technologically literate than them (Hyde & Jones, 2014). According to data and literature (for example, Ersin & Atay, 2021), besides advising the student teachers on the use of technology, mentors agree learning from the student teachers.

Student teachers, besides learning from their mentors, also learn from different sources. Cain learnt teaching techniques from department meetings, observing more experienced teachers, informal encounters with colleagues, conferences, and Education and Training Foundation (ETF) training. Julie advised Cain to be reflective and learn from colleagues. Job learnt from experienced teachers, one advised him on resources and the other one helped him on subject content knowledge – informal mentors (episode J.6.6). Literature; for example, Surrette (2020) and data agree that student teachers learn from informal and formal mentors, training sessions and observing experienced teachers.

To sum up this section, mentoring in FE is mostly generic and is for formative support. Mentors assist student teachers on the use of technology and student teachers also learn from experienced teachers, their mentors and training. How mentoring assists in the development of mathematical and pedagogical knowledge of mathematics student teachers, as seen by how mentors address student teacher needs, is further investigated in *Phase 2.* The results of analysis of the data collected during *Phase 1* and *Phase 2* are reported in much detail in Chapter 5 (see Section 5.1).

4.3.4 Institutional issues that could influence mentoring in FE

There are some issues which could not be categorised under the KQ dimensions but are of important to mentoring. These issues are about the mathematical and pedagogical knowledge development of student teachers but also cover wider institutional issues that are seen as having the potential of influencing mentoring practices. I refer to these as *Institutional issues* because they can be influenced by colleges, educational policies, and the Further Education (FE) curriculum. In this section, which is a precursor to what follows in Chapter 5 (see Section 5.2), I outline the *Institutional issues*.

Mentors view a *Mentoring structure* as a need which has to be put in place for mentoring to be effective. Due to time restrictions and haphazard mentoring, mentors and student teachers hold formal and informal meetings unsystematically and at random, hence the call for a structure. In one instance, student teacher Job complained that he did not get any help from the mentor when he needed it most due to lack of time available for mentoring. He said, “If I had a question, it was difficult to get help” (episode J.6.5). Cain’s mentor, Julie said there is need for a flexible mentoring structure (episode C.6.11), and Alex concurred when he said there should be mentoring timetables for mentors and student teachers which are flexible so that they can be put aside if there are ‘pressing’ issues (episode J.6.8). There is a lot of literature (for example, Boodt et al., 2021) that support mentoring structure.

Julie attended a training session run by ETF and she advocated for *Mentor training* (episode C.6.11). When discussing how to improve mentoring, Julie said every mentor should be offered training. Alex did not mention mentor training, after being asked during interview how mentoring could improve in FE. Literature (for example, Hobson, 2016; Villar & Strong ,2007) argues for mentor training.

Student teachers are observed to be *Teaching for examinations*. As a result of departmental specifications, student teachers’ lessons (and other teachers) follow specific steps (though different from college to college), which include examination type questions. Cain’s college follows the *5Rs* (episode C.3.4) where the last *R* is *Ready for examinations*; this is when students practice examination type questions. During interview, the student teachers said they teach for examinations as their aim is to assist students achieve a pass grade. Researchers like Noyes and Dalby (2020) give 'lack of enough time' to teach for conceptual understanding as the reason for teaching for examinations.

Student teachers, Job and Cain, were also observed to be *Contextualising mathematics to vocational courses and life experiences*. When asked during interview, Job said he used examples which are related to students vocation area of study and real life (episode J.2.13). Also, responding to the *Addition of fractions* mathtask (Figure 3.1), Job wrote, "I would ensure to explain with real life examples such as fractions of a pizza to help them [students] visualize why they have to find a common denominator." Cain though did not specifically mention relating to real life and vocational courses, his examples referred to real life; for example, the question: 'The probability that a new fridge has a fault is 0.015. What is the probability that a new fridge has no fault?' Student teachers were observed connecting teaching of mathematics to vocational courses and real-life experiences as this highlights the 'user-value' of mathematics (Noyes & Dalby, 2020).

The institutional issues: *Mentoring structure, Training of mentors, Teaching for examinations,* and *Contextualising mathematics to vocational courses and life experiences* are further investigated in *Phase 2.* The results of analysis of the data collected during *Phase 1* and *Phase 2* is reported in much detail in Chapter 5 (see Section 5.2).

4.4 Conclusion

Chapter 4 is divided into two sections: A and B. In Section A, I presented the data collected during *Phase 1* using mathtasks, lesson observations, mentor meeting observations, interviews with mentors, interviews with student teachers and documents in form of mentor reports. The data were presented in form of episodes selected according to how they show student teachers' mathematical and pedagogical knowledge enacted during teaching, student teacher needs, and the role of mentoring in the development of mathematical and pedagogical knowledge of mathematics student teachers as seen by how mentoring addresses the student teacher needs. In fact, this presentation of data could be taken as the initial analysis. The data were categorised using the KQ dimensions: *Foundation, Transformation, Connection* and *Contingency*.

In Section B, the data were analysed and discussed, and student teachers' mathematical and pedagogical knowledge enacted during teaching was brought to surface. Also, student teacher needs were identified. The role of mentoring in the development of mathematical and pedagogical knowledge of mathematics student teachers as seen by how mentoring addresses the student teacher needs was also brought to surface. Also institutional issues that have the potential of influencing mentoring, emerged.

To get deeper insight into *The role of mentoring* and *Institutional issues*, I had the opportunity to investigate them further. More data were collected from mentors using anonymised questionnaire and follow up interviews during *Phase 2*. The data were thematically analysed and reported in Chapter 5.

5 The role of mentoring in the mathematical and pedagogical knowledge development of mathematics student teachers in FE

5.0 Introduction

In Chapter 4, the analysis of the data collected during *Phase 1* brought to surface *The mathematical and pedagogical knowledge enacted by Further Education (FE) mathematics student teachers in teaching*, and *Student teacher needs* were identified (research question 1) as seen through the lenses of the Knowledge Quartet (KQ). The role of mentoring in the student teachers' mathematical and pedagogical knowledge development as seen by *How mentoring addresses the student teacher needs* was explored, and *Institutional issues which have the potential of influencing mentoring* emerged (research question 2).

During Phase 2, *How mentoring addresses student teacher needs* and *Institutional issues which have the potential of influencing mentoring* (research question 2) were further investigated. *Challenges faced and lessons learnt during e-mentoring mathematics student teachers in FE during the Covid-19 lockdowns* were also investigated (research question 3). Ten mentors responded to an anonymous questionnaire and seven out of the ten were interviewed. The questionnaire responses and the interview transcripts were thematically analysed. These findings were already reported in Chapter 4; therefore, in this chapter I revisit and expand already reported findings. In other words, the *Phase 2* findings together with *Phase 1* findings are reported in this chapter. The data also brings to surface *Challenges faced and lessons learnt during e-mentoring mathematics student teachers in FE during the COVID-19 lockdowns*. This chapter is organised into three broad sections:

- How mentoring addresses student teacher needs (Revisiting)
- Institutional issues that have the potential of influencing mentoring (Revisiting)
- Challenges faced – and lessons learnt – during e-mentoring mathematics student teachers in FE during the COVID-19 lockdowns

Before concluding this chapter, a mentoring model which is seen as having the potential of assisting the development of mathematical and pedagogical knowledge of mathematics student teachers in FE is proposed, and how the model is related to well established models is discussed.

5.1 How mentoring addresses student teacher needs (Revisited)

Data collected during *Phase 1* (reported in Section 4.3.3) show that mentoring in FE is mostly generic; some mathematics specific support offered to student teachers were observed. Mentoring is for formative support. Mentors assist student teachers with the use of technology. Besides learning from their mentors, student teachers also learn from other experienced teachers. In an attempt to find out more about the role of mentoring in the development of mathematical and pedagogical knowledge of mathematics student teachers as seen by how mentoring addresses student teacher needs, data were collected from mentors using a questionnaire and interviews during *Phase 2* of the study, and analysed using thematic analysis (Braun & Clarke, 2006). Preliminary results of the analysis of *How mentoring addresses student teacher needs* were presented at the British Society for Research into Learning Mathematics (BSRLM) conference and published in Machino (2021).

The themes that emerge from the analysis of data collected during *Phase 1* and *Phase 2* are discussed in this section, where I highlight how the themes could be understood in terms of theories of mentoring: *Learning by reflecting* and *Learning through apprenticeship* (Cain, 2009), which are discussed in the *Conceptual Framework* chapter (see Section 2.3.4). As the theoretical framework guiding this study is the Knowledge Quartet (KQ) (Rowland et al., 2009), which is also discussed in the *Conceptual Framework* chapter (see Section 2.2.2.8), I discuss how the themes could be linked to the KQ dimensions and corresponding codes. I also highlight the specific student teacher needs different themes attempt to address.

The themes discussed are:

- Doing Mathematics
- Observing (and Learning from) Experienced Teachers
- Teaching Mathematics
    - General teaching of mathematics
    - Teaching specific mathematics topics
    - *Attending to mathematical errors*

5.1.1 Doing mathematics

While mathematics student teachers are expected to have ‘adequate’ subject knowledge, this is not always the case as observed by Rowland et al. (2005). It seems there is no Government policy on who is responsible for the subject knowledge development of student teachers in the generic Initial

Teacher Education (ITE) environment in the Further Education and Training sector (FE). Responsibility of the development of subject knowledge of student teachers ends up in the hands of the mentors.

Mentors say they would enhance student teachers' mathematics content knowledge by asking the student teachers to work (or work with them) through mathematics questions, which is 'doing mathematics.' I present two episodes which illustrate the theme.

Episode 1: Working through past examination paper questions

An extract from a mentor meeting I observed showing Cain (student teacher) and Julie (mentor) working through mathematics questions:

> **Julie**: We also have hiccups when we do things for the first time. Functional Skills when we went for reform [which is change of examining board] in 2019. There were no examples of things they put in the syllabus. No exam questions or anything. This made it very difficult. [.....]. Next year it will be fine. You will be used to the changes of syllabus, as there will be change of examining boards.
> **Cain:** I saw the AQA[32] Functional Skills paper. It is easy. Let me share the screen.

Cain shared the screen and scrolled through the AQA paper. Both showed interest commenting on the questions. Cain stopped at a question (Figure 5.1) he showed interest at and worked through it. He used a calculator and they discussed each step. He got the answer which is 19.09.

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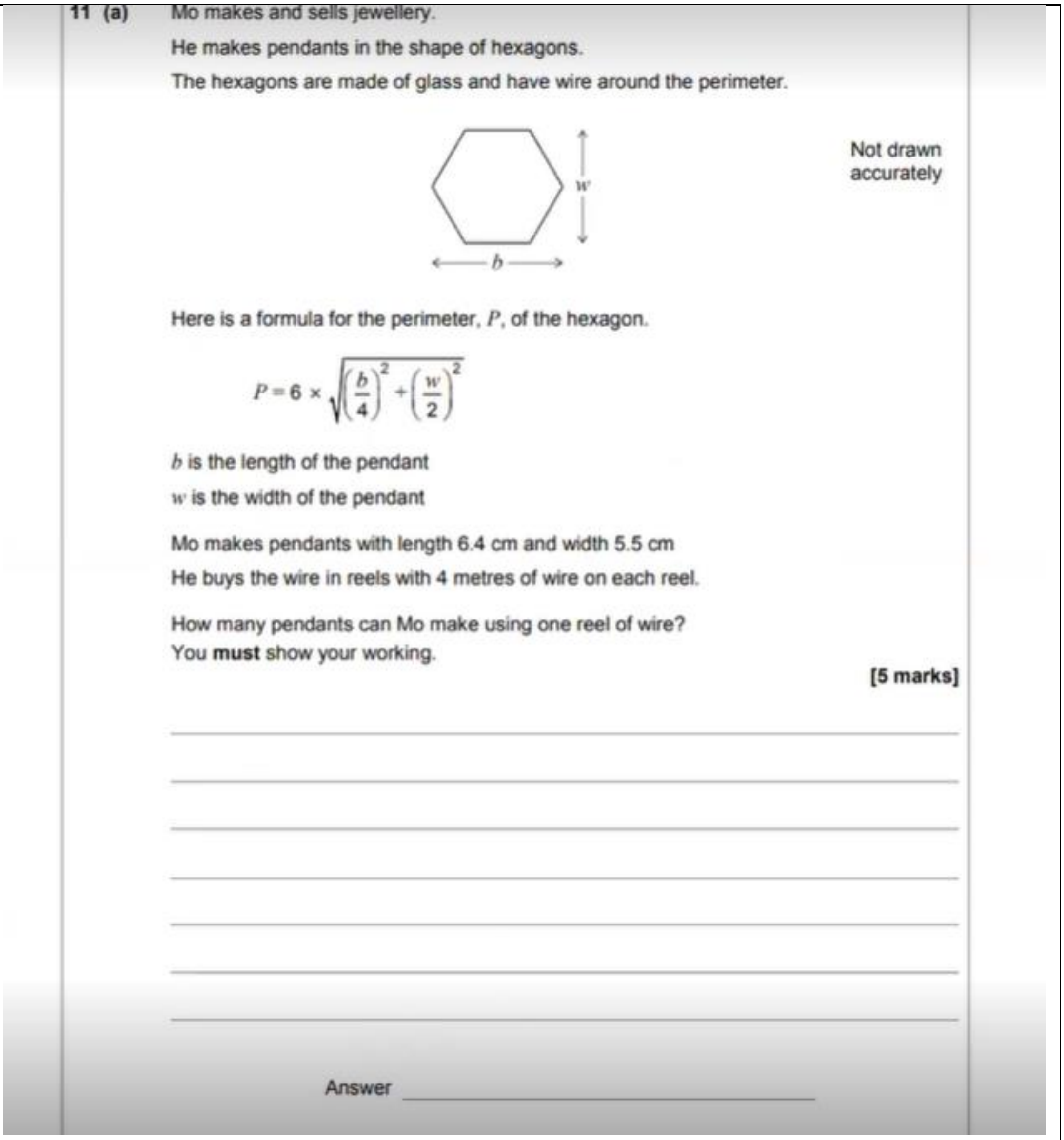
[32] AQA, the Assessment and Qualifications Alliance, is an awarding body in England, Wales and Northern Ireland. It compiles specifications and holds examinations in various subjects at GCSE, AS and A Level and offers vocational qualifications. AQA is a registered charity and independent of the government. However, its qualifications and exam syllabi are regulated by the Government ...(https://www.aqa.org.uk)



11 (a) Mo makes and sells jewellery.

He makes pendants in the shape of hexagons.

The hexagons are made of glass and have wire around the perimeter.

Not drawn accurately

Here is a formula for the perimeter, P, of the hexagon.

$$P = 6 \times \sqrt{\left(\frac{b}{4}\right)^2 + \left(\frac{w}{2}\right)^2}$$

b is the length of the pendant

w is the width of the pendant

Mo makes pendants with length 6.4 cm and width 5.5 cm

He buys the wire in reels with 4 metres of wire on each reel.

How many pendants can Mo make using one reel of wire?

You **must** show your working.

[5 marks]

Answer ______________________

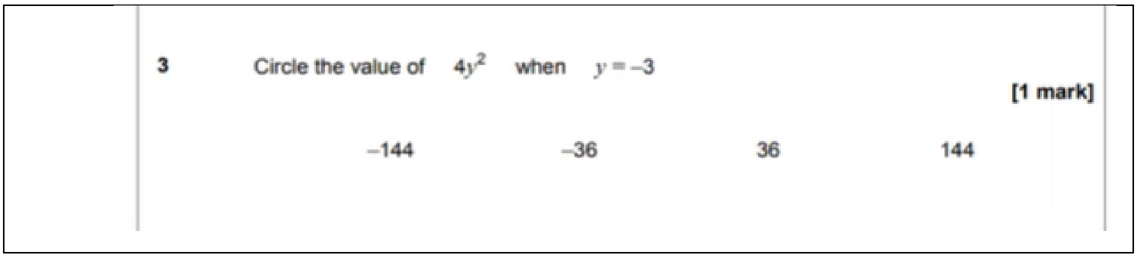
Figure 5.1 A question worked by Cain during mentor meeting

They checked the answer with the marking scheme; it was correct.

Julie: I want to go on site, but I have two students who want online.

Cain: That’s what AQA papers look like when you do Functional Skills.

Julie (working through a question: Figure 5.2); Minus three squared gives us 9, and 4 times 9 is 36.



3 Circle the value of $4y^2$ when $y = -3$

[1 mark]

−144 −36 36 144

Figure 5.2 A question worked by Julie during mentor meeting.

Episode 2: Assisting a student teacher working through a Venn diagram question

During an interview, Paul said he actually works through mathematics questions with the student teachers the way he works with the students. He gave an example of how he worked a *Venn diagram* question (Figure 5.3) with a student teacher who was struggling with the question.

50 people were surveyed. 30 have a brother. 25 have a sister. 6 have neither a brother nor a sister. Use this information to complete the Venn Diagram

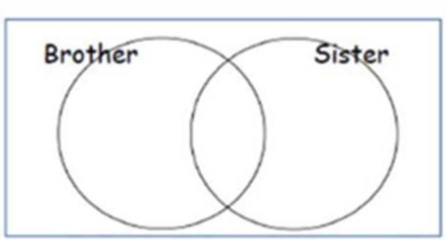


Figure 5.3 Paul's question on Venn diagram

Paul said he put the question in the chat and worked it with the student teacher. He also shared the question with me through the chat. He explained that “30 + 25 + 6 gives 61. Then 61 – 50 = 11. So, 11 goes into the middle.” I asked Paul whether he could consider using the algebraic method of writing an unknown; for example, x at the intersection and form an equation, which is $30 – x + x + 25 -x + 6 = 50$. Solving the equation gives $x = 11$. Paul said, “I have never used that. To throw algebra makes it more complex.”

Closely looking at episode 1, Cain is leading while Julie is following. It is not clear why Julie talked about going on site. Probably she wanted to move away from the paper while Cain was enthusiastic about working through the questions in the paper. In episode 2, Paul is seen explaining how he worked a question with a student teacher. Paul seems to rule out using different methods. While Paul might want to avoid ‘the complexity’ by not using the algebraic method, he might have been restricting his student teachers (and his own students) to only one method.

Discussing the issue of working through mathematics questions, Judy said she advises her student teachers, “[t]o work out the questions they would be teaching and to always be two weeks in working through the questions ahead of the topic they are teaching, and to practice the questions again immediately before the lesson.” Esther said she would ask the student teachers to do ‘homework’ on a topic before teaching it. M16[33]’s response to a question on how to assist the student teacher who gave the wrong formulae for *Area of circle* (Figure 3.4) reads, “Before teaching this question the [student] teacher would need to have covered *Area of a circle* and *Area of part of a circle*.” M20 agreed with Judy, Esther and M16 by writing, “Always work through examples before you complete them in class.”

Martin and Darren said they work through mathematics questions with the student teachers explaining how to teach the questions discussing any misconceptions. When explaining how he would assist a student teacher struggling with the mathematics, Don said:

> Difficult, difficult situation again because, again, confidence. If you are confident in your subject that you're teaching, teaching is still can be difficult, but it's even more difficult if you're not confident in the subject that you're trying to teach.

Don said he worked questions with the student teachers starting with the easy questions or topics. He said he would make mistakes deliberately so that the student teachers could spot the mistakes, and this would boost their confidence.

Giving another example, Paul said he identified through lesson observation that one of his student teachers was struggling with finding the centre of enlargement (Figure 5.4) by drawing lines from the vertices, when teaching *Transformations*. Paul said he demonstrated how to find the *Centre of Enlargement*, and asked the student teacher to go and study the topic.

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[33] Mentors who responded to the anonymous questionnaires were assigned code names: M13, M14. M15----.

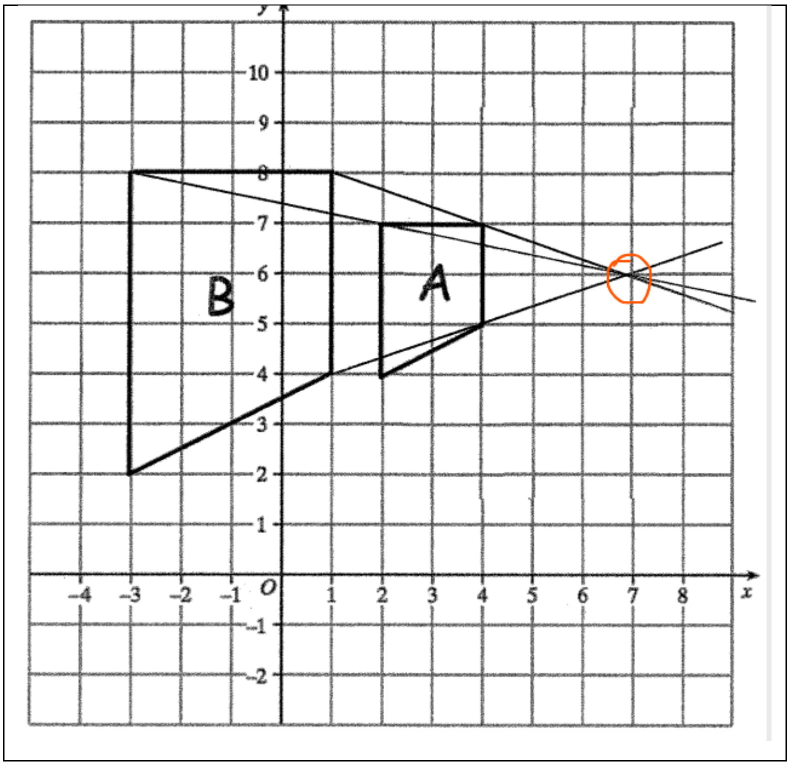

Figure 5.4 An example of a question on finding Centre of Enlargement

Paul said he made a follow up to see whether the student teacher had studied the topic but he did not explain how he followed up.

During another mentor meeting, without being asked, Cain enthusiastically explained one of his lessons. He said he taught *Interest using excel*. Julie said she was not confident with excel and wanted to learn more about it. Cain displayed an excel spreadsheet (Figure 5.5) and explained how he used excel in one of his lessons.

Start amount	Interest	Interest amount	End amount
£4,000.00	4.00%	£ 160.00	£4,160.00
£4,160.00	4.00%	£ 166.40	£4,326.40
£4,326.40	4.00%	£ 173.06	£4,499.46
£4,499.46	4.00%	£ 179.98	£4,679.43
£4,679.43	4.00%	£ 187.18	£4,866.61
£4,866.61	4.00%	£ 194.66	£5,061.28
£5,061.28	4.00%	£ 202.45	£5,263.73
£5,263.73	4.00%	£ 210.55	£5,474.28
£5,474.28	4.00%	£ 218.97	£5,693.25
£5,693.25	4.00%	£ 227.73	£5,920.98
£5,920.98	4.00%	£ 236.84	£6,157.82
£6,157.82	4.00%	£ 246.31	£6,404.13
£6,404.13	4.00%	£ 256.17	£6,660.29
£6,660.29	4.00%	£ 266.41	£6,926.71

Figure 5.5 Cain's demonstration on Using excel during mentor meeting.

Julie said, “You gave them life skills.” Again, as in episode 1, Cain was leading the working while Julie was following,

The mentors’ practices can be analysed through the theoretical lenses of *Learning through apprenticeship* and *Learning by reflecting*, as articulated by Cain (2009). *Learning through apprenticeship*, is evident when mentors work through mathematics questions alongside student teachers. This is observed in the practices of Paul, Martin, and Darren, which involve mentors modelling problem-solving strategies and pedagogical approaches, thus scaffolding the student teachers' learning process. *Learning by reflecting* aligns with Schön's reflective practitioner model, which emphasizes the importance of reflection-in-action and reflection-on-action. This is observed when Judy, Esther, M16, and M20 encouraged their student teachers to work through mathematics questions independently before teaching the questions. This practice allows student teachers to critically analyze and refine their instructional strategies. Working through mathematics questions could be mentor-led as in the case of Paul; it could also be student teacher-led as in the case of Julie and Cain. In mentor-led the focus is on direct guidance and feedback. In student teacher-led, emphases is on autonomous practice and self-directed learning, thereby reinforcing the principles of reflective practice.

Working through mathematics questions with the student teacher is supported by Feiman-Nemser and Parker (1990), who say it became apparent that *Doing mathematics* with the mentee is a way of making subject matter a part of the conversation in learning to teach. This study advocates for addressing student teacher needs related to subject matter knowledge by working through mathematics questions with the student teacher as mentioned by Feiman-Nemser and Parker (1990). *Doing mathematics* is not merely about mastering content but about understanding how to teach that content effectively, thus linking subject knowledge with pedagogical practice.

Doing mathematics is related to the *Overt subject knowledge* code of the KQ's *Foundation* dimension. The primary objective of engaging student teachers in solving mathematics problems is to deepen their understanding of mathematical concepts, thereby enhancing both the student teachers and the mentors’ subject knowledge. This process of engagement with mathematical tasks is essential for developing a strong foundation in mathematics, which is crucial for effective teaching. Unlike other themes that may focus on addressing a broad range of student teacher needs, this theme is specifically designed to address the *Gaps in subject knowledge* need. Mentors play a vital role in this process by actively participating in mathematical problem-solving activities alongside student teachers. This collaborative approach not only reinforces the student teachers' grasp of mathematical concepts but also allows mentors to model effective problem-solving strategies and teaching techniques. Through this shared experience of *Doing mathematics*, both mentors and student teachers can develop a deeper, understanding of the subject, ultimately leading to more effective teaching practices in the classroom. Therefore, it is highly recommended that mentors actively support the mathematical knowledge development of student teachers by engaging with them in solving mathematical problems. This hands-on approach not only strengthens the student teachers' content knowledge but also fosters a collaborative learning environment that benefits both the student teachers and the mentors.

5.1.2 Observing (and learning from) experienced teachers

Student teachers learn how to teach from their mentors and other experienced teachers during formal and informal encounters. Episode 3 and Episode 4 introduce and illustrate this theme.

Episode 3: Getting help from experienced teachers (informal mentors)

As reported in episode J.6.15 in *Chapter 4*, Job said he got help from experience teachers. I asked him how he selected the teachers and what help he received. He had the following to say:

> We were in the same team room. Mariam [pseudonym] [an experienced FE mathematics teacher] was very approachable. She put me under her wings. Whenever, I had a question she answered. If I had a resource from the internet, she helped me improve on it. If I had a gap in subject knowledge, especially in algebra, I would go to Peter [pseudonym] [another experienced FE mathematics teacher].

Episode 4: Observing an experienced teacher's lesson on Solving quadratic equations

As reported in episode C.6.4 in *Chapter 4*, what follows is a conversation captured during an online mentor meeting between Julie (mentor) and Cain (student teacher):

> **Julie**: What progress have you made so far?
>
> **Cain**: I watched a video from an online lessons when Max [pseudonym] [an experienced teacher] was teaching *Solving quadratic equations* using the formula [$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$] and one of the equations had a negative square root [the discriminant: $b^2 - 4ac$ was negative].
>
> **Julie**: What did you learn? What can you reflect and apply in your sessions?
>
> **Cain**: I have developed pedagogically, and I was able to see that Max included perfect square.

> If the square root [of the discriminant] is negative, it doesn't factorize. Perfect squares were included in the lesson.
>
> **Julie**: What did you benefit from watching maths, which is higher than what we deliver, which is what you like? If you don't understand the maths a visual representation will be helpful.

From the Episodes 3 and 4, it is seen that student teachers' learning to teach is influenced by experienced teachers through formal and informal mentoring. Formal mentoring involves actively assisting student teachers through direct or indirect guidance, often by assigning specific tasks to help them develop their teaching skills (Ambrosetti & Dekkers, 2010). In contrast, informal mentoring occurs when student teachers independently seek assistance or advice without the structured involvement of a mentor (Ingersoll & Strong, 2011; Hobson, et, al., 2009). Informal encounters were observed when Job had his resources 'checked' by Mariam, and when Peter assisted him developing his subject knowledge. Formal encounters were observed when Cain observed Max, and Julie encouraging Cain to reflect and apply what he learns to his lessons. It seems Julie is more interested in what Cain learnt, which is applicable to General Certificate of Secondary Education (GCSE) Foundation level[34], while Cain is enthusiastic about GCSE Higher level mathematics which Julie seems not to follow or understand. It's not clear where 'the visual representation' is coming from, probably to deviate Cain from talking about the higher-level mathematics and bring him to foundation level.

Most mentors said they ask student teachers to observe them (mentors) and other experienced teachers teaching the topics which they find difficult to teach or/and had gaps in mathematical content knowledge. Mentor Martin said student teachers should start by shadowing their mentors and other experienced teachers and gradually get into full teaching. Don said, "I would advise the student teacher to research into the topic before teaching. May be [-----] watch others teach the topic." Esther, discussing the student teacher whose teaching had errors said, "I would invite him or her to observe me teaching the topic…."

Discussing the advantages of observing experienced teachers, Judy said, "Student teachers come with their own methods. Some are traditionalists who use the traditional methods[35]." After prompting her to give an example of 'traditional' and 'modern' methods, she said in multiplication, some student

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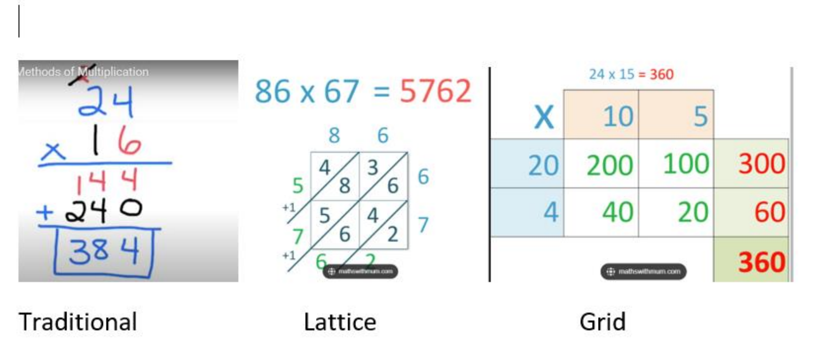
[34] GCSE Mathematics is taught at two tiers/levels: Foundation and Higher. College students usually study the Foundation tier; however, there are a few students who opt for the Higher tier.

[35] In the English context, the column method of multiplication is often referred to as the traditional method (which is also referred to as the conventional methods) while the grid and the Lattice methods are referred to as modern methods.

teachers use the column methods (traditional) they learnt at school and they could learn other methods like the grid and Lattice methods (modern) (Figure 5.6) from observing their mentors and other experienced teachers, but she gave a cautious statement, “One has to be flexible in terms of methods.”



Traditional Lattice Grid

Figure 5.6 Multiplication methods

The theme *Observing (and learning from) experienced teachers* can be interpreted through the lens of *Learning through apprenticeship* (Cain, 2009). This approach, rooted in Lave and Wenger's theory of *Situated learning,* posits that learning occurs through participation in a *Community of Practice (CoP),* where novices acquire skills by engaging with and emulating experts (Lave & Wenger, 1991). In this context, student teachers learn by observing mentors and more experienced teachers, imitating their teaching practices, and internalizing the pedagogical strategies demonstrated. The mentor, acting as a central agent, facilitates the trainee’s professional development (Cain, 2009). The theory of *Situated learning* is evidenced by the practices of mentors such as Martin, Don, Esther, and Judy, who encouraged their student teachers to observe and learn from them and other experienced teachers. This is a mentoring strategy where student teachers gain access to the craft knowledge of experienced teachers (Brown & McIntyre, 1993). Julie's encouragement for Cain to reflect on his observations of other teachers and apply this reflective insight to his own teaching exemplifies Schön's model of *Learning through reflection-in-action* and *reflection-on-action* (Schön, 1983).

What was observed in this study was also observed by Cain (2009) and Hobson (2002) who say student teachers learn by imitating their mentors’ teaching practices, and the mentor is a major agent for the trainee’s development: advising, directing and offering ‘practical tips’. Norley (2017) encourages student teachers to observe other teachers teaching mathematics to a variety of classes, to students on a range of vocational programmes across the college. Hobson (2002) observes that student teachers appreciate observing their mentors teaching due to the practical ideas they could show. This study agrees with literature that learning to teach is influenced by experienced teachers (including mentors).

The theme *Observing (and learning from) experienced teachers* plays a crucial role in the development of student teachers, touching upon all the KQ dimensions: *Foundation, Transformation, Connection, and Contingency*. By closely observing seasoned educators, student teachers gain valuable insights and practical knowledge that contribute to their development in every aspect of teaching. Student teachers build a strong *Foundation* by observing best practices. This foundational learning helps student teachers understand the essential components of effective teaching and prepares them for their own classroom experiences. The process of observing experienced teachers also fosters *Transformation*. Student teachers witness how theoretical concepts, taught in theory lectures, are applied in classroom settings. Through observation, the *Limited connections* student teacher need is addressed as student teachers learn how to connect concepts, procedures and representations within a lesson. Observing experienced teachers also prepares student teachers to handle the unexpected challenges of the classroom. They learn how to adapt to different situations, manage diverse student needs, and respond to unforeseen issues, which are all critical skills for any effective teacher. In the context of Initial Teacher Education (ITE) in Further Education (FE), and even within school settings, student teachers often look up to their mentors and other experienced teachers for guidance on various issues they encounter.

5.1.3 Teaching mathematics

Looking at the data and literature, it is recommended that mentors assist student teachers in teaching mathematics in three areas: *General issues in teaching mathematics; Teaching specific mathematics topics;* and *Attending to mathematical errors.*

5.1.3.1 General issues in teaching mathematics

Mentors and student teachers discuss general issues in teaching mathematics. The following episodes introduce and illustrate the theme.

Episode 5: Discussion on how to address students' misconceptions

What follows is a conversation I (Researcher) had with Martin, a mentor and manager in the mathematics department, regarding general issues in teaching mathematics:

> **Researcher:** Yeah, OK, so with your experience, have you ever met a student teacher who actually struggled, who actually struggled…..

> **Martin**: Yeah, I've done it with some. Um, what? Um, I can't remember the type of questions. But yeah, quite a few years ago I did sit them and we did look at common misconceptions of questions. So, I had a range of questions that I used with my own students that I was suggesting that they use with their students. But we had that opportunity before they went in and delivered that material to look at why they might be making misconception.
>
> **Researcher:** (nodding as a sign of saying continue).
>
> **Martin**: You know there's many teachers that will just say like the teacher in this case might have said no Georgia [pseudonym], completely wrong. It should be like this. Whereas maybe explore why Georgia said that, why there are differences. You know and you can do that with the person that you're mentoring and make sure you know you're doing it by best practise. You're saying to them, let's have a look at this, what may we get out of this? What do you think?

Episode 6: How to assist a student teacher who makes mistakes in teaching

I (Researcher) had the following conversation with Mentor Don on how he would assist a student teacher who is struggling:

> **Researcher**: A student teacher is making lots of mistakes. You are observing the lessons. How would you support that student teacher and give feedback?
>
> **Don**: The first thing I would do is I would go back to basics and use every resource that I possibly can. And then we are fortunate now that we've got so many online resources with diagrams, pictures, videos etcetera and I would always recommend backup knowledge with that. But before I even approached formulas, I would make sure that he understood or she understood. Sorry.
>
> **Researcher** (gives a nod to signal that he continues).
>
> **Don**: Area in general, you know, basic area, basic multiplication, um, and then how to. I would go back to basics on formula. What do you know, what do the letters mean? Um, substitution, that sort of stuff. And then gradually build up part by part.

In Episode 6, Martin was concerned with discussing and enlightening student teachers about misconceptions, and reasons behind students' answers, for example, saying "[e]xplore why Georgia said that," and Don wanted the student teachers to practice the mathematics from the basics, and this is supported by M13 who wrote, "I would like the student teachers to start from the basics."

Closely looking at the discussions, Martin was aiming at pedagogical content knowledge development while Don and M13 focused on mathematical subject knowledge development.

Discussing how they assist their student teachers develop subject knowledge, Judy and Darren said they direct their student teachers to internet resources. Paul said he assesses his student teachers' subject knowledge by discussing different topics and self-evaluation on the topics in the GCSE mathematics specification. The specification does not necessarily develop the mathematical content knowledge but it enhances the student teachers' Knowledge of Content and Curriculum (KCC) and Knowledge of Content and Teaching (KCT) (Ball et al., 2008).

Judy said she would assess her student teachers' mathematics subject knowledge using the Basic Key Skills Builder (BKSB)[36] where they would do an online assessment which is electronically assessed and assigned a level of achievement. The level of the mathematics knowledge the student teachers achieve would help her plan their developmental routes. Depending on BKSB results, Judy said she would give her student teachers books and past examination papers to boost their mathematics subject knowledge. Alex and Martin said they discuss the GCSE mathematics specification with the student teachers on areas the student teacher most struggles with.

After Julie had observed Cain's lesson, some of the points raised during the mentor feedback meeting (Appendix 5), and recorded as mentor meeting minutes are:

- Learners clearly happy to unmute – good rapport especially given online only
- Some learners very talkative in breakout rooms – this is good
- Learners shared their answers etc. on screens and collaborative working went really well
- Questions to students in group collaboration could be more specific, especially to bring those answers back to the main group

While Cain was praised for good rapport with his students, the mentor advised him to give students more specific questions to work through in breakout rooms. Since engaging learners is problematic when teaching online (and at times face-to-face), students can easily be off task if questions are not clear and specific. Another part of the report reads, "We can use teamwork for general GCSE resit classes in the future – e.g., most learners get most questions correct, so we could emphasise this fact

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[36] The Basic and Key Skills Builder (BKSB) tests are designed to assess the competence level of a candidate in the areas of English, maths and information and communication technology (ICT). https://www.bksb.co.uk/about/

as it encourages teamwork ---.” The statement seems to suggest that students in FE colleges work better when they learn collaboratively in breakout rooms during online lessons and working in groups during face-to-face lessons.

It was observed that Alex assisted Job on pacing and clarity of explanation as Job was observed to be going too fast resulting in unclear explanation. Alex also assisted Job on differentiation. This was set as a target and Job’s lessons observed had evidence of differentiation. While Cain’s explanation was at times observed to be long and winding (and not clear), and the work assigned to students was not well differentiated, Julie was not seen addressing this.

General issues in teaching mathematics also includes integrating technology in teaching. Job (episode J.6.3) and Suzy (episode S.4) were advised by their mentors on how to develop ‘effective’ PowerPoint presentations by reducing the animation. Still in episode J.6.3, Alex is seen praising Job for produced ‘good’ PowerPoints, implying that the advice given was already bearing fruits. Esther said she learnt how to use the smartboard from her mentor.

The issues raised by mentors are about assisting student teachers on general teaching of mathematics; for example pacing, differentiation and questioning techniques are applicable to other subjects as well; they are generic.

The theme of *General issues in teaching mathematics* can be framed within the theory of *Learning by Reflecting* (Cain, 2009). This theory posits that deep reflection on personal teaching experiences enables student teachers to derive meaningful insights and conclusions about their pedagogical practices (Cain, 2009). A mentor, acting as a facilitator, can prompt this reflection by encouraging the student teacher to critically analyze their teaching methods, outcomes, and student interactions. Discussion about teaching and learning styles can further enhance this reflective process. By contrasting *teacher-centred* and *student-centred approaches*, the mentor could help the student teacher to understand the impact of these styles on student engagement and learning outcomes. *Teacher-centred rote learning approach* where the teacher is the primary source of knowledge, could be juxtaposed with *Pupil centred inquiry-based approach* that emphasizes active student participation and autonomy in learning, and this could be discussed with the student teacher. Discussing how to address common misconceptions in mathematics; for example, ‘add tops, add bottoms’ when adding fractions (Hart, 1981), provides practical examples that could stimulate deeper thinking in the student teacher.

Mentors expressed their willingness to discuss mathematical issues with their student teachers as observed by Campton and Stevenson (2014) who say mentors and student teachers should take time to talk about mathematics; for example, how the mathematics being taught has informed choice of examples and tasks.

General issues in teaching mathematics are visible across various KQ dimensions, but they appear particularly prominent within the *Theoretical underpinning of pedagogy* code of the *Foundation* dimension. For instance, discussions around misconceptions highlight how deeply theoretical insights can influence teaching practices. These discussions are instrumental in enhancing student teachers' overall knowledge of teaching mathematics, potentially shaping their planning and instructional strategies. Given the importance of theoretical understanding in effective mathematics teaching, it is recommended that mentors proactively address student teachers' needs by engaging in discussions about general issues in mathematics education. As highlighted throughout this thesis, ITE in FE is generic, placing the onus on mentors to guide the mathematical and pedagogical development of student teachers. Therefore, mentors should be encouraged to discuss various teaching approaches, such as *pupil-centred, inquiry-based learning* and *teacher-centred, rote-learning* methods. These discussions should not be limited to a prescriptive format; rather, they should be flexible and responsive to the specific needs of the student teacher. The varied requirements of FE mathematics student teachers necessitate a tailored approach, where mentors adapt their guidance based on the unique needs of each student teacher. By fostering a dialogue that addresses both general issues and specific teaching methodologies, mentors can significantly contribute to the development of a well-rounded, theoretically informed teaching practice in their mentees.

5.1.3.2. Teaching specific mathematics topics

Mentors said they assist student teachers on how to teach specific mathematics topics. Episodes 7 and 8 introduce and illustrate the theme.

Episode 7: Assisting a student teacher teaching *Area of circle and semi-circle*

When responding to the mathtask 4: *Area of circle and semi-circle* (Figure 3.4) where a student teacher gave the wrong formula for area of the circle, M17 wrote:

> I would advise the student teacher to use a starter to revise the formula for the area of the circle and parts of the circle. Start with easier questions first before moving to the 4-mark question. For example, a task on matching the parts of the circle, where students work in

> pairs. A mnemonic to remember the formula. Corbett maths videos and worksheets, Century nuggets, Barton diagnostic questions can be helpful for explanation or further practice.

Episode 8: Assisting student teacher teaching *Perimeter of a semi- circle online*

A typical example of assisting student teacher to teach a specific topic online was given by Julie who said she explained to Cain, her student teacher, how to teach measuring perimeter of a semi-circle online. She explained how she taught her students. She said:

> My students struggled with *Perimeter of a semi- circle*. Grasping *Perimeter of the semi-circle* was really bad. I used kitchen utensil [showing a water glass- Figure 5.7]. I had this telling them where to measure. I told them you don't measure all around but the curve and the line across. It's difficult to draw a semi-circle on Zoom.

Figure 5.7 Julie showing how to find Perimeter of a semi-circle using a glass of water

In episode 7, Mentor M17 is seen explaining how s/he would assist the student teacher to teach a specific topic: *Area of the circle and semi-circle*, while in episode 8 Julie is seen assisting Cain on teaching a specific task online: *Measuring the perimeter of the semi-circle*.

During interview, Judy said she discusses lesson plans and resources with the student teachers before teaching, and M13 added, "There should be clear framework and expectations in relation to lesson planning and prep. This should be reviewed prior to delivery of the lesson so it can be refined by the mentor and discussed with the student teacher." It can be seen that Judy and M13 would be assisting the student teachers to teach specific topics by reviewing lesson plans and resources.

During one of the interviews, Alex said he normally does not discuss specific topics with student teachers but if they come with a specific topic to discuss, he would discuss it with them or if he picks up something from observation they could discuss it and assist the student teacher. He gave an example of how he assisted Job, his student teacher, on teaching *Converting between fractions, decimals and percentages*. He said:

> I remember it clearly. The student teacher was teaching *Converting between fractions, decimals and percentages*. He was converting fractions to percentages without calculator. I advised the student teacher to think of other conversions which are fractions to decimals to percentages and the other way.

Job said when planning a practical activity, he would ask his mentor Alex to check the activity. He gave an example of an activity on *Area and perimeter* where students were drawing shapes to measure and calculate area and perimeter. Job said, “My mentor advised me to improve the activity by having students draw different shapes.” While it is not clear what shapes Job intended students to draw and what ‘different shapes’ means, it shows the mentor Alex assisting Job on teaching a specific topic*: Area and Perimeter.*

While discussing a lesson on converting, fraction to decimals and vice versa taught by Cain, Julie and Cain focused on how to use different calculators to convert fractions to decimals and vice versa. Cain was leading the discussion while Julie was following. Cain said, “With this calculator (Figure 5.8),

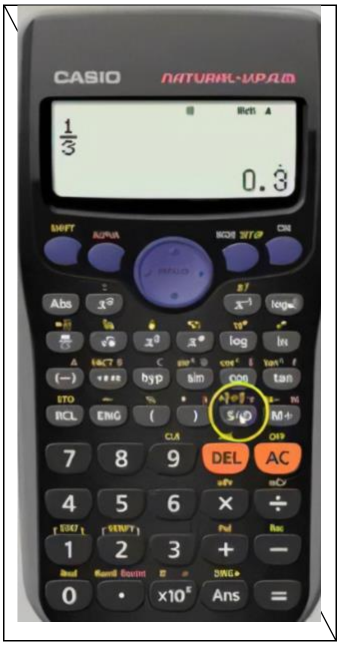

Figure 5.8 Calculator with SD button

you press the SD button to change between fractions and decimals. Julie showed her calculator similar to Cain’s. Cain showed another calculator (Figure 5.9), and explained, “This does not have that SD

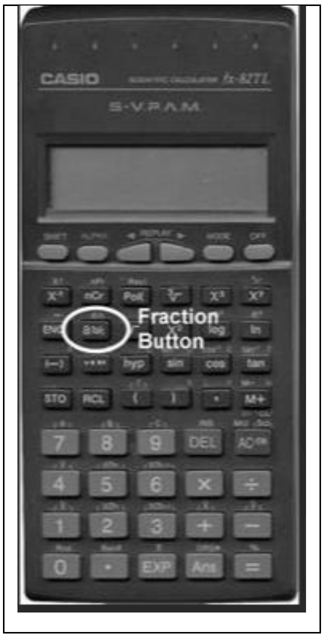

Figure 5.9 Calculator without SD button

button. If you press the fraction button, it does not work.” He said it was difficult to explain how to use a calculator online. He explained that he shared the screen with his students to show a video, but the screen was too small, and he could do nothing about it. Julie said, “Do you know what? It’s good to have some tech issues, for you to reflect and learn.” While Julie did not offer any practical help, she wanted Cain to learn from mistakes and improve. Alex, M17 and M13 said they explain specific steps of teaching particular topics to student teachers.

General issues in teaching mathematics encompass broad educational philosophies, whereas, *Teaching specific mathematics topics* is concerned with the actual lesson delivery. *Teaching specific mathematics topics* can be understood through the lens of *Learning through apprenticeship* more than *Learning by reflecting*. *Learning through apprenticeship*, as conceptualized by Lave and Wenger (1991), emphasizes the importance of *Situated learning* where novice teachers learn by engaging in teaching practices under the guidance of mentors. This approach aligns with Brown and McIntyre's (1993) notion of gaining access to the craft knowledge of experienced teachers. In this context, mentor teachers provide direct instruction, model effective teaching strategies, and offer feedback, thereby facilitating the development of practical teaching skills in student teachers. While *Learning through apprenticeship* is predominant, elements of *Learning by reflecting* are also observed. *Learning by reflecting*, a concept advanced by Schön (1983), emphasizes the importance of reflective practice.

Reflective practice involves critically analysing one's teaching experiences, identifying areas for improvement, and adapting strategies to enhance student learning outcomes (Schön, 1983). For example, Julie's encouragement for Cain to reflect on and learn from teaching strategies that do not yield the expected results.

Literature (for example, Maxwell, 2014; Lucas, et al, 2012) points that ITE in FE is mostly generic; it focuses on the application of generalised pedagogies which can operate across subject boundaries. The subject specialism relies on trainees’ ability to contextualise their learning to their own specialism with the support of subject mentors (Lucas et al., 2012). It seems there is no (or very little) literature on mentoring FE mathematics student teachers on teaching specific topics. Noyes and Dalby (2020), whose research interests are on mentoring mathematics student teachers in FE, do not discuss teaching specific mathematics topics. This makes this study’s *Teaching specific mathematics topics* theme a novel idea which might be a helpful subject specific addition to the mostly generic ITE in FE.

Teaching specific mathematics topics is closely aligned with the *Teacher demonstration* code of the *Transformation* dimension of the KQ. This connection is crucial because effective mathematics instruction hinges on how well student teachers can convey mathematical concepts to their students. Although *Teaching specific mathematics topics* might appear to comprehensively address all the needs of student teachers, it is primarily concerned with addressing *Unclear explanation* need. One of the common challenges faced by student teachers, and even by some experienced educators, is the difficulty in clearly explaining mathematical concepts. This lack of clarity can hinder students' understanding and engagement with the subject matter. Therefore, providing targeted support to student teachers in teaching specific mathematical topics is essential to improving the quality of their explanations. Moreover, student teachers in FE come from diverse educational backgrounds and bring varied levels of experience to their teaching practice. Some may last have been in the classroom years ago, as students themselves, during which time educational approaches and the curriculum may have evolved significantly. This gap in experience and knowledge can result in difficulties when trying to explain certain topics effectively. These student teachers may not receive sufficient support in generic teacher education programmes, where the focus tends to be broader and less specialised. Consequently, they may struggle with the teaching specific mathematical topics. By providing tailored assistance that focuses on particular mathematical concepts, student teachers can develop clearer and more effective instructional strategies. This targeted support is vital for ensuring that they are well-equipped to meet the diverse needs of their students and can deliver high-quality mathematics education.

5.1.3.3 Attending to mathematical errors

Mathematics student teachers (and student teachers of other subjects and even qualified teachers) make errors in teaching. In this study, data and literature show that there is need to correct the student teachers' errors. In other words, this theme is about correcting mistakes made by student teachers in teaching. This is the attention to the precision of the mathematical language; for example, use of terminology, and the correctness of the mathematical processes. The episodes that follow introduce and illustrate this theme.

Episode 9: Intervening when a student teacher's teaching has errors-'taking over the lesson'

During interview, I (Researcher) had the following conversation with Judy about how to promote correct teaching by addressing incorrect teaching by a student teacher who gave the incorrect formula of *Area of circle* (Figure 3.4):

> **Researcher**: This student teacher was teaching *Area of the circle*. The student teacher made a lot of mistakes. The first mistake was to say area of circle is π times diameter. And this student teacher was corrected by a student and he went on to say the diameter is from side to side. The radius is half. He failed to work out the question and he just gave the answer and moved on.
>
> **Judy**: Right. Um, that's a significant error and I feel that I would have to intervene.
>
> **Researcher**: If you have such a situation, how would you help this student teacher? You see the student teacher, you are seated, you're observing, you see this error. How would you support this student teacher?
>
> **Judy**: I would have to intervene there. I could not let that pass.
>
> **Researcher:** How?
>
> **Judy:** Because it will be to the detriment of the learners that are in the classroom. Yeah. And one learner has already spotted that this, this teacher has, does not know what they're talking about. So, their opinion of that teacher is going to be plummeting at the moment and the class is going to experience a lot of confusion. So, probably in that situation what I do is say, say, thank you. Thank you very much. [A long pause]. That's lovely. OK. I'll let you sit down now and we'll have a chat about the observation later. OK. And then I'd revisit that question with the entire class on the board and then start to get them to contribute their answers and their methods for working out and develop it into a more interactive session to ensure that there is always no confusion between areas.

Episode 10: Intervening when a student teacher's teaching has errors - 'a bit of a laugh'

During interview, I (Researcher) had the following conversation with Alex about how to address errors in teaching by the student teacher who gave the incorrect formula of *Area of circle* (Figure 3.4):

> **Researcher:** You completed a task where a student teacher gave a wrong formula for *Area of a circle*. Do you remember that?
>
> **Alex:** Oh. Yes. I remember that.
>
> **Researcher:** So, in this case, to be brief, how would you help a student teacher whose teaching needs improvement?
>
> **Alex:** Teachers can make mistakes deliberately for students to point it out or just making silly mistakes. We all make mistakes, approach maybe. You know, having a bit of a laugh and use it as a development point, then I'd say that actually that's really important what happened at some point in your lesson. If this is lack of knowledge, actual lack of mathematical knowledge, I'd say please find a copy of the specification on circles you know, when we are having a meeting can you bring to me?

Unlike Judy who would take control of the lesson, Alex would prefer to make the errors lighter - a bit of a laugh - and discuss it after the lesson using the specification. The approaches mentors employ in correcting errors in teaching are seen to be varying from Judy's 'taking over the lesson' to Alex's 'a bit of a laugh.'

M14 wrote that s/he would tell the student teacher about the error; explaining to him or her the correct formulae during the feedback meeting. M23 wrote, "Explaining to the student teacher that the formula is the key and also relate every question to real life." M14 and M23 both raised the issue of correcting the formula but M23 went a little further to mention connecting mathematics to real life: an issue which is important in FE mathematics teaching as discussed in Section 5.2.4.

Another example of how to address errors in teaching is given by Suzy, a pre-service student teacher whose mentor did not participate in the study. During interview Suzy said she was observed by her mentor teaching *Drawing bar charts*. She said her scale was not uniform and the gaps between bars were not equal (see Figure 5.10 which is my interpretation of Suzy's incorrect and correct bar chart). Suzy said during the feedback meeting, her mentor explained the correct way of drawing bar charts. Suzy said she was able to draw the correct bar chart during another lesson teaching a different class.

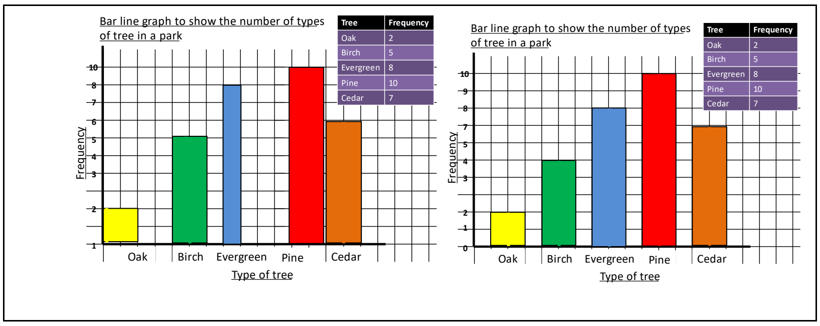

Figure 5. 10 Incorrect Bar Chart (left); Correct Bar Chart (right)

Learning through apprenticeship is observed more than *Learning by reflection* in this theme. The apprenticeship model which argues that student teachers should learn through gaining access to the craft knowledge of experienced teachers (Brown & McIntyre, 1993) is observed in how the mentors address the student teachers' errors. For example, Judy's idea of telling the student teacher to sit down while she 'shows him/her how to teach' is arguably mentoring through apprenticeship. It seems that Judy's idea of taking over the lesson may compromise student teacher's role in the classroom and break his/her relationship/trust with the class. So, Judy's dedication to teaching mathematics without errors may compromise student teachers' teaching status. Another example of apprenticeship mentoring is when Paul said he would ask the student teacher to go and study the topic and then he would teach the student teacher the way he would teach students (Episode 2). In fact, all responses show some elements of the apprenticeship mentoring. However, Alex's idea of making the situation lighter by using 'a laugh and use the errors in teaching as a development point (target),' might be seen to have some *Learning by reflecting* characteristics as the student teacher would reflect on his or her errors in teaching.

The idea of addressing student teachers' errors in teaching is mentioned by Norley (2017) who says after lesson observation during feedback, the student teacher should be asked a range of open and probing questions to give her/him the opportunity to reflect further upon her/his sessions, and areas for development including errors in teaching relating to the observations, and this should be discussed (not dictated) with the student teacher. The mentors and Norley (2017) agree about addressing errors in teaching but in different ways: from taking over the lesson to discussing (not dictating) with the student teacher.

Research indicates that mentor meetings often emphasize the generic aspects of lessons, with minimal attention given to the mathematical content within mathematics lessons (Lin & Acosta-Tello, 2017). In contrast, *Attending to mathematical* errors shifts the focus of mentor meetings to the intricacies of mathematics subject knowledge and pedagogy. This theme deliberately avoids the broader, generic elements of teaching, instead honing in on the precise and accurate delivery of mathematical content.

The theme of *Attending to mathematics errors* is visible in all dimensions of the KQ, highlighting its critical importance in mathematics education and directly addressing several key needs of student teachers. In the Foundation dimension, teaching mathematics without errors is vital. Gaps in a teacher's subject knowledge can lead to errors that undermine the learning process. Looking at Foundation dimension, this theme specifically addresses *Gaps in subject knowledge* and *Use of terminology* student teacher needs, ensuring that student teachers not only understand mathematical concepts themselves but are also equipped to teach them effectively. In the Transformation dimension, the emphasis on teaching without errors is crucial' when teachers demonstrate mathematical concepts. Clarity in explanations and the precise use of terminology are necessary for students to grasp the material, thus aiming to address *Unclear explanation* needs. For the *Connection* dimension, teaching without errors is indispensable' in creating lessons with coherent and well-connected parts. Since mathematical concepts build upon one another, errors can disrupt the logical flow of a lesson, leading to confusion. By maintaining teaching without errors, student teachers can help students form meaningful connections between different mathematical ideas, reinforcing their overall understanding. This theme addresses *Limited connections* student teacher needs if the *Connection* dimension is the focus. Finally, in the *Contingency* dimension, focusing on teaching mathematics without errors enhances a teacher's ability to adapt lessons in response to student needs or unexpected developments. When content is correct and well-prepared, student teachers are better equipped to adjust their lessons, addressing misunderstandings or deepening engagement, as necessary. Conversely, errors can hinder a teacher's flexibility, making it more challenging to respond effectively to students' questions or learning difficulties. Looking at the *Contingency* dimension, this theme addresses all student teacher needs as it enhances student teachers' flexibility in dealing with the dynamics of the mathematics lessons.

To sum up the findings of the analysis of data collected during Phase 1 and Phase 2 about how mentoring assists in the development of mathematical and pedagogical knowledge of mathematics student teachers as seen by how mentoring addresses student teacher needs and what literature says, mentoring in FE ITE tends to be generic and primarily focuses on formative support. However, the actual mentoring practices vary significantly, often falling at opposite ends of a spectrum.

On one end, some mentors take a highly interventionist approach, such as stepping in during a lesson to correct a mathematical error. On the other end, some mentors provide only minimal guidance, offering light touch recommendations after observing a lesson. The mentoring leans more towards *Learning through apprenticeship*, where student teachers learn by doing and observing, rather than *Learning by reflecting*, which would involve more critical reflection and discussion. Furthermore, the mentoring practices observed seem to align more with *judgementoring* where the focus is on assessing and correcting rather than *developmental* which would prioritize growth, reflection, and deeper understanding.

To better support the development of mathematical and pedagogical knowledge, mentors are encouraged to:

- Engage actively with student teachers by working through mathematical problems together, fostering a deeper understanding of the subject matter
- Encourage student teachers to observe and learn from experienced teachers, but with a focus on reflection and discussion about what they observe
- Assist student teachers with teaching mathematics in general, teaching specific topics and paying attention to errors when teaching

Mentoring is not immune to other factors; it is affected by institutional issues which are discussed in the following section.

5.2 Institutional issues that have the potential to influence mentoring in FE (Revisited)

During the analysis of the data collected during *Phase I* some institutional issues seen to have the potential of influencing mentoring practices emerged and were further investigated in *Phase 2*. As explained in Section 4.3.4, these issues are about the mathematical and pedagogical knowledge development of student teachers but also cover wider institutional issues that are seen as having the potential of influencing mentoring practices. I refer to these as *Institutional issues* because they can be influenced by colleges, educational policies, and the Further Education (FE) curriculum.

5.2.1 Mentoring structure

Mentors and literature support the idea of having a mentoring structure. Esther, one of the mentors who were interviewed, proposed a mentoring 'plan' (structure) which should be agreed between the mentor and the mentee where mentor meetings are held monthly, and student teachers are observed after every six weeks to give them 'time to grow.' Another mentor, Martin was in support of the mentoring structure. He said the dates and time of mentoring events; for example, lesson observations and mentor meetings, should be on the mentor and student teacher's timetables, but flexible. Martin explained that the structure should be a rough outline related to the teacher training programme, and mentor meetings should be before and after lesson observations from the *Teacher Education Department*. Alex advocated for a structure which should be on the mentor and student teacher timetables with mentor meetings scheduled to be held weekly or at worst fortnightly "[a]s this allows student teacher needs to be picked up quickly." Julie said that mentors struggle with time; therefore, a structure with events timetabled would be ideal. Don said the time factor is key, and he proposed having a mentoring structure incorporated into the timetables to allow for mentor meetings and observations. Don also advocated for all mentors in an institution to have meetings themselves which should be timetabled as well.

A mentoring structure could have stages as suggested by Judy who proposed a structure with first few weeks of student teacher observing the mentor and other experienced teachers. This would be followed by mentor sharing lessons with the student teacher. Then gradually the student teacher gets more teaching time leading to teaching full lessons. Martin supported a structure with stages but added that the structure should depend on the individual student teacher needs. There were suggestions that a mentoring structure should also include diagnostic assessment of the student teacher's mathematical subject knowledge. M14's questionnaire response reads, "A student teacher would benefit from a diagnostic assessment to check on his or her mathematics subject knowledge, so he or she gets rigorous mentoring and bolstering his subject knowledge in grey areas." Judy suggested individualised mentoring depending on diagnostic assessment results. Many mentors say mentoring structure is beneficial but one mentor, M18 responding to the questionnaire wrote, "A structure may not be suitable as the needs of the mentees are different and so mentoring needs to meet those needs." While M18 does not agree with an institutional structure, she or he seems to agree on individualised structured mentoring.

A study in South Africa by Tsotetsi and Mile (2021) reports that pre-service teachers feel that there is no formal programme (structure) guiding them at their placement school; mentors guide student teachers as they see fit. Many student teachers claim their mentoring is random and haphazard, and mentors also report that the mentoring they provide is variable (Hudson, 2013). Supporting the mentoring structure, Boodt et al. (2021) advise FE leaders and managers to "[m]ake sure that mentors and mentees are allocated time in their timetables to meet on a regular basis" (page 7). Ma'rufi et al.,

(2020) add their voice by saying that teacher professional development, especially for beginner teachers, should be through teacher induction and mentoring programmes (structures). The implementation of a good induction and mentoring programme must be systematic and planned based on the concept of collaboration and partnership among teachers (Ma'rufi et al., 2020) including mentors and student teachers. Lin and Acosta-Tello (2017) advocate for a well-structured mentoring model with clear goals.

The structure could be effective if mentors are recognised, valued and acknowledged by the college management and/or by the government, in form of financial incentives and/or reduced workload. For the structure to be a success, there should also be institution commitment to training of mentors.

5.2.2 Training of mentors

Mentors and literature support the idea that mentors should be trained but viewed the training in different ways. Some mentors viewed experience as very important. Darren said, "Mentors should be trained. Mentors should be up to date with current knowledge about teaching of maths." As mentioned in *Chapter 4*, Julie, who attended a training course run by Education and Training Foundation (ETF) said, "I benefited from the training module I did. Mentors should be trained. I am an advocate for mentor training." Martin said mentor training should be 'standard,' meaning it should be same for all mentors in FE, but he said the training is not all that important as "[s]ome people are good mentors by nature." Alex, like Martin, said training is not all that important as experience makes one a good mentor. He said, "I feel, my experience as a teacher would be the best." He added (but without conviction) "But if there was some mentor training end to end training that be really, yeah would be really good." Esther also advocated for mentor training, but like Alex and Martin, she said experience as a teacher is very important. Don supported mentor training but said experience as a teacher is the most important factor when it comes to mentoring a student teacher; he said:

> I wasn't trained to be a mentor. It was just sort of accepted that if you're teaching and you've done it for a few years, you can be a mentor. I mentor by sharing my experience. Training will be an added bonus.

Paul said the college officials responsible for mentors should identify needs and train mentors according to needs; he said, "It should be individualised." M20 wrote, "Yes, I did the mentoring course and have continued to up skill in this area. If you are trained you know that you need to listen, much more than you need to talk.” According to M20, an area which need mentors to be trained on is report writing and giving student teachers feedback. S/he wrote:

> The mentors need to be trained on how to critique a student teacher’s work without crushing their confidence. The hardest part of mentoring is telling student teachers where they are going wrong. Mentors should be taught this concept and given the tools to give feedback.

M15 supported M20 and wrote:

> Mentor training should focus on giving constructive feedback and basic counselling techniques. It is important that all mentors are trained to understand their role and responsibilities with regards to supporting their student teachers. Training could be on observing lessons and how to record a student teacher’s progress. Training should be on two types of mentoring, general teaching skills and subject specific. Teaching skills should be mentored to develop good classroom practice and subject specific used to ensure competence in the area being taught.

Hankey (2004) says training of mentors is another aspect that requires attention in the FE sector. Hobson et al. (2015) note that a wide range of impediments to effective mentoring currently exist; the most notable impediments include issues with the selection and training of mentors. Mentor training in FE is very patchy: some (probably a small minority) colleges’ practice is very good, while some (probably the majority) colleges’ practice is weak and virtually non-existent, with many mentors of student teachers and qualified teachers not trained appropriately or not trained at all (Robinson & Hobson, 2017). Providing mentors with a well-designed mentoring training programme can assist in facilitating a more effective mentoring process (Villar & Strong, 2007). Luneta (2003) views mentor training as professional development, in that as teachers undergo training as mentors they acquire essential skills, such as analysis, reflection and general supervision. Purposeful and effective professional development of mentors is often a proposed solution in many of the present debates about education, including teacher quality, teacher retention, and the student achievement (Naseem & Crutcher, 2016). Literature about teacher mentoring suggests that if mentors in teacher education programmes do not have significant professional development on mentoring, even a thoughtfully organized formal induction programme could be ineffective in preparing good teachers, undermined by unprepared and untrained mentors (Naseem & Crutcher, 2016).

Mentors and literature agree that mentor training should focus on developing listening skills, how to observe lessons, record student teachers' progression, and how to give student teachers constructive feedback. The training should also include how to assist pedagogical and mathematics knowledge development of the student teachers. Mentors view mentor training as essential. However, mentor training is not universally accepted as experience as a teacher is also important in successful mentoring and some teachers are good mentors by nature.

5.2.3 Teaching for examinations

The debate about teaching mathematics for examinations and/or for conceptual understand is ongoing in mathematics staffrooms in FE colleges (probably in schools and universities as well). It is institutional expectations in FE colleges to raise the pass rate (Grade 4 and above) of GCSE mathematics students; therefore, teachers follow prescribed lesson structures (remember the 5 Rs in episode C.3.4) which include examination questions. On the questionnaire and during interviews, I asked mentors the question, "Would you encourage your student teacher to teach for examinations? Please explain why?" In this section, I discuss the responses together with *Phase 1* findings.

Job and Cain, the student teachers I observed teaching for a year were seen to be referring to examinations in all their lessons. They argued that the end goal of the students is passing the examinations. Esther, a mentor said, "Time is limited so we end up teaching for exams. We try to cover all the topics." Alex, a manager and a mentor, agreed with Esther and said the following:

> We are judged by the results […] We have limited time for delivery to our learners. People who get into teaching want to teach for the actual education, for the knowledge [conceptual understanding]. We can teach for knowledge but, ultimately we are delivering a course with an end assessment, summative assessment. I would say, reluctantly, we are more driven to make sure they pass the exam.

Martin, who supported teaching for examinations argued:

> A student will have been taught all basic skills at primary less analysis. There is no time to teach basic skills. You have to teach for exams. GCSE and Functional Skills are nationally set, and it covers priorities so the student teachers can teach for exams.

M13 agreed with other mentors about teaching for examinations and wrote:

> Although it is important to teach wider skills, it is not always possible. A GCSE learner studying maths in FE colleges has 32 weeks to recover the skills they should have learned over at least two years in school. Ultimately, learners are sitting an exam and the exam technique needs to be taught. As an example, it is not enough to teach a learner how to do calculations involving fractions if they cannot apply this to an examination question involving problem solving. Overall, there must be a large amount of the delivery devoted to exam preparation or teaching to the test.

M18 wrote that the priority is to have students pass examinations meaning the student teachers should be encouraged to teach for examinations, and M17 wrote, “Apart from obtaining maths skills for everyday life and employment, students need to be familiar with exam style questions to pass their exams.”

Don who also support teaching for examinations had the following to say:

> I must admit I do like to teach towards an exam because I personally believe that's their goal. That's what learning is about because they want to pass an exam. But having said that, I like to use the teaching towards an exam as a pathway rather than a direct route so I can come off topic off task and teach them other things along the way. I only teach the functional skills now and the topics I have to cover are many topics. I don't have enough weeks, especially on the fast track so I have to teach to exam.

M23 wrote, “Yes and no. I will encourage the student teachers to teach for both so learners can pass and also relate their learning to real life too.” M21 wrote, “I think it is a good idea and strategy is to teach partly towards exams.” M20 explained that he/she encourages the student teachers to teach for understanding but refer to examination:

> In FE yes; although you and I have to teach for conceptual understanding, rather than procedural competence, so that they can interpret the questions correctly. I mention the exams a lot, and I'm happy for mentees to point out when and how this material is relevant for the learners. Most FE learners just need this for their journeys, and it is our job to get as many of them as possible to where they want to go.

The teaching for conceptual understanding; that is teaching for students to understand the reasons behind the procedures but referring to examinations is supported by M16 who wrote:

> No. I encourage student teachers to teach the curriculum for the purpose of the learner gaining a greater understanding of the mathematics. This is the purpose of education, and the exam results SHOULD reflect the understanding the learner has in the subject. If the learner is taught the curriculum to a level where they understand the subject then a natural progression would be for the learner to do well in their exams.

M15 said teaching for examinations is good but should come towards the end of the course and wrote, “Towards the end of the course, yes, as exam practice for both question interpretation and timing is essential.” Paul said that he advises his student teachers to teach for examinations towards the end of the year by giving students some questions from past examination papers.

Darren, unlike other mentors, is against teaching for examinations. He said, “I believe not to teach for exam. Teaching maths is imparting life skills to students. If teaching for exam they memorize and regurgitate and forget about it.” M19, who supported Darren’s argument wrote:

> No, if the learners don't know the maths they won’t pass the exam. Focus on getting them competent on the basics before moving on. Exams are only for school governors, not the students, so I would encourage the student teacher to think about what is right for each student.

The analysis show that there are three perspectives of looking at the ‘teaching for examinations’ question: teaching for examinations; teaching for examinations and for conceptual understanding; and teaching for conceptual understanding. Those who preferred teaching for examinations understand the need for teaching for conceptual understanding but argue that there is not enough time to cover all the topics while teaching for conceptual understanding. Those who preferred to teach for both examination and conceptual understanding said conceptual understanding leads to passing examinations, while those who are against teaching for examinations argued that mathematics is imparting life skills to students, and if students master the concepts they pass the examinations. Looking at the questionnaire data: 37.5% preferred teaching for examinations; 50% preferred teaching for examinations and conceptual understanding; and 12.5% preferred teaching for conceptual understanding. Therefore, it could be said that most FE mentors would mentor their student teachers to teach for conceptual understanding while referring to examinations.

FE mathematics teachers understand the need to develop student mathematical skills, but they are constrained by the time (Noyes & Dalby, 2020). The one-year course is not enough to cover all the GCSE topics. To make things worse the timetabling is often confusing, and classes takes long to settle (Noyes & Dalby, 2020), thus reducing the one-year to several months, and this leaves the teachers (mentors and student teachers included) with no choice but to teach for conceptual understanding while referring to examinations.

5.2.4 Contextualising mathematics to vocational courses and life experiences

I asked mentors in the questionnaire and during interview: "What do you see as the importance of connecting mathematics topics to vocational courses and real life? How would you help your student teachers in making the connection if you see it as important?" In this section, I discuss the mentors' responses to these questions together with *Phase 1* findings.

As reported in *Chapter 4,* Job and Cain, the student teachers observed teaching were seen to be giving examples relating to students' vocational courses and real-life situations. Responding to the *Addition of fractions* mathtask (Figure 3.1), Job wrote, "Real life examples help students visualize mathematics questions." During interview Job said, "Students have the mentality that, I am doing maths, but I am not going to need it but when it applies to real life or vocational course, they are motivated to do the maths." Cain was not specifically observed contextualising mathematics to real life and vocational courses but his examples referred to real life; for example, the *Percentage increase and decrease* question using ice cream sales (episode C.1.4).

Responding to a questionnaire, M16 wrote:

> This is very important for learners to gain a realisation that mathematics is everywhere and that it will be important/useful to learn for everyday life. I would suggest to the student teacher to liaise with vocational teachers to discuss whether specific mathematics arises in their vocation and also gain an understanding of what is taught in the vocational subjects with the intention of contextualising maths problems into familiar situations.

M21 had the same idea as M16 and wrote, “It is a very useful thing to have experience in vocational knowledge and the mathematics required in the specific vocations.” M23 added, “It [contextualising mathematics] makes understanding mathematics interesting and learners to see the sense.”
M20 wrote:

> This is important if it can be done and is good for getting their interest every now and then. The demands of the GCSE curriculum preclude much of this though. We have done some work looking at the maths content of other courses, to open their eyes about the relevance of maths in many subject areas though, and this has helped mentees to see the relevance themselves.

M19 suggested, “To some extent, I think teach the theory first, then apply to real world if there is a link. If there is no link to real world [or vocational courses], don't force one.”

Not all mentors viewed connecting mathematics to real life and vocational courses as beneficial. M13 made some observation and wrote:

> Over the years of an embedding agenda, I have not seen any significant increase in attainment that is attributed to vocational embedding. What is evident is that learners seem to feel that maths is a standalone subject that they study as they have to. As an example, a learner could tell me the calculations involved in working out how many bricks are needed to build a wall but could not link this to a calculation on the number of carpet tiles needed to cover a floor. Both solutions involved the same mathematical skill of area and division. The learner would not accept this and believed that the two skills were unlinked. It has become almost a badge of honour for many to hold their hands up and say, ‘I can’t do maths.’

There was consensus among most mentors that not all topics could be contextualised. Martin said, “You need to make the topic relevant but at times it’s difficult, and not important to link to vocational courses.” Don said, “Its good. Not all topics are related to real-life and vocational courses.” M15 wrote, “Very limited as the GCSE is general. Can have some limited benefits in contextualising a topic.” Paul said connecting mathematics to vocational courses and real-life is important if it can be done and is good for getting student interested.

Data show that mentors and student teachers would like to contextualise the teaching of mathematics to vocational courses and real life experiences, and this is also seen in literature. Dalby and Noyes

(2015), in an analysis of a series of case studies of vocational student groups in FE colleges in England, show that practices in mathematics and vocational courses are contrasting; therefore, contextualisation could weaken perceptions that mathematics is an isolated and irrelevant subject. Adopting mathematics classroom practices that reflect the surrounding vocational culture creates greater coherence for students and has positive effects on their engagement with mathematics learning (Greatbatch & Tate, 2018). Contextualised learning of mathematics improves understanding and retention in learners but this needs to be well-planned and reinforced across all curriculum areas (Education and Training Foundation, 2014).

Mentors who participated in this study view the need for connecting mathematics teaching to vocational areas as vital, and literature says the same. This study goes further than literature when saying that the connection of GCSE mathematics to vocational courses and real-life situations is not always easy (and at times impossible) to make while literature suggests than it is easy to connect GCSE to vocational courses. The contextualising of mathematics to vocational courses and real life makes mathematics more relevant to students, and this should be regarded as good practice and mentors could guide their student teachers into doing that.

The contextualising agenda in the teaching of mathematics in FE is research driven. Funded by the Department for Education (DfE) and delivered by the Education and Training Foundation (ETF), the programme: *Centres for Excellence in Maths (CfEM)* explores what works for teachers and students, with regards to delivering sustained improvements in mathematics outcomes for students in FE (Education and Training Foundation, 2022). A study by Cowlan et al. (2023) (on behalf of CfEM) says, "Our initial findings are that contextualisation has the potential to provide longer term benefits of [student] increases in engagement, effort, interaction, understanding and, ultimately, grades" p. 3.

To sum up this section, analysis of data collected during *Phase 1* and *Phase 2,* and literature come up with four Institutional issues - *mentoring structure; training of mentors; teaching for conceptual understanding while referring to examinations;* and *contextualising the teaching of mathematics to vocational courses and real-life* - that colleges could consider as they have the potential to improve mentoring.

It is important to reminder the reader that this study was conducted during the COVID-19 pandemic; therefore, mentoring was affected by the sudden shift from physical to virtual classrooms during the lockdowns. Obviously, there were challenges and lessons learnt which I discuss in the section that follows.

5.3 Challenges faced – and lessons learnt – during e-mentoring mathematics student teachers in FE during the Covid-19 lockdowns

Before getting into details about this section, it is important to mention the origin of the section and how it is related to the whole study. Immediately after this study had been approved by the University of East Anglia (UEA) School of Education and Lifelong Learning (EDU) Ethics Committee and just before data collection, all educational institutions went under COVID-19 lockdowns. This 'forced' me into collecting data in unfamiliar environment of e-teaching and e-mentoring. I observed challenges faced by teachers and mentors working in this unfamiliar environment. This triggered my interest into investigating the challenges and the lessons learnt while teaching and mentoring FE mathematics student teachers during COVID-19 lockdowns. Preliminary results of the analysis of *Challenges faced – and lessons learnt – during e-mentoring mathematics student teachers in FE during the Covid-19 lockdowns* were presented at the British Society for Research into Learning Mathematics (BSRLM) conference and published in Machino (2023).

The education systems globally went into a state of emergency when COVID-19 struck and there was no choice but to go online in teaching and Initial Teacher Education (ITE). Mentoring of student teachers had to go online as well. However, the education systems learnt a lot from this experience which could be beneficial during the post COVID-19 era. Learning and teaching remotely has been an immense challenge, but in some cases, it stimulated deeper and more connected thinking (Office for Standards in Education, 2021). COVID-19 inadvertently forced us to revisit our 'traditional' deeply held views and challenged us to think creatively so that we may survive and thrive in this new landscape; it allowed us to open our minds to 'non-traditional' routines and practices (Howard, 2021). The crisis caused by COVID-19 resulted in mathematics teachers (in fact all teachers) being forced to rely on digital technology for teaching and learning regardless of their existing technology related beliefs and practices. This forced and sudden change could be viewed as an opportunity for significant shifts to occur in how mathematics teachers use technology in future face-to-face, online and blended classroom teaching (Attard & Holmes, 2020). Government bodies (for example, Office for Standards in Education, 2021) and researchers in education (for example, Attard & Holmes, 2020) acknowledge the problems caused by COVID-19, but take this as an opportunity to learn from.

In this section, I discuss challenges faced during e-teaching mathematics students and e-mentoring mathematics student teachers in FE colleges during the pandemic, the lessons learnt and issues that are beneficial during the post COVID-19 era. The discussion is organised under the following sub-topics:

- Teamwork
- Digital technology
- Personal and professional relationships
- Mathematics teaching needs physical demonstration and students need to be prompted to be on task
- Recording lessons and meetings

5.3.1 Teamwork

Finding time for mentoring was challenging during face-to-face teaching before the COVID-19. M13 has the following to say while responding to questions on challenges and lesson learnt during e-mentoring:

> Time is a challenge when mentoring. Often full workloads prevent mentoring from taking place in a relaxed and open atmosphere. Too often mentoring a trainee is an additional duty and without incentive for the mentor. Through COVID lockdowns there was improved conversation and discussion due to more free time as team planning exercises saved individuals planning time.

Unlike during the face-to-face teaching before COVID-19, there was an increase in team planning during COVID-19 because teachers were supposed to teach online, but the knowledge of teaching online was scarce, so sharing ideas and collaboration in planning were helpful options available.

A student teacher, Cain, explained that the mathematics department members (individually and collectively) at his college produced lesson plans and resources which were used by all mathematics teachers. I asked Cain, “How do you plan your lesson activities?” Cain said the following:

> The lessons were planned quite a while back, actually. So, what we've done is we have so far this year developed a bunch of sessions. Before the start of this term, the lessons were developed by the head of department. And then the ones after that they were done by a whole mixture of us because they are the ones we need for online sessions.

The use of already developed lesson plans and resources could be seen as saving time for student teachers and mentors.

Savory and Glasson (2009) observe that formal mentor meetings are difficult to arrange if the mentor and mentee are not given time in which to carry out these meeting; often mentors are allocated full timetables with mentoring not given any time. This is echoed by Cullimore and Simmons (2010) who find evidence of mentors having insufficient time to carry out their role due to ‘unsympathetic’ timetabling and, more generally, mentors receiving insufficient support and recognition from college management. Highlighting the shortage of time (and other problems), Shields et al. (2021) say, “Challenges were noted by student teachers and mentor teachers related to time, planning, and ever-changing technology” (p. 84). During the pandemic, the problem about insufficient time for mentoring was reduced due to teamwork. Teamwork during the pandemic is also observed by Shields et al. (2021) who say, “Mentor teachers and student teacher candidates working together during the spring 2020 semester [during COVID-19 lockdowns] grappled to discover the most effective tools, resources, and strategies to provide quality instruction to students” (p. 70).

Responses from participants (for example, M13) agree with literature (for example, Cullimore & Simmons, 2010; Savory & Glasson, 2009; Shields et al., 2021) regarding shortage of mentoring time. However, this study goes a step further by discovering that teamwork saves time. The practice of team planning might have been in existence before COVID-19, but there is no evidence pointing to its advantages of saving time as the team planning was not all that important due to teachers ‘knowing what to do’ during face-to-face teaching. The practice of team planning could continue post COVID-19 as it has the advantages of freeing time for mentoring and other activities, and also teachers have the opportunity to share ideas.

5.3.2 Digital technology

The need for teachers to develop skills in using digital technology (thereafter referred to as technology) was advocated well before COVID-19. Mishra and Koehler (2006) develop a framework: *Technological Pedagogical Content Knowledge (TPCK)* which is an expansion of Shulman’s (1986) *Pedagogical Content Knowledge (PCK)* to include technology. Armstrong (2014) observes that as technology continues to develop and evolve, the role and expectations of the teacher also continue to change. The use of technology in mathematics lessons has been going on for a long time, and it keeps on developing, but COVID-19 accelerated the development. Due to COVID-19 pandemic, the technological knowledge development among mathematics teachers (in fact among all teachers) increased but the challenges faced and the lessons learnt need to be understood, and in this section, I attempt to do that.

5.3.2.1 Mentor and student teacher attitude

The main challenge of online teaching was mentor and student teacher attitude. Don, a mentor who was interviewed, agreed that technology was important in mentoring and teaching during the pandemic. He talked about the expansion of technology in teaching and learning but he admitted that he was not keen on technology when saying the following:

> Some people have loved online training and teaching. Others, like me, are not so keen on online. I'm a bit of old fashioned. I am more of a pencil and paper person, but yeah, everything that's online encouraged students to learn because there are so much in technology.

Some mentors; for example, Don, had 'negative' attitude as they believed pen and paper to be better than the computer; therefore, it could have been challenging for managers to convince such mentors and teachers of the usefulness of technology during the COVID era, and worse still during the post pandemic era. It would have been even more challenging to convince mentors like Don to encourage and support their student teachers in the use of technology in their classrooms.

M19's attitude was rather positive but was cautious as s/he thought pen and paper might be better than computers and wrote, "Brilliant idea, as long as the equipment is age appropriate and does not confuse students. At times, a pen and paper can encourage learners to solve problems themselves rather than relying on a computer system." A cautious mentor M16 added by writing the following:

> If technology, is used in teaching to facilitate and support education then I feel it is very beneficial. There has to be analysis as to whether the technology actually supports learning or whether it is making the experience more robotic with less of a human perspective that is essential for a holistic teaching experience. As a student teacher it could be wise to include technology from the start of the teaching career to develop a keen understanding of how to implement the technology. But I would suggest some limitations on the use whilst still learning more fundamentals of teaching.

M16's cautiousness implies that s/he is not convinced of the benefits of technology and this is a challenge. Don, M19 and M16 agreed that mentoring student teachers on the use of technology would be beneficial but they are very cautious.

A study by Mulenga and Marbán (2020) examines prospective teachers' online learning mathematics activities in the age of COVID-19 pandemic, and claims that student teachers' learning to use technology is affected by their attitude, and this agrees with this study.

5.3.2.2 Availability of technology

During a mentor meeting, Julie asked her mentee Cain how he would ensure equality in the use of technology as some students did not have access to computers and smart phones. Although Cain did not understand Julie's question properly (as his answer was off topic), the question shows that Julie had some concerns about students who did not have access to the computers and smart phones. For those with access to computers and smart phones, internet problems were observed; for example, when Job was observed by his mentor Alex teaching the webcam was not functioning properly, and some students did not see the screen. In this case, it is seen that mentoring is affected as Alex was not able to see the teacher-student interaction as the webcam was not functioning properly. The feedback given to Job was on the technological problems instead of mathematical and pedagogical issues. He was advised to test the computer before the lesson "[a]nd to be as enthusiastic as during face-to-face sessions" and no mathematical and/or pedagogical issues were given as advice in the report (see Appendix 7). When Cain was observed the observer from the *Teacher Education Department* could not hear the students but could hear Cain. There are some places (or some rooms in the same house) which might have internet problems, and this negatively impacted on the quality of e-teaching and e-mentoring meetings.

The issue of availability of the computers and/or smart phones and internet connection is also mentioned by Chirinda et al., (2021) who say:

> This study found that teachers and learners at schools in contexts of historical disadvantages were unable to shift smoothly to online teaching and learning because of insufficient digital resources such as smartphones, data, Wi-Fi and internet connectivity. However, South African learners at privileged schools effortlessly transitioned from face-to face learning to online learning through Zoom, Teams, Google Classroom (p.10).

Chirinda et al.'s (2021) study, carried out in South Africa, highlights both access of computers and/or smart phones and internet connectivity as problems which affected the transition to online teaching in less privileged schools. This study carried out in the United Kingdom observed connection to the internet problems more than access to computers problems. Although Chirinda et al.'s (2021) study does not explicitly mention mentoring challenges stemming from access to computers and/or smartphones, and internet connectivity, it can be argued that observing a student teacher teaching a class where some students lack computer access or face internet connectivity issues poses significant obstacles to mentoring. Assessing the student teacher's mathematical and pedagogical knowledge under such circumstances undoubtedly proves challenging.

5.3.2.3 Technological literacy

Some mentors and student teachers lacked the technological literacy, which is the skillset to effectively use, evaluate, and create information using digital technologies and platforms responsibly (Hague & Payton, 2010). Technological illiteracy was a challenge during the pandemic. Martin said he observed that some mentors struggled with technology, and they learnt a lot during the pandemic. Darren said mentors have to learn technology so that they share the technological knowledge with their student teachers, and Don had the following to say:

> For me personally, my eyes were opened to the amount of resources that are online that are available, I wasn't aware of. Yeah, I now use *Microsoft Forms*. I learned all that by myself and I'd never seen them before. I sort of continue to use them in the classroom because we're, you know, we're not at home and teaching from home. We are in the classroom doesn't mean that we can't use the online resources as such.

Martin, Darren and Don’s statements imply that some mentors (and other teachers) were not technologically literate before the pandemic, and have improved. This technological illiteracy is observed by Bierema and Hill (2005) who say access to technology is not limited to physical access as intellectual access can also be a challenge as some student teachers and some mentors might not have the technological literacy and knowledge on the use of technology in teaching and learning mathematics. Meletiou-Mavrotheris et al. (2023) say, “A significant challenge that has emerged in the international literature concerns educators’ limited skills in the use of digital technologies to support ERT (emergency remote teaching)” (p. 2).

In agreement with Martin, Darren and Don, literature, for example, Howard (2021) says teachers’ ability to use video-conferencing software has developed immensely alongside that of confidence and competent levels in its use. Overall, teachers upskilled themselves in the use of technology, and they were more comfortable in its use in lessons after the pandemic. The use of technology in the face-to-face classroom was observed to have increased after COVID-19 (Howard, 2021).

5.3.2.4 Digital marking and assessing student work

One of the benefits of technology which is directly linked to teachers' technological knowledge development is digital marking and assessing student work. Alex had the following to say:

> Things which I think we have learnt whilst teaching online which could be carried forward back into the classroom is having some self-marking work set on an online platform such as *Microsoft Forms*. This can save the teachers' time in marking students' work and increase time for mentor meetings.

However, Alex thought computer marking needs to be supplemented with physical marking as he argued, that "[s]till physically marking pieces of work should continue to be able to give detailed feedback." The use of digital technology could be beneficial for assessment: both formative and summative. A teacher could assign students work which is assessed using technology like *Microsoft Forms*, and the results could be used for formative and summative assessment. One of the challenges faced during teaching online in FE colleges (probably in schools as well) was to assess students and award them the final GCSE and A-Level grades called Teacher Assessed Grades (TAGs). This was challenging for experienced teachers and obviously more challenging for student teachers. Alex said Century[37] helped teachers in assessing students in his college and this saved teachers a lot of time. According to Alex, the use of software like Century could be continued into the post COVID-19 era.

Alex's views are supported by findings of a study by Lu et al. (2023) that has made the following observation:

> --- the utilization of online assessment techniques facilitates timely monitoring of students' progress, and the provision of immediate feedback to the learners helps in preparing students with digital skills required to function in the 21st-century workplace, among others. In view of these, it was recommended that tertiary institutions should initiate workable policies that will encourage the effective use of online assessment by lecturers.

Darragh (2021) reports a study on *Online Mathematics Instructional Programmes (OMIP)* used in New Zealand primary schools which emphasises the use of digital technology platforms like Mathletics, Studyladder, MathsBuddy and Sumdog. These platforms are similar to Century which was used in

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[37] Century is a teaching learning platform that uses digital technology to assess and assign students work due to their understanding. (https://www.century.tech)

Alex's college as reported earlier. The OMIP has advantages of time saving and giving instant feedback and constantly assesses student to ensure progress; "It promotes understanding in a personalised [and differentiated] way, engages and motivates students to practise skills, is aligned to the curriculum, and is stress free and safe" (Darragh, 2021, p. 271).

Both the data and literature advocate for online assessment to be continued beyond COVID-19; therefore, it is recommended that mentors assist student teachers on online assessment software. Mentors could support student teachers by providing training on digital platforms like *Microsoft Forms,* demonstrating good practices, and offering guidance on feedback and assessment strategies employed by the institution.

5.3.2.5 Student engagement

Among the challenges faced during online teaching, student engagement was the most talked about. Mentors and student teachers had some concern that during online lessons students rarely switched their cameras on and contributed, leaving teachers thinking they were 'talking to themselves.' During lesson observation, I also observed that students rarely switched on their cameras and contributed. In one of the mentor meetings, Cain complained that his students rarely contributed verbally or through the chat. I will revisit this issue during the *Mathematics needs physical demonstration* Section 5.3.4.

In an effort to make online lessons more interesting and engaging, mentors and student teachers had to look on the internet for ideas and resources. M21 responding to a questionnaire wrote, "It's very important to be able to use all resources available to us in the classroom including computer-based resources and real-life examples which can be shown through the internet." M20 who was more enthusiastic had the following to contribute:

> Good, there is some good stuff out there. We are using Dr Frost[38] and BKSB with success, and I know other colleges that are using Hegarty Math[39] with success. Success here means that students like it, and it encourages engagement and participation; therefore, mentors should 'teach' student teachers technology.

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[38] DrFrostMaths provides an online learning platform, teaching resources, videos and a bank of exam questions. At (DrFrostMaths.com)

[39] Hegarty Maths is a fantastic online learning platform which supports students with independent maths study. It contains hundreds of videos explaining and modelling key maths skills and concepts, as well as thousands of questions which students can complete to check their understanding. (https://hegartymaths.com)

M14 added her or his voice by saying the following:

> Mentors need to utilise diverse methods of technology as opposed to traditional methods of teaching. Use of latest interventions in IT such as multi-media which brings learning to life comes in handy in improving student participation. We can bring in videos, animations, movies, video clips, music and other media into learning process to help students develop skills and understanding.

M13 summarised the challenges of using technology during e-teaching and e-learning by writing the following:

> It is good practice to incorporate technology in learning, but it depends on many factors, such as access to computing, IT reliability, teacher ability [and attitude] to use technology, **learner engagement** (my emphasis) and of course the benefit it may have over nontechnology based teaching and learning.

After observing that students would be online but not focusing on schoolwork due to lack of motivation and/or distractions from family members (especially young siblings), Chirinda et al. (2021) conclude that e-teaching was challenging due to student limited engagement. Homitz and Berge (2008) argue that learners are not motivated to learn during e-learning and e-teaching due lack of in-person interaction as naturally, physical interaction encourages and nurtures learners' social skills.

Literature and this study agree that student engagement during online teaching and learning was challenging. This was also challenging to mentors as student teachers were looking forward to mentors for assistance on how to engage learners and the mentors did not have answers. Alex said, "To engage learners has proved to be challenges; they easily disengage. In face-to-face mentoring there is more to talk about than online. The main problem is we don't have answers to problems mentees brings about online teaching" (see Episode J.6.7 in Section 4.2.1). The problem of student engagement also affected the mentoring process as mentor-mentee discussions were mostly about how to engage students, and the mathematics issues were secondary.

5.3.2.6 Mentor/mentee collaboration

In mentoring, the mentor/mentee relationship is crucial in the development of the mentee and the mentor as well. During interview, Martin said he observed that some mentors struggled with technology; therefore, mentors and student teachers worked collaboratively on technological knowledge development. Technology has brought about collaboration between mentors and their mentees. Darren said, “Most young people might know the technology so mentors should learn from mentees as well.”

Mentors Julie and Alex agreed that they learnt from their student teachers, Cain and Job, respectively. Julie said she uses Cain’s quizzes and praised him and openly admitted that she learned a lot from Cain as “[h]e is good at technology.” Alex said he learnt from Job the idea of uploading formulae and definitions into the chat.

Mentor learning from mentees mentioned in this study is also observed by Ersin and Atay (2021) who quote the following from a student teacher:

> From time to time though, she [mentor] had problems uploading some materials. I helped her with that. I showed her how to do it. It was a good collaboration. I think she also learned something from me because she said, I have things to learn from my young colleagues (p. 208).

Mentors learnt from student teachers, and this improved the mentor/mentee relationship as the hierarchical structure of this relationship was challenged. As a lesson learnt, this collaboration and learning from each other could continue into the post COVID-19 era. This might be seen as change of dynamics in mentor/mentee relationships as moving from an expert-neophyte model to a collaboration model. Shields et al. (2021) observe that student teachers and mentors’ overall experience of co-teaching during the COVID-19 pandemic was beneficial as mentors and student teachers learned to use technologies they might not have used and “[t]eacher candidates were more proficient with the technology tools and taught their classroom mentor teachers how to utilize technology effectively” (p. 87).

As a lesson learn from COVID-19, student teachers and mentors could continue to learn from each other on the use of technology (and also other areas in teaching).

5.3.2.7 Technology to be part of ITE

Due to the benefits of technology learnt during the pandemic, there is a strong argument for incorporating technology as one of the main courses of ITE in FE. Darren said technology has to be an integral part of teacher training and mentors should know a lot about it to share with their student teachers. Alex also thought technology should be an integral part of ITE in FE when saying, “We are moving forward every year, more digital based, so technology should be taught to student teachers.” Alex gave an example of Century, which is used at his college. He said all staff need to be competent in using Century; therefore, mentors should understand Century and share the knowledge with their student teachers. Esther said, “Technology should be part of teacher training. Mentors should train mentees on the use of technology. When I was a student teacher, I learn about how to use the smartboard from my mentor.”

In schools for a student teacher to gain Qualified Teacher Status (QTS), s/he has to pass an Information and Communication Technology (ICT) test. This is not a requirement for gaining Qualified Teacher Learning and Skills (QTLS) (FE QTS equivalent); therefore, it might be argued that FE student teachers should learn technology as part of their ITE. Most mentors who responded to the anonymous questionnaire were in favour of technology being an integral part of ITE in FE.

Data agree with Shields et al. (2021) who say, “Educator preparation programs should prepare student teacher candidates in the areas of technology” (p. 87). Thomas et al. (2021), while reporting a study on challenges faced by student teachers related to Covid-19 closures of schools, say teacher preparation programmes should consider incorporating technology into the curriculum so that future teachers may more flexibly incorporate technology while teaching both in-person and online.

As a lesson learnt, this study proposes the inclusion of digital technology in the FE ITE due to overwhelming support for the idea from mentors and literature.`

5.3.3 Personal and professional relationships

The mathematical and pedagogical knowledge development of a student teacher takes place in an environment where the personal and professional relationship between the mentor and the student teacher is conducive for that development to take place.

Responding to the anonymous questionnaire, M14 wrote, “Working at physical distance from each other, trainees might start to feel disconnected from personal and professional relationships and the mentor needs to constantly check with trainee using emails, texts, video calls on [Microsoft] teams and numerous platforms.” M17 described “--- the absence of real face to face interaction” as a problem of online mentoring. At some point during strict COVID-19 lockdown, a student teacher, Job missed the deadline for marking mock examination papers which were supposed to be used for Teacher Assessed Grades (TAGs). During an observed mentor meeting, Job was asked by Alex, his mentor, why he missed the marking deadlines. He replied:

> As it is my first year to do the TAGs. It was really very difficult. I did not do marking in my last role. I did not understand the strange words and symbols in the mathematics marking scheme. If I had a question, it was difficult to get help.

During face-to-face teaching, Job used to turn to other teachers: Mariam for pedagogical issues and Peter for mathematics content issues. During Job's 'difficult' times during COVID-19 lockdowns, the mentor had lost sight of the student teacher's needs; Job felt disconnected from personal and professional relationships.

Howard (2021) observes that the long-established and close personal working relationships and bonds which have been forged between student teachers and their mentors have proved to be the bedrock of the student teachers' success. However, online mentoring can easily fall into the trap of losing sight of student teachers' unique needs, particularly in asynchronous formats, where student teachers' voices and personalities are reduced to lifeless text responses on a message board (Burgess, 2007). The abruptness of the transition from face-to-face to virtual mentoring also meant that many mentees felt lost as their mentoring modality changed and they were not included in ongoing communication or goal setting (Speer et al., 2021). However, a study by Marino et al. (2022) indicates that online mentoring interactions, although different from face-to-face, are valuable and allows the establishment of supportive relationships for the mentees.

Something new coming from this study is that the COVID-19 induced e-mentoring has taught mentors and student teachers that meetings can be online using different platforms like *Microsoft Teams* and *Zoom*. This is particularly important and helpful even during face-to-face working where mentors and mentees might be at different campuses, and there is an urgent need for a discussion.

5.3.4 Mathematics teaching needs physical demonstration and students need to be prompted to be on task

Unlike subjects like history and literature where teachers and students can discuss online, mathematics needs physical demonstration where teachers and students interact.

Responding to the questionnaire, M18 wrote, “Not being able to have direct contact with the mentee and observe proper lessons,” as one of the challenges of e-mentoring. M16 wrote, “There are certain topics in mathematics that were harder to teach online than others (compass work for example). This made observing lessons and getting a true reflection of the student teacher’s ability problematic.” M20 wrote, “It is also very hard to teach maths properly online, you need to be there to see what they are doing so you can counteract misconceptions and correct errors.” It can be said that teaching mathematics online; for example, how to draw an angle of 60˚using ruler and compasses, is challenging. Observing a student teacher teaching such a topic online and giving feedback to the student teacher is equally (if not more) challenging. One of the mentors, Julie said, “Assisting student teachers teaching *Perimeter of a semi-circle, Plans, Elevations & Bearing* and using compasses online is challenging.” She explained that she had to use kitchen utensils to teach *Volume of cubes & cuboids* and *Perimeter of semi-circle*. She also said (with emphasis) “Teaching our low-level learners really need face-to-face teaching.”

Besides the physical demonstration, students often need to be reminded or prompted to be on task. Students in FE lack motivation and disengage during mathematics lessons (Noyes & Dalby, 2020), and during online lessons all student teachers and mentors (probably all teachers) agreed that students lacked interest and did not turn on their camera. This problem is not unique to FE students as Hooper and Nardi (2021) who carry out a small-scale study on university mathematics teaching and learning online observe that, “[s]tudents’ insistence on keeping cameras and microphones off was highlighted by all interviewees as the biggest challenge of the move to an online learning environment” (p. 4), and they call the online classes ‘faceless audience.’ Teaching without seeing the students (faceless audience) is problematic and could be demotivating to the teachers, especially student teachers.

Turning to internet resources which could be used in teaching mathematics online, M21 wrote, “Learning to use computer-based activities confidently” as a lesson learnt. M21 continued, “The internet is full of software which could aid teaching any topic successfully.” The challenges brought by COVID-19 have opened avenues for teachers, mentors and student teachers included, to explore the internet for resources. For example, a mentor and mentee could learn how to use different software in the classroom: virtual and physical. During an interview student teacher Cain said that when students did not understand how to find gradient of straight line $y = mx + c$, in an online lesson, he used autograph[40]. He said, “It worked really well and the students understood it.” Mentors could

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[40] Autograph is a graph plotter that comes with a broad variety of features ranging from the simple plotting of functions to the creation and analysis of statistical figures. (https://risekasap.weebly.com/autograph-maths-software.html)

continue the use of online tools learnt during the pandemic in their physical classrooms, support their student teachers and learn from them in the use of the tools.

Besides the many resources and technological tools available on the internet which aid the teaching of mathematics, it seems physical demonstration is still needed. Irfan et al. (2020) say one of the obstacles faced during teaching mathematics online is the limitations of writing mathematical symbols and the limited basic capabilities of the learning management system and multimedia software to support online learning**.** The implementation of e-learning presents new challenges to mathematics education lecturers due to difficulties in explaining mathematical concepts online without the physical demonstration (Irfan et al., 2020). Cedillo et al., (2021) argue that teaching of mathematics is a clear example of these challenges of online teaching, since it is usually considered one of the most challenging subjects, and one that conventionally requires a classroom environment to be taught appropriately. The challenge of teaching mathematics without physical demonstration brought about many benefits and the most talked about being that teachers learned how to use computer-based activities confidently, and these skills could be used in the physical classes.

5.3.5 Recording lessons and meetings

Before COVID-19 lessons were recorded but it seems the pandemic accelerated the recording. M20 gave the lesson learnt by writing the following:

> We have learnt all sorts of things, like that lessons can be recorded, or you can join in online classes to observe, both of which can be used for mentoring and reflection, and mentor meetings could be recorded as well for future reference.

Esther, when answering a question about the advantages of online mentoring said, “You can record the lessons.” At the college where Cain (student teacher) and Julie (mentor) teach, online lessons are recorded, uploaded and stored centrally for teachers to review.

Velle et al.’s (2020) study on Initial Teacher Education (ITE) during COVID-19 reports one of the advantages of online teaching as the ability to record sessions so that teachers (and students) could then go back to them. FE students studying mathematics could benefit by having lessons recorded as they could go back and ‘do’ missed lessons. Students in FE may miss class due to various reasons; for example, taking on increased responsibilities for siblings or being under pressure to make a contribution to family income by working part-time, and the most serious effect is often on mathematics since students commonly view this as the least important part of their study programme (Noyes & Dalby, 2020). This could be evidenced by an observation that student attendance for mathematics is widely reported as being lower than the college average (Greatbatch & Tate, 2018).

A student teacher might teach a lesson while being observed by the mentor and record the lesson. During the mentor meetings, the mentor and the student teacher could use the video to discuss the lesson. Letuka and Mollo (2022) report a study where student teachers record their lessons which are used by mentors and teacher education lecturers for assessment and feedback. Howard (2021) observes that alongside the use of digital platforms to support dialogue and assessment of trainees, institutions and departments have used remote observation and recording of lessons to supplement school visits. The practice of recording lessons might have been used in mathematics education research for some time; for example, in video clubs (Jacobs et al., 2010), but it seems there is little literature on recording online lessons for mentoring purposes. This observation is noted by Güler and Çelik (2022) who say, although videos are becoming widespread as resources for teacher education, a limited number of studies have focused on the use of video recordings in an e-mentoring application in order to improve professional skills such as noticing and reflecting.

Mentors and student teachers could carry on the practice of recording lessons and mentor meetings during face-to-face teaching and mentoring. As a lesson learnt from the COVID-19 lockdowns, there is need for a shift, from mentors being physically present in the classroom observing and assessing student teachers' teaching competence, to assessing video-recorded lessons. However, recording lessons has its own limitations such as child protection and General Data Protection Regulation (GDPR) considerations when seeking to observe and record 'live' images of students (Howard, 2021).

In summary, data and literature indicate that teamwork during the pandemic allowed for more time to be dedicated to mentoring and other professional activities. Teacher attitudes, access to technology, and technological literacy significantly impacted the effectiveness of e-mentoring, though teachers generally improved their technological skills during this period. Student engagement was low during online lessons. Technology improved the relation between mentors and mentees as mentors learn from mentees as well. Given the substantial evidence supporting the use of technology, I strongly recommend that *Technology* be made a core component of Initial Teacher Education (ITE) in Further Education (FE). Although e-teaching and e-mentoring posed challenges—particularly in subjects like mathematics, where physical demonstration is crucial—there were valuable lessons learned that can inform and improve post-pandemic teaching practices. Recording lessons and meetings for later review emerged as a beneficial strategy. Despite the challenges, the insights gained from this period can offer significant benefits moving forward.

5.4 Proposing a mentoring model

Data and literature (for example, Graham, 2006) show that mentoring in schools and colleges is fragmented, and lacks curricular definition; it is disconnected from other components of teacher preparation programs. Office for Standards in Education (2003) observes lack of systematic and effective mentoring arrangements for trainees on the majority of FE teacher training courses as a major weakness. Hudson (2013) is concerned that mentoring practices in FE are varied, and this has been observed in this study; the mentoring of the two main participating student teachers is varied. While both student teachers receive generic mentoring, Cain has more mathematics specific support than Job. It is hoped that a mentoring model would reduce the fragmentation and variability in the mentoring practice in FE as mentors would be guided by a clearly defined model.

Mentoring in FE does not address student teacher needs as observed by Hobson et al. (2015) who say a wide range of impediments to effective mentoring currently exist. A model which is developed with the aim of addressing student teacher needs is needed in FE ITE especially in mathematics where student teacher needs are many and varied.

Another concern which strengthens the argument for a mentoring model is about the qualifications of student teachers on entry into ITE in FE. It was observed that some FE student teachers' highest qualification in mathematics is a Grade C (now a Grade 4) at GCSE, and some have degrees in mathematics (or degrees with strong mathematics elements). This seems to be related to an observation that while mathematics student teachers in schools and in FE colleges are expected to have 'adequate' subject knowledge, this is not always the case (Rowland et al., 2005). A model is needed for mentors to assist student teachers with limited subject knowledge.

Besides the student teachers, the mentors also need assistance with their own mathematical knowledge development. Hankey (2004) says there is lack of availability of mentors who are themselves qualified to teach. Also, Eliahoo (2009) observes that not all trainees are allocated mentors and of those allocated, not all match their mentee's subject specialism; some mentors are not qualified teachers, and some have little or no training and, indeed, no wish to be mentors. The story of Mentor Julie tells what is happening in FE colleges with regards to mentoring. It is worthy looking at an interview I (Researcher) had with Julie:

> **Researcher**: Can you please tell me how you became a maths teacher?
>
> **Julie**: I started working in retail, then did *National Vocational Qualification (NVQ) Level 2*. I was then employed by the college to teach adults in workplaces. I then did *Levels 3 and 4 CTLLS [Certificate in Teaching in the Lifelong Learning Sector]* and started teaching *Adult Numeracy.* Then got forced into teaching GCSE.
>
> **Researcher**: What motivated you to be a mentor?
>
> **Julie**: I was pressured into it. But I just signed up for a mentoring course. So, I'm hoping as well that will help me. I do enjoy maths well but I’m not like an A Level maths person, so obviously when you've got someone like Cain's [name changed] maths which is just far superior to mine.

Julie does not have any qualification in mathematics, but is mentoring a student teacher to teach mathematics. Additionally, a large proportion of the FE mathematics workforce is non-specialist (Noyes et al., 2018). The mentors come from the pool of non-specialists mathematics teachers. Surely, there is need for a model to guide these mentors.

Based on the reasons mentioned above, there is a strong argument for proposing a mentoring model that could be employed by mentors to assist in the mathematical and pedagogical knowledge development of mathematics student teachers in FE by addressing the student teachers’ needs. I propose these themes (see Section 5.1): *Doing mathematics; Observing (and learning from) experienced teachers;* and *Teaching mathematics* be taken as elements of a normative model*: The DOT Mentoring Model* (Figure 5.11), as it proposes ways that could address the student teacher needs identified (see Section 4.3.2) in the data analysis in this study. In the following section, I present the proposed model.

5.4.1 The DOT Mentoring Model: The Doing mathematics- Observing (and learning from) experienced teachers -Teaching mathematics

It should be stated that the proposed model is not linear; mentors could employ the elements in any order depending on a particular student teacher’s needs. However, it is suggested that mentors work mathematics questions with the student teachers and encourage (or asking) them to observe (and learn from) experienced teachers including their mentors. It is recommended that student teachers be assisted in teaching mathematics in general, teaching specific mathematics topics, and attending to mathematical errors. The model works well in an environment where there is institutional commitment to *Mentoring structure* and *Training mentors* (see Section 5.2). It is recommended that lessons learnt during COVID-19: *Teamwork* and *Use of digital technology* in teaching be put in place (**see Section 5.3) when employing the model.**

Finally, the model is not a standalone model; it is developed from a study grounded on a well-established theory – the Knowledge Quartet (KQ) (Rowland et al., 2009). The elements of the proposed model are related to the KQ dimensions and codes (see Section 5.1).

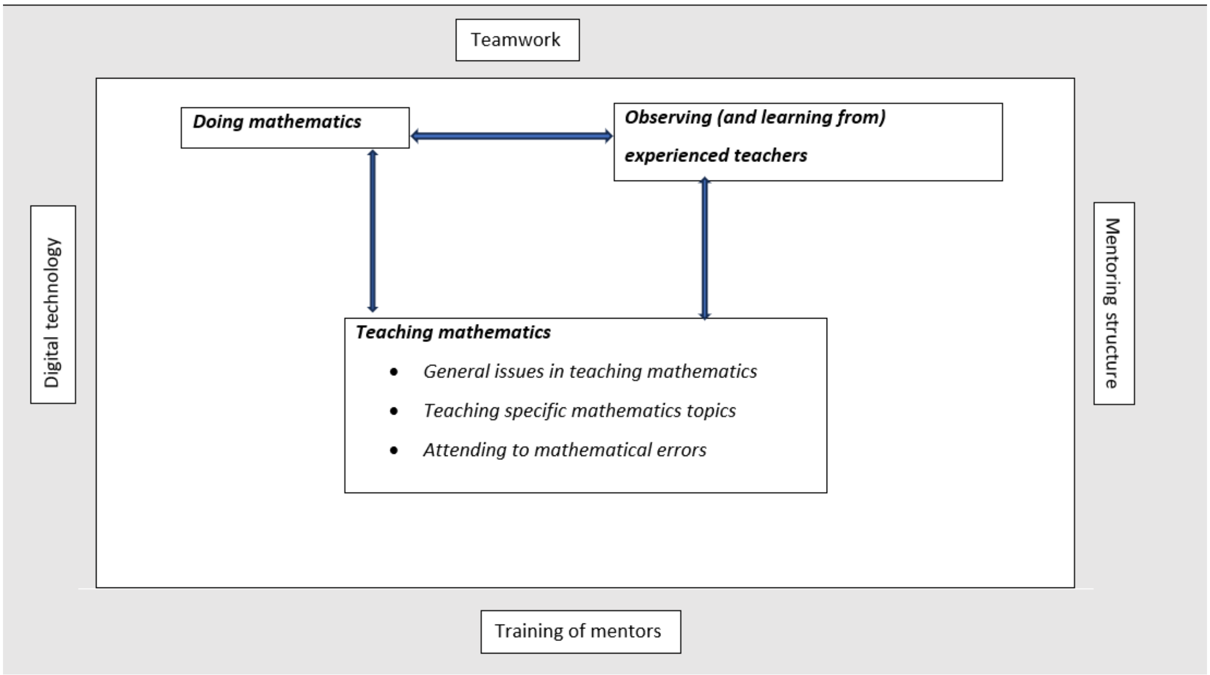

Figure 5. 11 The DOT Mentoring Model

After introducing the new model, I explain its significance in comparison to existing models. By examining four established mentoring models, I illustrate the unique benefits and advancements of *The DOT Mentoring Model*. I highlight the intended purposes of these established models and demonstrate the necessity of *The DOT Mentoring Model*.

5.4.2 How The DOT Mentoring Model relates to other mentoring models

In this section, I discuss two generic mentoring models, one mathematics-specific model, and one model specific to FE mathematics student teachers (see Section 2.3.5). I examine how these models relate to *The DOT Mentoring Model*, highlighting their intended purposes and identifying areas they do not address, which *The DOT Mentoring Model* aims to address. It is important to note that *The DOT*

Mentoring Model is not meant to replace these existing models, but rather to complement them, offering an additional approach to mentoring.

Wang and Odell’s (2002) Humanistic, situated apprenticeship and critical constructivist model

The humanistic perspective is concerned with the importance of emotional support where mentors are expected to function as counsellors, friends, and good listeners. From the apprenticeship perspective, learning to teach emphasizes the importance of collaborating with expert teachers and mentors who are expected to function as coaches or models of teaching for novices. From the critical constructivist perspective, mentors and prospective teachers are regarded as generators and learners of new knowledge and practices.

Wang and Odell’s (2002) Humanistic, situated apprenticeship, and critical constructivist model addresses fundamental mentoring issues, such as the mentor-mentee relationship, and collaboration between the mentor and the student teacher which are crucial for the development of student teachers. This approach proved particularly important during the COVID-19 lockdowns, when e-teaching and e-mentoring practices highlighted instances where mentors were learning from student teachers (see Section 5.3.1). The apprenticeship perspective, which positions mentors as coaches or teaching models for novices, aligns with the *Observing (and learning from) experienced teachers* element of *The DOT Mentoring Model*.

However, Wang and Odell’s (2002) model is not subject-specific; therefore, it does not address the particular gaps in subject knowledge that student teachers might have. This makes it less suitable for Further Education (FE) student teachers, particularly those in mathematics, who often exhibit varying degrees of subject and pedagogical knowledge. These specific needs can be addressed more comprehensively by *The DOT Mentoring Model*.

Li et al.’s (2021) Roles of mentoring.

Li et al. (2021) investigate the roles played by mentors, and come up with a model they call *Role of mentoring* with the following stages:

- creating a good relationship with the pre-service teacher
- informing pre-service teachers about the school system
- sharing pedagogical knowledge
- being observed by pre-service teachers

- addressing various aspects when providing feedback

Li et al.’s (2021) *Roles of mentoring* model addresses several issues about mentoring student teachers. The model encourages good relationship between the mentor and the student teacher which is very important in assisting the development of student teacher’s subject and pedagogical knowledge. Additionally, the model highlights the significance of familiarizing student teachers with the school or college system, including its policies; this helps student teachers to integrate smoothly into the new environment. While *The DOT Mentoring Model* does not address these issues, its meeting point with the *Roles of mentoring* model is on *Sharing pedagogical knowledge* and *Being observed by pre-service teachers*; both models advocate for student teachers to learn from their mentors.

Like Wang and Odell’s (2002) *Humanistic, situated apprenticeship and critical constructivist* model, Li et al.’s (2021) *Roles of mentoring* model is generic and does not address the subject knowledge gaps making it less suitable for FE mathematics student teachers in the generic Initial Teacher Education (ITE). This is where *The DOT Mentoring Model* becomes particularly valuable, as it is tailored to enhance the mathematical and pedagogical knowledge development of mathematics student teachers.

Campton and Stevenson’s (2014) Mentoring strategy

In an effort to increase ‘the mathematics’ in mentor meetings discussions, Campton and Stevenson (2014) advise that it is important discussions with beginning (and student) teachers do not focus only upon generic features; for example, classroom organisation, behaviour management and lesson structure, but also upon ‘the mathematics’ itself. Discussions are expected to include how the mathematics being taught has informed choice of examples and tasks, how learners’ understanding developed, and how the teacher’s own understanding has changed through the process of preparing to teach a topic (Campton & Stevenson, 2014).

Unlike the generic models proposed by Wang and Odell (2002) and Li et al. (2021), Campton and Stevenson’s (2014) *Mentoring Strategy* model is specific to mathematics teaching. Similar to *The DOT Mentoring Model*, Campton and Stevenson’s (2014) model focuses on addressing the needs of student teachers in mathematics by encouraging mentors to discuss issues such as ‘the choice of examples and tasks’ during mentor meetings.

Campton and Stevenson's (2014) model, which is designed for mentoring mathematics teachers in secondary schools does not offer assistance in addressing gaps in mathematics subject knowledge. This might be because a degree in mathematics (or a degree with a strong mathematics component) is generally a prerequisite for entry into secondary school Initial Teacher Education (ITE). In contrast, individuals with only a GCSE Grade C (now Grade 4) in mathematics can pursue training to become GCSE mathematics teachers in further education (FE) (see Table 4.1 in Section 4.1). *The DOT Mentoring Model* is designed to specifically address mathematics student teacher needs like *Gaps in mathematical knowledge* and *Improper use of terminology (and mathematical errors).*

Norley's (2017) Stages of mentoring

In the academic year 2014-2015, Kevin Norley was asked to mentor three mathematics student teachers undertaking Postgraduate Certificate in Education (PGCE) in post-compulsory education in an FE college in England (Norley, 2017). Kevin Norley gives the stages of the mentoring process he followed over the year which are:

- initial discussion with the student teacher
- student teacher observation of the mentor
- initial observation
- questioning and challenge
- area of development; summary and reflective practice
- concluding the mentor/mentee relationship; and looking into the future (Norley, 2017)

Norley's (2017) model is specific to mathematics student teachers in FE, and is very similar to *The DOT Mentoring Model.* Norley's (2017) model encourages mentors to demonstrate pedagogical approaches whereby methods used in problem solving are accepted and encouraged provided that they lead, through workings that can be followed and checked to a correct mathematical answer. This could be visible in *Observing (and learning from) experienced teachers* and *Teaching mathematics* elements of *The DOT Mentoring Model*.

While Norley's (2017) model looks comprehensive enough to address most student teacher needs, it does not address the *Gaps in mathematics student teacher* need. This is the gap *The DOT Mentoring Model* addresses.

The DOT Mentoring Model serves as a complementary approach to existing mentoring models by addressing areas which do not cover their intended purposes, particularly for FE mathematics student teachers. Wang and Odell's (2002) model emphasizes emotional support and collaborative learning but lacks subject-specific focus. Li et al.'s (2021) model promotes strong mentor-mentee relationships but is also generic. Campton and Stevenson's strategy focuses on mathematics teaching at secondary school level, and does not address FE specific issues. Norley's model is comprehensive and tailored to mathematics FE student teachers but doesn't address gaps in mathematical knowledge.

5.5 Conclusion

In Chapter 4, I reported the finding of the data collected using mathtasks, classroom observations, mentor meeting observations, interviews with the student teachers, interviews with the mentors and documents in form of mentor reports, with the Knowledge Quartet (KQ) and thematic analysis used as the analytic tools. In Chapter 5, I reported the findings of data collected using mentor completed anonymous questionnaire and mentor interviews, and the data were thematically analyzed. As some themes reported in Chapter 4 were further investigated in Chapter 5, the analysis in Chapter 5 also includes data reported in Chapter 4.

Data analysis also show mentors calling for mentoring to have a structure and mentors to be trained. FE mathematics teachers are advised to teach for conceptual understanding while referring to examinations, and also contextualise their examples to their students' vocational areas of study and real-life situations. There were challenges of e-mentoring; and also, lessons that could be beneficial post COVID-19 era. The COVID-19 triggered e-mentoring taught the education community the importance of teamwork, digital technology, the need to sustain professional and personal relationships and how to teach online topics which need physical demonstration. The need to record lessons and meetings is one of the lessons which could be beneficial post COVID-19.

How mentoring could assist in the development of mathematical and pedagogical knowledge of mathematics student teachers in FE could be summarised by three themes: *Doing mathematics; Observing (and learning from) experienced teachers;* and *Teaching mathematics*; these themes give rise to a proposed model*: The DOT Mentoring Model*.

In Chapter 6, I conclude the study.

6 Conclusion

6.0 Introduction

In this chapter, I remind the reader of the aim of the study and give its brief summary. This is followed by presenting research questions (RQs). Then, the summary of the findings is presented diagrammatically followed by discussing how the findings address the RQs. The study's substantive, theoretical and methodological contributions are discussed. The implications and recommendations of the study to policy makers and practitioners are given. This is followed by a discussion of the limitations of the study. Then, I move on to give the areas which could be suitable for future research. I conclude the chapter (in fact, the research study) with my personal reflections on conducting this study.

6.1 The aim of the study and a summary of the research process

The aim of this study is to develop an empirically grounded normative framework on how mentoring could assist the development of mathematical and pedagogical knowledge of further education (FE) mathematics student teachers.

The study was conducted in two interrelated phases, with Phase 1 feeding into Phase 2. During *Phase 1*, data were collected from five student teachers and two mentors using mathtasks, lesson observations, mentor meeting observations, interviews with student teachers, interviews with mentors, and documents which are mentor reports. Mathtasks can be described as classroom situation-specific incidents which are hypothetical but grounded on learning and teaching issues that previous research and experience have highlighted as seminal and are likely to occur in actual practice (Biza et al., 2007) (for full detail see Section 3.4.1.1). The Knowledge Quartet (KQ) (Rowland et al., 2009) in tandem with the thematic analysis (Braun & Clarke, 2006) were employed to analyse the data. *The mathematical and pedagogical knowledge enacted by student teachers in teaching* was brought to surface, and *student teacher needs* were identified. *How mentoring addresses the student teacher needs*, and *Institutional issues that could influence mentoring* were identified, and these two findings were further investigated during *Phase 2*.

During *Phase 2*, data were collected from ten mentors who responded to an anonymous questionnaire, and from seven out of the ten who were interviewed. The data, together with *Phase 1* data, were analysed using thematic analysis. More information on *How mentoring addresses the student teacher needs* was obtained. Also, more information on *Institutional issues that could* *influence mentoring* was brought to surface. *Challenges faced and lessons learnt during e-mentoring mathematics student teachers during the Covid-19 lockdowns*, emerged.

6.2 The research questions (RQs)

The research questions (RQs), given in Chapter 1 and stated below, were identified having in mind the Knowledge Quartet (KQ) theoretical framework dimensions: *Foundation, Transformation, Connection* and *Contingency*, and thematic analysis as the lenses through which I would achieve the aim of the study.

To achieve the aim, I attempt to address the following RQs:

- **RQ 1**: What mathematical and pedagogical knowledge is enacted by further education mathematics student teachers in teaching, and what are the student teacher needs?
- **RQ 2**: How does mentoring address the student teacher needs, and what institutional issues influence mentoring practices?
- **RQ 3:** What are the challenges and lessons learnt during e-mentoring further education mathematics student teachers during COVID-19 lockdowns?

6.3 Summary of the findings and answering research questions

I introduce this section by presenting a diagrammatic representation of the findings of the study (Figure 6.1). The colour coding represents the five different areas investigated in this study. The areas colour coded blue and brown represent issues explored during *Phase 1* addressing RQ 1. The areas colour coded yellow and green represents areas investigated during *Phase 1* and further investigated during *Phase 2* and they address RQ 2. The area colour grey represents areas which were explored during Phase 2 and addressing RQ 3. This is followed by a summary of the findings, and how the RQs are answered.

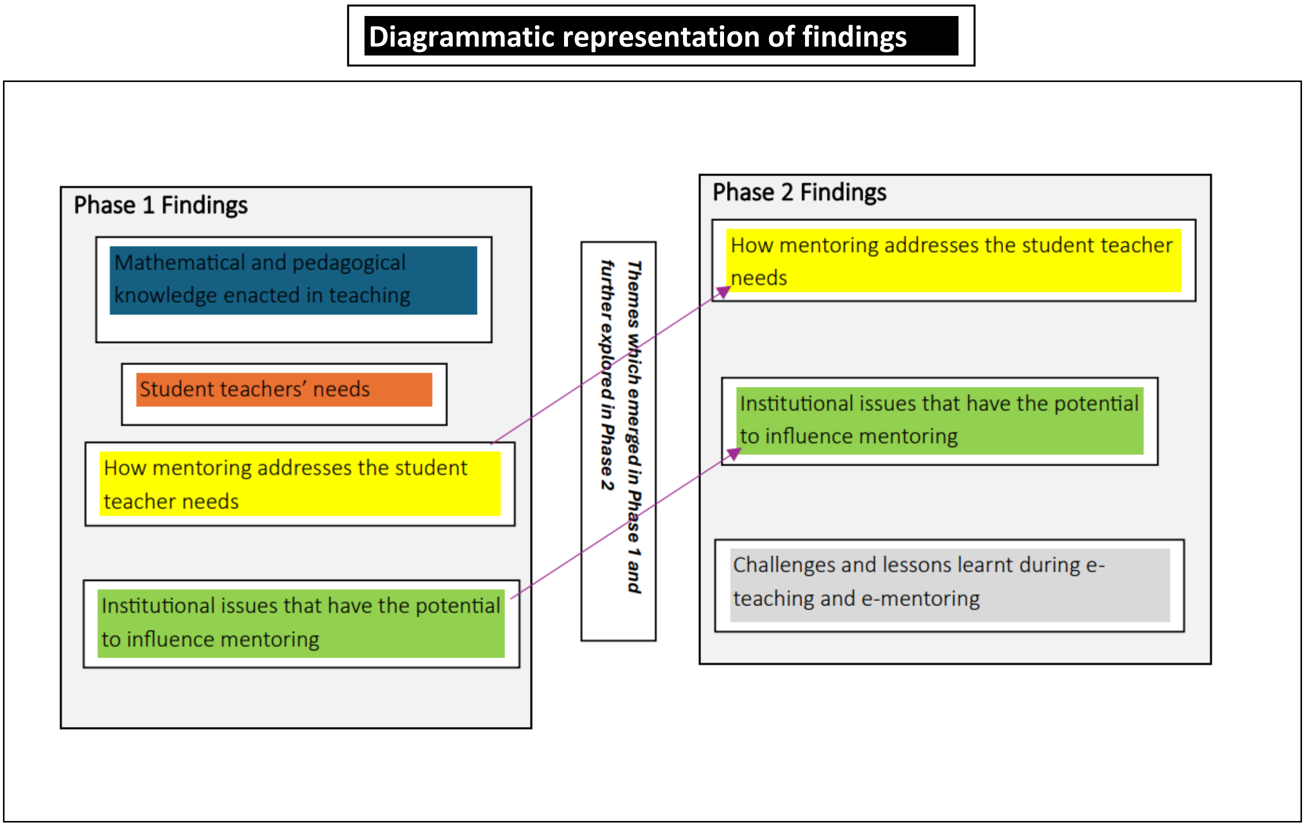

Figure 6. 1 Diagrammatic representation of findings

6.3.1 Answering RQ 1

In an attempt to answer RQ 1, student teachers completed mathtasks, and were observed teaching online throughout the 2020/21 academic year[41]. Mentors and student teachers were interviewed and mentor meetings were observed. Additionally, mentoring reports about the performance of the student teachers were collected. Using the KQ and thematic analysis to analyse the data, the knowledge enacted during the teaching is bought to surface, and student teacher needs are identified.

6.3.1.1 Mathematical and pedagogical knowledge enacted by further education mathematics student teachers in teaching

The subject knowledge of the student teachers is varied. Two out the five student teachers are observed to have 'secure' subject knowledge with fewer errors observed. The other three are observed to have 'insecure' subject knowledge with more errors observed. The two main participating student teachers are seen to be (over) relying on the internet for resources in their teaching, and there is no evidence to suggest that they check for the accuracy and suitability of the resources for their classes. Two of the five participating student teachers' theoretical underpinning of pedagogy is

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[41] The UK academic year runs from September to July.

observed as they mention theories like *Pedagogical Content Knowledge (PCK),* which is the integration or amalgamation of pedagogy and content knowledge (Hyde & Jones, 2014), and common misconceptions during interview and while responding to mathtasks. There is no evidence to show the other three student teachers' knowledge of theoretical underpinning of pedagogy. During teaching, the explanation of the student teachers is observed to be procedural and in most cases a single method is used. The choice of representation is observed as the student teachers use a lot of diagrams to demonstrate the concepts they are teaching. The differentiating of examples assigned to students for practising is observed at both ends: differentiation and no differentiation; examples used by one student teacher are differentiated to cater for different ability groups while there is no evidence to show that examples used by the other student teacher are differentiated. The student teachers' lessons are observed to be overloaded with different topics which are unrelated; there are no connections between concepts, between procedures and between representations. Student teachers use colloquial terminology more than mathematical terminology. The anticipation of complexity of topics is observed as the student teachers explain common mistakes students make and warn the students of the anticipated difficulties. There is a lot of mentioning of examination and examination style questions are used in every lesson showing the recognition of the conceptual appropriateness of the *General Certificate of Secondary Education (GCSE)* FE one year revision course whose main purpose is making students pass the examination. References to real-life situations and the vocational area of study are made in some cases. *Contingenc*y is difficult to observe during online lessons without having access to the chat, but there are some instances, especially in responses to mathtasks, which show the student teachers' intentions to use student understanding to move the lessons forward. Adjusting lessons due to the (un)availability of resources is observed, but rarely, during the observed lessons.

Having analysed the data and discussed the results with reference to the student teachers' qualifications, it seems there is connection between 'good' subject knowledge and successful teaching. It is observed that student teachers with higher qualifications (for example, A-Level mathematics and a degree in mathematics or a degree with a strong mathematics component) make fewer errors in teachers and relate teaching to theory (theoretical underpinning of pedagogy) while student teachers with lower qualifications (for example, Grade C mathematics at GCSE) make more errors in teaching and do not relate their teaching to theory. Literature supports this assertion; for example, Stevenson (2020) who says it is generally agreed that 'good' subject knowledge is an important prerequisite for successful teaching.

6.3.1.2 Student teachers' needs

In an attempt to identify the mathematical and pedagogical knowledge enacted during teaching, student teacher needs are identified. Student teacher needs discussed in the previous section are:

- gaps in subject knowledge
- relying on procedural explanations
- sticking to a single method
- lack of clarity in explanations
- limited connections made between examples, between procedures and between representations
- lack of theoretical underpinning of pedagogy
- Improper use of terminology (and mathematical errors)
- (over) rely on internet resources

The student teachers' mathematical and pedagogical knowledge enacted during teaching is varied; therefore, it follows that the student teacher needs are also varied. The student teacher needs identified in this study are also mentioned in literature. FE student teacher needs are varied as their experiences and qualifications on entry into Initial Teacher Education (ITE) courses are varied (Greatbatch & Tate, 2018; Maxwell, 2014). Some student teacher needs, especially gaps in mathematical content knowledge, are a result of low qualifications as observed by researchers in mathematics education; for example, Ball et al. (2008), Ma (1999) and Rowland et al. (2005) and Government agencies; for example, Education and Training Foundation (2016).

6.3.2 Answering RQ 2

In an attempt to answer RQ 2, data were collected by interviewing student teachers, interviewing mentors, observing mentor meetings, collecting mentoring reports and questionnaire responded to by mentors. The KQ and thematic analysis were employed to identify common themes which show how mentors address student teacher needs. Institutional issues that could influence mentoring practices, but could not be categorised under the four KQ dimensions: *Foundation, Transformation, Connection* and *Contingency,* are identified.

6.3.2.1 How mentoring addresses the student teacher needs

As mentioned in Chapter 4 (see Section 4.3.3), Initial Teacher Education (ITE) in the Further Education and Training sector (FE) is mostly generic (Maxwell, 2014; Lucas, et al, 2012), and subject specialism relies on trainees' ability to contextualise their learning to their own specialism with the support of subject mentors (Lucas et al., 2012). Lawy and Tedder (2012) claim that it is not clear whether the emphasis of mentoring is upon support for the learning and professional development of the student teacher, or whether the aim is focused upon assessment and the decision to award a qualification and a licence to practice in the sector. Mentoring observed in this study, is for formative support; it is not used as a tool for assessment of competence, and this is not in agreement with Lawy and Tedder's (2012) study.

Mentors are observed working through mathematics questions with their student teachers as a way of enhancing their (student teachers and the mentors as well) mathematical content knowledge. This is a way of making subject matter a part of the conversation between the mentor and the student teacher (Feiman-Nemser & Parker, 1990). Student teachers, besides learning from their mentors, also learn from different sources which include observing more experienced teachers, informal encounters with colleagues, conferences, and Education and Training Foundation (ETF) training. Learning from experienced teachers observed in this study is also mentioned by Cain (2009) and Hobson (2002) who say student teachers learn by imitating their mentors (and other experienced teachers) teaching practices. Mentors are observed assisting student teachers on the use of technology in the classroom, and on teaching specific mathematics topics. As mentioned earlier, subject specialism in a generic teacher education environment, relies on trainees' ability to contextualise their learning to their own specialism with the support of subject mentors (Lucas et al., 2012); this might be interpreted to mean mentors assist in teaching specific topics. Besides assisting in the teaching of specific topics, mentors are observed discussing general teaching of mathematics. Campton and Stevenson (2014) say mentors and student teachers should take time to talk about mathematics. Student teachers (and any other teacher) make errors in teaching, and mentors are observed attending to the mathematical errors. Norley (2017) says after lesson observation during feedback, the student teachers should be asked a range of open and probing questions to give them the opportunity to reflect further upon their sessions; this should include identifying areas for development including the errors in teaching relating to the observations.

To sum up this section, data and literature agree that mentors could assists the development of mathematical and pedagogical knowledge of mathematics student teachers by addressing the student teachers' needs. This could be done by working through mathematics questions (doing mathematic) with the student teachers, encouraging the student teachers to observe (and learn from) more experienced colleagues, and assisting the student teachers in teaching. Assisting in teaching includes enlightening student teachers on general issues in teaching mathematics, teaching specific mathematics topics and attending to mathematical errors.

6.3.2.2 Institutional issues that have the potential of influencing mentoring

Mentoring is carried out haphazardly due to lack of a structure, and mentor meetings are often informal and happen only when time is found. The data and literature (for example, Lin & Acosta-Tello, 2017) show the need to develop a mentoring structure where mentoring is timetabled for both the mentor and the student teacher. Also, data and literature (for example, Hobson et al., 2015; Hankely, 2004; Luneta, 2003) point to the fact that mentoring could improve if mentors are trained. Due to lack of enough time to cover a two-year GCSE mathematics course in one year (Noyes & Dalby, 2020), mentors say student teachers (in fact all teachers) should teach for conceptual understanding while referring to the examination. Mathematics students in FE, according to mentors, student teachers and literature (for example, Noyes & Dalby, 2020) lack motivation and could easily disengage as they feel they are 'forced' to study mathematics (and English). Connecting the teaching of mathematics to the students' vocational courses and real-life, although not always straight forward, could make the students see the 'user-value' of mathematics and this could improve engagement and motivation.

In summary, Institutional issues that have the potential of influencing mentoring are: *Mentoring structure; Mentor training; Teaching for examinations; and Contextualising mathematics to vocational courses and life experiences.*

6.3.3 Answering RQ 3

In an attempt to answer RQ 3, data were collected by interviewing student teachers and mentors and inviting mentors to respond to a questionnaire, which among other questions, required responses to a question about challenges of e-mentoring during the COVID-19 lockdowns, and lessons learnt. The data were thematically analysed.

6.3.3.1 Challenges faced – and lessons learnt – during e-mentoring mathematics student teachers in FE during the Covid-19 lockdowns

COVID-19 forced e-teaching and e-mentoring brought about many challenges, but from these challenges the education system (and other sectors in the economy) learnt a lot which is beneficial post pandemic.

Before COVID-19 lockdowns, data and literature (for example, Savory & Glasson, 2009) show that mentors and student teachers had little time for mentor meetings and other mentoring activities like lesson observations. During COVID-19, teachers had to share ideas and there was teamwork in planning and preparing resources which left mentors and student teachers with time for mentoring activities. Teamwork increased time for mentoring activities and this could continue during the post COVID-19 era. It appears, there is no (or very scarce) literature on 'teamwork increasing time for mentoring.'

Teachers have been using digital technology in their mathematics (and other subjects) classrooms for a long time (see Armstrong, 2014), but COVID-19 accelerated the use, and with the acceleration came challenges and opportunities. The most common challenges when using technology was mentor and student teacher attitude, and technological literacy as noted by Mulenga and Marbán (2020). Teachers had to teach online; therefore, the attitude had to change and they had to be trained (self-training and/or trained by colleagues). Availability of technology which is the physical (computers and smart phones) and connectivity (internet) were challenges reported by mentors and observed during lessons, and also seen in literature (for example, Chirinda et al.'s, 2021). Data and literature (for example, Meletiou-Mavrotheris et al., 2023) show that teachers (including mentors and student teachers) found it difficult to engage students online but the use of 'engaging' digital technology tools helped alleviate the problem. The use of technology increased collaboration among mentors and student teachers as mentors also learn from student teachers (Shields et al.'s, 2021). Mentors and literature, especially Shields et al. (2021) call for technology to be part of ITE in FE.

Mentors observe one of the challenges faced by teachers especially student teachers, while working online, as loss of personal and professional relationships with other student teachers and more importantly with their mentors. It seems there is no literature on loss of personal and professional relationships during the pandemic and this study might be the first study to bring the issue to attention. This experience taught mentors and student teachers (in fact the whole education community and beyond) that communication is important and could be maintained using online platforms like *Zoom* and *Microsoft Teams*. This could continue during the post COVID-19 era.

According to mentors and literature (for example, Irfan et al., 2020) teaching mathematics needs physical demonstration; for example, constructing angles using a pair of compasses. Observing student teachers' online lessons which need physical demonstration was challenging to mentors. These challenges opened avenues for the discovery of internet software and resources which could assist in teaching different topics which otherwise could have been impossible to teach without physical demonstration. The software and resources learnt (or discovered) during the pandemic are useful even when the pandemic is over, and the teaching and learning has returned to face-to-face.

Online teaching increased the use of computer/online marking using software, like *Microsoft forms,* which assesses students' work and give feedback. This also released time for mentoring activities. On computer marking, Lu et al. (2023) are seen encouraging online assessment as it provides immediate feedback to students and saves time which could be used for other professional activities like lesson observations. Computer marking was in existence during the pre-pandemic era, increased during the pandemic era, and could continue during the post pandemic era.

Mentors and literature (for example, Velle et al.'s, 2020) agree that recording lessons and meetings is beneficial to mentors and student teachers, as the recordings could be used to facilitate discussions. Recorded lessons could also be beneficial to students who miss lessons.

The challenges during the COVID-19 lockdowns have turned into opportunities. The problem of not knowing how to teach online leads to teamwork which saves time. The teaching online was problematic to teachers but it leads to increased use of technology in teaching. Some of the opportunities from the challenges include use of platforms like *Zoom* and *Microsoft Teams* for meetings and communication leading to maintaining personal and professional relationships; and recording lessons and meetings.

6.4 The study's substantive, theoretical and methodological contributions

6.4.1 Substantive contribution

The study has made substantive contribution by highlighting what mathematics student teachers and mentors in the further education context do (data from observation: lessons and mentor meetings), and their perceptions of mathematics education (data from interview and mentor meetings). Data from mathtasks has also shown student teachers' understanding of the mathematics at GCSE level (subject knowledge) and how to teach the mathematics (pedagogical knowledge).

6.4.2 Theoretical contribution

One of the key triggers of this study is to cover the gap in literature about the mentoring of mathematics student teachers in further education context. Whilst much research has been carried out on school-based mentoring of mathematics teachers (students and qualified), a relatively small amount of research in FE exists. Researchers on mentoring in FE concentrate on generic mentoring. This leaves mentoring mathematics student teachers in FE under-researched, and this study contributes to literature by filling the gap.

More importantly, this study has contributed to theory by proposing an empirically grounded normative model: *The DOT Mentoring Model*. Additionally, the study suggests some amendments to the formulation of certain KQ codes.

6.4.2.1 The DOT Mentoring Model

This study has contributed to theory by proposing an empirical mentoring model: *The DOT Mentoring Model* (see Figure 5.11 in Section 5.4 Chapter 5) which has three key elements: *Doing mathematics – Observing (and learning from) experienced teachers – Teaching mathematics. The DOT Mentoring Model* should be taken as a normative model as it proposes ways of how mentoring is expected to be done. The proposed model is an attempt to support mentors in assisting the mathematical and pedagogical knowledge development of mathematics student teachers in the Further Education and Training sector (FE) by addressing the student teachers' needs. The model is mathematics specific in the generic Initial Teacher Education (ITE) environment. Mentoring in FE is varied (Hudson, 2013), fragmented and lacks curricular definition, and disconnected from other components of teacher preparation programmes (Graham, 2006). *The DOT Mentoring Model* is intended to reduce the fragmentation and variability in the mentoring practice in FE as mentors would be guided by clearly defined steps.

In the following section, I provide a summary of the elements of *The DOT Mentoring Model*, focusing on the student teacher needs each element aims to address. I highlight how these elements align with the theories of mentoring: *Learning through Apprenticeship* and *Learning by Reflecting,* as outlined by Cain (2009). Additionally, I discuss the relationship between *The DOT Mentoring Model* elements and the Knowledge Quartet dimensions and corresponding codes.

Doing mathematics

Mentors say they work through mathematics questions with their student teachers, which is *Doing mathematics*, and they were observed doing that; for example, going over past examination papers. This element aligns with Feiman-Nemser and Parker (1990) who say working mathematics with the student teacher is a way of making mathematics a part of the conversation in learning to teach. *Doing mathematics* with student teachers could be seen as a way of addressing the 'gaps in subject knowledge' student teacher need through *Learning by reflecting* and *Learning through apprenticeship.* This element could be seen as related *Overt subject knowledge* of the KQ's *Foundation* dimension.

Observing (and learning from) experienced teachers

Mentors are of the opinion that student teachers learn through the influence of experienced teachers; therefore, they could be encouraged (or asked) to observe experienced teachers, including their mentors, teaching topics they find difficult to teach and/or have gaps in mathematical content knowledge. This element aligns with literature (for example, Cain, 2009; Hobson, 2002) which says student teachers learn by imitating their mentors. Norley (2017) encourages student teachers to observe their mentors teaching. This element could be seen as *Learning through apprenticeship* and addressing all student teacher needs, and relating to all the KQ dimensions: *Foundation, Transformation, Connection* and *Contingency*, as student teachers observe (and learn from) experienced teachers in order to develop in all aspects of teaching.

Teaching mathematics

The element *Teaching mathematics* is divided into three sub-elements: *General issues in teaching mathematics; Teaching specific mathematics topics;* and *Attending to mathematical errors*, which are briefly discussed below.

Mentors and their student teachers are observed discussing mathematical issues; for example, misconceptions and common mistakes made by students. This theme supports researchers like Campton and Stevenson (2014) who observe mentors expressing their willingness to discuss mathematical issues with their student teachers. Discussing general issues in teaching mathematics could be viewed as *Learning by reflecting*. This sub-element aims at addressing limited knowledge of *Theoretical underpinning of pedagogy* need as the discussion could include theories of learning, student misconceptions and common errors in learning mathematics. This sub-element is more visible in the *Theoretical underpinning of pedagogy* code of the *Foundation* dimension.

According to data, mentors and student are observed discussing how to teach specific topics. This sub-element includes the mentor discussing lesson plans and resources with the student teacher before lesson delivery. There is no literature (or there is very little) specific to mentors and student teachers discussing the teaching of specific mathematics topics in the FE context; therefore, this sub-element might be a new addition to literature. This sub-element could be seen as *Learning through apprenticeship*, and aiming at addressing all student teacher needs. Teaching specific mathematics topics is seen in all KQ dimensions but appears to be more visible in *Teacher demonstration* code of the *Transformation* dimension.

Student teachers, like anyone else, make errors while teaching. After lesson observation, the mentor could pay attention to correcting the errors observed in teaching . The mentors and literature; for example, Norley (2017) agree that student teachers' errors in teaching should be addressed. This sub-element aims at addressing *Improper use of terminology (and Mathematical errors)* student teacher need, and it could be seen as *Learning through apprenticeship* and *Learning by reflecting*, and related to the *Transformation* dimension of the KQ especially *Teacher demonstration*.

Employing *The DOT Mentoring Model*, developed from this study which is grounded on the KQ and related to its dimensions and corresponding codes, could be useful to mentors in assisting student teachers' mathematical and pedagogical knowledge development by addressing student teachers' needs. The model works well if mentors are trained (and valued) and there is a mentoring structure. There should also be institutional commitment to teamwork and use of digital technology in the classroom.

6.4.2.2 Amendments to the formulation of some KQ codes

Another contribution of this study to theory is proposing some amendments to some KQ codes. The original developers of the KQ, Rowland and Turner (2017) do not rule out additions and revisions of codes when saying:

> Although our experience to date indicates that the fundamental anatomy of the Knowledge Quartet is complete, we take the view that the details of its component codes, and the conceptualisation of each of its dimensions, are perpetually open to revision (p. 108).

I am aware that the KQ was developed when teaching and learning took place in the physical classrooms and the use of digital technology was not all that important. In response to the rapid integration of technology into the teaching and learning of mathematics accelerated by the COVID-19 pandemic, there is a pressing need for mathematics teachers to develop their technological literacy.
Kayali (2019) adopts a broader view of resources in which resources can be material resources (e.g. textbooks) or social interactions (e.g. discussion with colleagues), and makes suggestions of new codes for the KQ. The additions Kayali (2019) suggests are "[u]se of resources (under *Transformation*), knowledge of examination requirements (under *Foundation*), knowledge of software (under

Foundation) and connections between resources (under *Connections*)" (p. 188). Looking at Kayali's (2019) suggestions and this study, technological literacy (which Kayali calls knowledge of software) stands out as the most significant in mathematics teaching and learning; therefore, I propose an additional code: *Use of Technology* to the *Transformation* dimension.

During the pandemic (and probably a few years before), the use of textbooks was overtaken by the use of internet resources; therefore, I also propose the *Foundation* code *Adherence to textbook* be amended to *Adherence to internet resources and textbooks*.

6.4.3 Methodological contribution

The study's methodological contribution is the proposal of new mathtasks as instruments for data collection. These mathtasks, which can be used in teacher education to trigger student teachers' reflection and explore their mathematical knowledge for teaching (Biza et al., 2007), have been designed and employed in the FE context. Additionally, these mathtasks are available for use by other researchers as data collection instruments. Furthermore, the study demonstrates the versatility of the Knowledge Quartet (KQ) framework, originally intended for analyzing data from observed lessons, by showing its applicability in analyzing data derived from mathtasks, mentor meeting observations, interviews, and questionnaires.

6.5 Implications and recommendations for practice and policy

The study has shed light into the practice of mentoring mathematics student teachers in FE with specific reference to the role of mentoring in the development of mathematical and pedagogical knowledge of further education mathematics student teachers. The results of this study have the potential of influencing practice and policy in mentoring in general and mentoring mathematics student teachers in FE in particular.

Practice: The understanding of the mathematical and pedagogical knowledge enacted by FE mathematics student teachers in teaching, and student teacher needs has the potential to improve how mentors support student teachers in addressing their needs. As student teachers who come into the FE ITE are from different academic and professional backgrounds (Greatbatch & Tate, 2018), mentors are recommended to first identify the knowledge enacted by the student teachers in teaching and student teacher needs. After the needs identification, mentors are advised to address the needs by employing *The DOT Mentoring Model* which is made up of three elements: *Doing mathematics; Observing (and learning from) experienced teachers; and Teaching mathematics.*

As per study’s conclusion regarding teaching for examinations, I recommend that FE mathematics teachers teach for conceptual understanding while referring to examinations, and student teachers could be mentored to do that as well. Data and literature show that FE mathematics students are not motivated to study mathematics; therefore, I recommend mentors assist their student teachers to connect the teaching of mathematics to students’ vocational courses and real-life experiences as this shows the ‘user-value’ of mathematics (Noyes & Dalby, 2020), and could motivate students to study mathematics.

Practitioners (mentors and student teachers included) should consider the lessons the education system learnt during COVID-19 lockdowns which could be carried forward to post pandemic era. This includes teamwork, use of digital technology, maintaining personal and professional relationships, and recording lessons and meetings.

Policy: Some of the problems in mentoring FE student teachers are a result policy inconsistency. This study recommends the enactment of polices in some areas of mentoring.

Education and Training Foundation (ETF) launched a *Mentoring Framework* posted on its website[42] on 7 June 2021, which is accompanied by three guides: one for mentors, one for mentees and one for leaders. The framework aims to:

- establish a shared understanding of effective mentoring practice
- enhance the quality of mentoring for practitioners
- ensure that mentoring is supportive and nurturing
- help mentees and mentors to develop teaching, learning and assessment strategies which meet learners’ needs (Education and Training Foundation, 2021)

While the ETF should be applauded for the *Mentoring Framework* which is useful in guiding training and structuring mentoring practices, the framework should be accompanied by policies which enforce its implementation. Without clear policies, the otherwise ‘good’ *Mentoring Framework* might not achieve the desired aim; mentoring might still remain haphazard and varied.

Department for Education (DfE) funded the ETF from 2020 to 2023 to develop ‘high quality’ mentoring training to support teachers from early careers onwards (Education and Training Foundation, 2020). The ETF mentor training courses are offered to mentors, mentees, leaders, managers, and mentoring

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[42] https://www.et-foundation.co.uk/news/etf-launches-mentoring-framework-and-guides/

coordinators from colleges in England in receipt of funding from the Education and Skills Funding Agency (ESFA)[43]. The courses are not compulsory; it is up a particular college to send its staff (or not) for training. Looking at the calls from literature and data for mentors to be trained, I recommend enacting a policy which makes training of mentors mandatory.

I also recommend enacting a policy on a *Mentoring structure* which enforces mentoring activities to be timetabled for both mentors and student teachers. There should also be a policy about recognition of mentoring where mentoring is taken as a promotion with some financial incentives like pay rise or some 'thank you bonus.' Such policies might remove (or at least reduce) the haphazardness and variability of mentoring practices.

Due to the need for the development of digital technological knowledge among teachers, this study recommends that *Digital Technology* be part of the ITE curriculum in FE; it should be one of the core courses.

6.6 Limitations

One of the aspects I was looking for was how student teachers respond to student ideas, errors and misconception using the Knowledge Quartet's *Contingency* dimension. Data and literature plus my experience as a practitioner, and discussions with colleagues show that during e-teaching students were almost always on mute with cameras switched off and rarely participate in lessons. This made it difficult to see the student teacher's contingency action during teaching. Online lessons use the chat box where students post their contributions. I did not have access to the chat; therefore, it was impossible to see students' contributions. Limited teacher-student interaction made it difficult to see if students were understanding the student teacher's explanation or not. More importantly, it was difficult to see if teacher's actions were a result of students' answers, questions, suggestions or ideas. Therefore, I was not able to fully utilise the KQ as *Contingency* was not used as initially planned; meaning the mathematical and pedagogical knowledge enacted by student teachers in teaching was not fully explored. This study could be replicated during face-to-face teaching and mentoring.

Due to ethical reasons, I was not able to connect the questionnaire responses to the interviews responses. During data collection it was not possible to use interviews to explore questionnaire

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[43] The ESFA was formed on 1 April 2017 following the merger of the Education Funding Agency (EFA) and the Skills Funding Agency (SFA). It brings together the existing responsibilities of the Education Funding Agency (EFA) and Skills Funding Agency (SFA), creating a single agency accountable for funding education, apprenticeships and training for children, young people and adults. (https://www.gov.uk/government/organisations/education-and-skills-funding-agency)

responses further. This might have left some issues raised while responding to the questionnaire not fully explored.

My initial plan was to conduct a cross section study by collecting data from a sample of more than ten student teachers and more than ten mentors. Due to the COVID-19 pandemic, my sample size was five student teachers and two mentors. However, this limitation turned to be an opportunity as I had to go back to the drawing board and change my plan. I ended up conducting a longitudinal study for one year from the initial sample followed by a cross section study from an additional ten mentors; that is telling the story from different angles.

There are chances that my personal interests which include my curiosities, biases, ideological commitments, epistemological assumptions, theoretical frameworks, and professional commitments have influenced the process of carrying out this study (Ravitch & Riggan, 2012). Although these subjectivities cannot be eliminated, it is important to identify them and monitor them to make clear how they may be shaping the collection and interpretation of data (Merriam & Tisdell, 2016).

6.7 Future Research

- **Student teachers' contingency action in the physical classroom**: While this study was conducted online, there is value in extending it to a physical classroom setting. Exploring student teachers' contingency actions in face-to-face teaching environments could provide deeper insights into how the student teachers respond to students' questions, suggestions, answers, and understanding (or not understanding). I encourage further research in this area to enhance the understanding of student teachers' contingency action.
- **Expansion of *The DOT Mentoring Model***: This study proposes a mentoring model known as *The DOT Mentoring Model: The Doing mathematics - Observing (and learning from) experienced teachers -Teaching mathematics*. A promising area for future research and practice is the implementation and evaluation of this model in teaching contexts. By assessing *The DOT Mentoring Model*'s effectiveness in real teaching situations, the model's ability to support the mathematical and pedagogical knowledge development of mathematics student teachers in the Further Education and Training sector (FE) can be refined and validated. This will be my next step in my research journey, and I welcome collaboration from other researchers and practitioners in this endeavour.

6.8 Personal reflections

The journey to a PhD degree has been an experience I never dreamt of when I first approached my supervisor, Dr Irene Biza, asking if she could be my supervisor. The diverse learning experiences I have had since joining the University of East Anglia's School of Education and Lifelong Learning as a part-time PhD student are experiences which have transformed me as a person, as a teacher and as an academic. I have also met, talked to and laughed with people I had only read and admired their work; one of them is Professor Tim Rowland.

This research study gave me the opportunity to learn deeper about research in mathematics education. During my first year, reading and my supervisor made me shift from my ontological position of objectivism and epistemological position of positivism to the socio-constructivist perspective of ontology and the interpretivist perspective of epistemology. I read a lot of studies and theories on mathematics education, and some of them impacted on my practice as a mathematics teacher. I began to question and understand the 'why' and 'how' of the behaviour of my students and my colleagues; I became more analytic. I became more interested in how the practice of mentoring impacted on the student teachers. As I progressed with my studies into the data collection stage, COVID-19 emerged and my plan had to change and I ended up having two phases of data collection. This gave me an understanding of the dynamics of social science research, and the need to be flexible and organised as a professional and as a person in life outside academia and work.

Progressing through the years of my PhD studies, I had the exciting opportunity of participating at British Society for Research into Learning of Mathematics (BSRLM) conferences: https://www.bsrlm-members.org.uk/pages/15-conferences. I presented and published papers about my research. I was pleasantly surprised when I realised that BSRLM welcomed and valued my contributions as an early career researcher, and on several occasions, I was asked to chair some presentation sessions. At UEA, I had the experience of being a research associate of the MathTASK project: https://www.uea.ac.uk/groups-and-centres/a-z/mathtask. I developed my understanding of mathematics education by participating in monthly Research in Mathematics Education (RME) https://www.uea.ac.uk/groups-and-centres/research-in-mathematics-education-group meetings. I would also like to express my sincere 'thank you' to the group for brilliant meetings which made me feel valued and respected as a person and as an academic. The discussions and scrutiny of papers, including my work, was so inspiring and encouraging that I always looked forward to the meetings.

Finally, this research study has taught me, metaphorically, that the road to a PhD degree in Social Science is dusty and rocky with many potholes and blind spots to negotiate but; ultimately, there is a destination.

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Declaration of published work

Parts of the research work for this thesis have been presented at the British Society for Research into Learning of Mathematics (BSRLM) conferences and published in conference proceedings. The publications in the conference proceedings are reports of the ongoing analysis.

Conference Papers

Machino, N. (2023) Mentors' views on challenges faced – and lessons learnt – while mentoring mathematics student teachers in FE during the Covid-19 lockdowns. In: Proceedings of the British Society for Research into Learning Mathematics. British Society for Research into Learning Mathematics. https://ueaeprints.uea.ac.uk/id/eprint/92408/1/BSRLM_CP_43_1_07.pdf

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Appendices

Appendix 1: Phase 1 Interview Guides 1

Student teacher

1. Can you please briefly give me your experience as a maths teacher or in maths in general before you start your training?
2. How often are you observed and have mentor meetings?
3. How do you plan your lessons, putting together the lesson plan and resources? (Probe on intend and lesson structure, time allocating to activities).
4. Can you please tell me what you discuss in your meetings, for example after lesson observation?
5. Discussion on the lesson observed and mathtask.
    - In your lessons you refer to exam many times. Can you please explain the reasons?
    - You also refer to real life situations in your teaching. How does that help?
    - When teaching fractions, you used top and bottom in one of your lessons. What are other terms you can use?
    - During your lessons, how do you know that students understand what you are teaching them? (To probe on self-marking, feedback, engaging and motivating the students)
    - It seems you prefer student put their answers in the chat in place of saying the answer. Why is putting answers in chat more important than explaining?
    - What are your thoughts on teaching 9.3 x 4.24 – 1.5 x 7.77 by rounding and estimation? (To discuss BIDMAS)?
    - You gave students questions to find HCF of 112 and 42 by finding factors of the numbers. In case of large numbers, do you think students will get the correct answer (to discuss factor tree)?
    - You differentiate your students' work a lot. How do you do that and why?
    - At the end of your lessons, you ask students to rate their understand. Why is this important?

Mentors

1. Can you please tell me about your experience as a maths teacher and as a mentor?
2. How do you know your mentee's strength and weaknesses in lesson delivery and how do you help him improve? To probe on
    - Use of mathematical terminology
    - Use different ways of explaining e.g., using a tree diagram for LCM and HCF.
3. What are your mentoring strategies?
4. Are you involved in evaluating the performance of your mentee? (Why do you think about giving a grade, pass/fail to the mentee?)

Appendix 2: Phase 1 Interview Guides 2

Student teacher

- Tell me about a lesson/topic that you have taught recently where you were confident about the mathematical content you were teaching, and you felt secure going in to teach the topic. Why were you confident/how did you gain this knowledge?
- Tell me about a lesson/topic where you felt less confident and secure with the mathematics, or where you were challenged by difficult questions from students. What happened next/how did you follow this up?
- Can you tell me what you have learned in your theory courses you use in the classroom?
- How do you select the questions you give students?
- Where do you get the resources from?
- How do you connect your lessons and steps in one lesson? Concepts, procedures,
- Can you explain any situation you had to change what you were teaching because of students understanding (or not)?
- What can you point as improving because of mentor help?
- Finally, what are the things you would like to see change in mentoring?
- Student-teacher interaction during COVID-19 (Student engagement, motivation, and feedback)

Mentor

1. What have you helped your student teacher to improve?
2. What are the problems of mentoring online? How have you been doing with your mentee?
3. What are your views on student-teacher interaction during COVID-19?
   (Student engagement, motivation, and feedback).
4. How would you like mentoring to improve in colleges?

Appendix 3: Phase 1 Interview Guides 3

Student teacher – Cain

1. **Foundation: Theoretical underpinning of pedagogy**

- Can you tell me what you have learned in your theory courses you use in the classroom?
- Tell me about any reading which has impact on your teaching?
- Tell me about conferences and Education and Training Foundation (ETF) trainings you have attended and how does that impact on your teaching?
- What does the 5 Rs mean? Where did you get them from?

2. **Transformation, connection & contingency**

- How do you plan your lessons in general? Putting resources together, how do you get your resources? Where do you get the resources from?
- How do you select the questions you give students?

3. Discuss mathtask 3.
    - ➢ area of a ring – to include π
    - ➢ relationship between dimensions of the circle
    - ➢ my do you think the task was too difficult for Foundation tier
    - ➢ What do you mean by, "While the question is likely an exam one, in they could draw it to **scale on squared paper and consider areas that** way."

4. How do you contextualize teaching into vocational course and real life
5. Why do you emphasize Emphasizing exam questions?
6. Is there anything you would like to tell me about your experience as a student teacher?

7. **Mentoring**

- How often do you hold mentor meetings?
- What can you point as improving because of mentor help?
- What are the things you would like to see change in mentoring?
- How do you plan and teach low and high ability groups? **Issue raised by the mentor.**

8. **Teaching during COVID pandemic**

- Student-teacher interaction during COVID-19 (Student engagement, motivation, and feedback). Have you ever discussed this with your mentor?
- Advantages and disadvantages of online teaching.

Student teacher – Job

1. **Foundation: Theoretical underpinning of pedagogy**

- Can you tell me what you have learned in your theory courses you use in the classroom?
- Tell me about any reading which has impact on your teaching?

2. **Transformation, connection & contingency**

- How do you plan your lessons in general? Putting resources together, how do you get your resources? Where do you get the resources from?
- How do you select the questions you give students?
- How do other teachers help you in planning and lesson delivery?
- How does your mentor help in planning and lesson delivery?

3. **Specific topics to be discussed.**

Discuss mathtask 3.

- ➢ area of a ring – to include π.
- ➢ Equations and expressions- difference?
- ➢ Solve 2b -6 = 4. What are the other methods you can use?
- ➢ How would you teach mean, mode, median and range to avoid students mixing these up?
- ➢ Venn diagram terminology?
- ➢ HCF and LCM of 10 and 15 other methods?

4. How do you contextualize teaching into vocational course and real life?
5. Why do you emphasize Emphasizing exam questions?
6. Is there anything you would like to tell me about your experience as a student teacher?

4. **Mentoring**

- How often do you hold mentor meetings?

- What can you point as improving because of mentor help?
- What are the things you would like to see change in mentoring?

5. **Teaching during COVID pandemic**

   Student-teacher interaction during COVID-19 (Student engagement, motivation, and feedback). Have you ever discussed this with your mentor?
6. Advantages and disadvantages of online teaching.

Mentors- Julie and Alex

- What can you say about how you have helped your mentee develop?
  - Pedagogically
  - Mathematically
- What are the problems and advantages of mentoring online? How have you helped your mentee?
- What are your views online student-teacher interaction? How have you helped your mentee?
- Engagement
- Motivation
- Feedback
- What are your views on the following?
  - Mentor training. When you were appointed as a mentor, where you give some training/guidelines for mentoring?
  - Structuring the mentoring programmes
  - Timetabling mentoring
  - How would you like mentoring to improve in colleges?

Or /and

- How many times have you observed your mentee this year?
- How do you give him feedback?
- How often do you have mentor meeting? Formal and informal.
- Last time we discuss that mentor's work should be a structure? How would you like the framework to look like?

Appendix 4: Phase 2 Mentor Interview Guide

Mentor interview guide

(approximately 20 minutes)

Welcome -– Ask them if they are ok to audio/video record -switch on audio/video recording -introduction with a brief description of the study and confirmation of their consent.

A. General questions about participants' background and experience

1. Can you please tell me about your qualifications?
2. How long have you been teaching in an FE college?
3. For how long have you been a mentor?

B. Questions about teaching mathematics and mentoring

4. What motivated you into teaching maths in an FE college?
5. What motivated you to be involved into mentoring?
6. What is the role of the mentor in your view?
7. How would you support a student teacher on the mathematical subject knowledge? Please give examples.
8. How would you describe your mentoring strategies?

C. MathTASK

- ➢ Let's discuss the mathtask you completed (Sharing in on the screen the mathtask). [Remind the participant that you cannot link their identity with the responses they have given to the questionnaire. Can you please tell me more about how you would assist the student teacher work out the question?
- ➢ How would you assist the student teacher teach the question?

D. General questions about mentoring

9. What are your views on the following?
    - ➢ Structuring mentoring; that is designing a programme to be followed by mentors and mentees throughout the mentoring process
    - ➢ Mentor training
    - ➢ Technology to be part of the teacher education curriculum
    - ➢ Teaching for exams

    - Connect maths teaching to real life and vocational areas
    - The challenges and opportunities of online teaching during COVID-19. What have we learnt which we can carry forward to the post Covid era?

10. How would you like mentoring to improve in colleges?

Appendix 5: Julie's Report about Cain

Friday 5th March PGCE Mentor Meeting

Feedback on Observation – 4th March 6pm – 7pm

Learners clearly happy to unmute – good rapport especially given online only.

Some learners very talkative in breakout rooms – this is good.

Learners shared their answers etc. on screens and collaborative working went really well.

- How to get other learners involved though – especially those without microphones
- I used a slide to recap some aspects of multiples and factors – the homework – but possibly it was too busy and inconvenient for learners if they needed to get catch up material from it
- Questions to settle in group collaboration could be more specific, especially to bring those answers back to the main group
- Good that learners are working with each other and setting up networking for peer learning opportunities and support
- 'Equals Sign' activity was really good with good explanations of equality
- Good introduction to algebra especially emphasizing it as shorthand
- Diagrams used for explanation and feedback of equals sign quiz were very good
- Good use of goal-free question for learners who finish the quiz quickly – with good answers and work from learners too!
- Good idea to include non-examples for edge cases
- Mentimeter worked well for the large numbers of learners involved in the group

AOB:

Can we use teamwork for general GCSE resit classes in the future – e.g. most learners get most questions correct, so could emphasis of this fact encourage teamwork in normal resit learners to do more peer-learning?

Appendix 6: Cain’s Final Teaching Report Form by Julie

School of Education and Professional Development

Cert Ed/PGCE/PGDipE Lifelong Learning

Teaching Report Form

This form should be used to provide a summary of a trainee’s progress, development and any areas of concern at two key points during professional teaching experience in the practice-based modules. The first report should be completed at the end of Module 2 (Becoming a Subject Specialist Teacher followed by a final report at the end of Module 3 (Being a Subject Specialist Teacher).

The trainee should invite staff who have worked with them during their professional teaching experience (such as specialist mentors, tutors, observers, etc) to provide feedback on their performance in a range of competencies and how they are developing over the teaching module period. The form may be copied and completed individually by all staff who have worked with the trainee or presented as a combined report. **You may wish to discuss your comments with the trainee and/or his/her personal tutor.**

The comments within the form will provide the trainee with evidence towards their Grading assessment process. Although professional teaching experience/placement staff are not required to grade individual trainees, they might wish to discuss the grading criteria with the trainee when completing this Teaching report.

A copy of this form should be included in the relevant teaching file and submitted to the trainee’s PERSONAL TUTOR.

Name of trainee teacher Cain (name changed)	**Form completed by:** **Name:** **Julie (Name changed)** **Position:**
Location of teaching professional experience	**Dept./Section**
Period of report (tick as appropriate):	**Personal tutor**

Module 2 (first report) ■ **Module 3 (final report)** ■	

Comments: Each section includes some prompts for guidance but please provide any relevant comments which you think are appropriate.			
Attendance (tick as appropriate)	**Excellent**	Good	Poor
Punctuality (tick as appropriate)	**Excellent**	Good	Poor
General progress and contribution to the department	Cain (name changed) made good progress this year.		
Relationships with staff *(Ability to work in a team, collaboration, use of initiative)*			
Range of teaching experience undertaken to date *(courses, levels, modules, groups)*	Cain (name changed) has been teaching a range of different courses in the maths department, he teaches GCSE and Functional Skills L1 to our 16-18 groups. Cain (name changed) is also delivering our Dash to GCSE course which started in January and is for 4 hours every Thursday evening.		
Subject / Curriculum knowledge *(Is it relevant, appropriate and current?)*	Cain (name changed) has excellent subject knowledge that is very relevant to what he is delivering.		
Planning, organisation and time management			
Use of a range of appropriate teaching techniques and resources	Videos made to help students with the revision. Cain (name changed) has embraced using autograph after he attended a maths conference where it was demonstrated, he has		

(including willingness to try different approaches)	decided to use the software to help aid his students in trying to work out an equation from 2 points.
Interaction with students *(Ability to generate interest, manage and motivate students)*	Cain (name changed) made excellent progress with this and was seen adapting questioning techniques to help engage all his students. He made good progress in motivating his studies and a student had said that he has made maths seem interesting. Cain (name changed) has a great relationship with his Dash GCSE students and from the videos of his live sessions you can see as they feel comfortable in asking questions.
Student assessment and record keeping *(Ability to assess student progress and maintain relevant records)*	Cain (name changed) has made sure that all of his student's assessments are recorded and all of his teaching files are up to date. All lockdown records up to date and has been involved in producing centre assessed grades for all of the maths students this year.
Response to feedback *(including ability to seek and ask advice, action planning)*	Cain (name changed) responds to feedback that he has been given, he adapted different questioning techniques and using whiteboards to get the answer. Cain (name changed) is open to suggestions as to how he can get better in what he is doing. He is happy to get the opinions of teachers that having been doing this longer than him but is also very good at giving a new view on what to do.
Extra curricula activities and experience of wider tutor role *(attendance at meetings, events, activities outside timetabled sessions.)*	Cain (name changed) has taken on lots of extra activities this year to help aid his teaching, Cain (name changed) regularly participates in the team meeting that we have weekly. Cain (name changed) attended a maths conference back in October and came away with ideas that he could use in the classroom and has demonstrated them in his sessions. Cain (name changed) has also attended lots of training sessions with TEL to help enhance his teaching.
Key areas where trainee has shown progress and development	Group work to engage and address peer learning
Key areas where trainee needs further experience	I feel that to help Cain (name changed) with his training and development it would be very good for him to have an experience of teaching all levels of function skills.
Any areas of concern	Leave blank if no concerns unless highlighted.

Main Recommendations and action points: to help further the trainee's development. *(It may be helpful to refer to Grading criteria and trainee’s action planning in their Personal Development Plan/e-portfolio)*
The recommendation that I would like to make for Cain (name changed) for the next year is to do more peer observations, I feel that looking at how other members of the team deal with curriculum delivery and students will only help to progress his teaching.

Mentor YES ( ) NO ( ) [please tick]

Subject Specialist YES ( ) NO ( ) [please tick]

Other please specify YES ( ) NO ( ) [please tick]

Signed	**Date**

This form is part of the trainee's claim that outcomes have been achieved. Your comments are much appreciated and will be helpful in the trainee’s progress and development planning. Thank you

Appendix 7: Job’s Observation Report by Alex

Date: 23/11/20	Department/ class		
Observer: Alex (name changed)	Campus	(21 on register)	Time: 16:10 – 16:20
Teachers Name	Room	Comment	
Job (name changed) Point of entry	online	Simplifying Rations. 7 learners. 9 absent. Worksheet on ppt. Learner asked to simplify questions. Gave them a few mins to try. Then showed answers to they could self-mark. Reliant on chat box function to feed back to learners. Clear explanation	
Behaviour/engagement		Web cam not working but Jon used the ppt and verbal explanation to assist as a work around. Learners were patient. One learner typed they could not see the screen so Jon suggested they leave and re-join. He tried to enlarge the screen but did not work for all learners, but most. Most seem to engage in the exam style questions. Sharing Ratio was introduced as many could not access the prior task. Jon gave responses to prior task and said it was a recap anyway.	
Actions		To practice IT before start of lesson to insure it is working correctly Try to give feedback more timely using a platform that gives instant feedback such as MS forms Could improve upon delivery of online session to be as enthusiastic as face-to-face sessions.	
		Learner voice feedback (L1 Skills for Progression group). He goes too fast and doesn’t explain clearly.	

Further Observation Required: No

Appendix 8: Planning Schedule

Time	**Activities**
March 2020	- *Probationary Review*
April – August 2020	- *Working on ethics documentation and submission of ethics application. Revision and resubmitting of ethics application (if applicable).* - *Ethics approval*
September-October 2020	- *Networking for fieldwork; getting access to colleges and recruiting participants.* ➢ *Phoning and emailing gate keepers in 15 sampled colleges seeking permission to carry out research in their colleges.* ➢ *Once permission is granted, the H.O Ds are* emailed *mathtasks for student teachers to complete.*
	Phase 1
November – December 2020	- *Analysing mathtasks completed by student teachers.* - *Selection of the participating student teachers, mentors and students* - *Getting consent from the student teachers, mentors and students*
January – February 2021	***Data Collection Cycle 1*** - *Carrying out lesson and mentor meeting observations* - *Conducting interviews* - *Collecting mentor observation reports and mentor meeting minutes.*
March 2021	- *Analysing the data and designing the second cycle of data collection*
April- May 2021	***Data Collection Cycle 2*** - *Sending mathtasks to participating student teachers* - *Carrying out lesson and mentor meeting observations* - *Conducting interviews* - *Collecting observation reports and mentor meeting minutes.*
June 2021	- *Analysing the data and designing the second cycle of data collection*
July – August 2021	***Data Collection Cycle 3*** - *Sending mathtasks to participating student teachers* - *Carrying out lesson and mentor meeting observations* - *Conducting interviews* - *Collecting documents; mentor observation reports and mentor meeting minutes.*

September – December 2021	*Organising data and collecting further data if the sample happens to have part-time student teachers on a two-year training course or* *Data analysis.*
	Phase 2
January – May 2022	*Collecting further data*
June 2022- July 2024	*Data analysis* *Writing thesis chapters* *Dissemination through presenting at conferences and journals articles*
August - September 2024	*Finalising writing* *Submission*

Appendix 9: Approved EDU REC applications

9.1 Phase 1 Approval

EDU ETHICS APPROVAL LETTER 2019-20

APPLICANT DETAILS	
Name:	Natheaniel Machino
School:	EDU
Current Status:	**PGR Student**
UEA Email address:	**N.Machino@uea.ac.uk**
EDU REC IDENTIFIER:	**2020_5_NM_IB**

Approval details	
Approval start date:	**29.6.2020**
Approval end date:	**30.9.2025**
Specific requirements of approval:	The continued monitoring of the potential effects of witnessing any 'poor mentoring' and to respond to any negative impact for yourself and for others regarding this. To ensure your supervisor sees the explicit consent from gatekeepers to agree to allow you to view mentoring reports; only completing this aspect of the project if also consented to by the mentor and student teacher.
Please note that your project is only given ethical approval for the length of time identified above. Any extension to a project must obtain ethical approval by the EDU REC before continuing. Any amendments to your project in terms of design, sample, data collection, focus etc. should be notified to the EDU REC Chair as soon as possible to ensure ethical compliance. If the amendments are substantial a new application may be required.	

Kate Russell EDU Chair, Research Ethics Committee

9.2 Phase 2 Approval

13.1 Ethics ETH2122-0140: Mr Natheaniel Machino: Approval

Date Created	28 Sep 2021
Date Submitted	05 Oct 2021
Date of last resubmission	16 Oct 2021
Date forwarded to	18 Oct 2021 committee
Researcher	Mr Natheaniel Machino
Category	PGR
Supervisor	Dr Irene Biza
Faculty	Faculty of Social Sciences
Current status	Approved

Appendix 10: Application for ethical approval of the research project: Documentation

Applicant and research team

Principal Applicant

Name of Principal Applicant

Mr Natheaniel Machino

UEA account jkb18mzu@uea.ac.uk

School/Department

School of Education and Lifelong Learning

Category

PGR

Primary Supervisor

Name of Primary Supervisor Dr Irene Biza

Primary Supervisor's school/department

School of Education and Lifelong Learning

Project details

Project title

Teacher Education in Further Education: The role of mentoring in further education mathematics student teachers' mathematical and pedagogical knowledge development.

Project start date.

01 Oct 2021

Project end date.

30 Sept 2024

Is the project?: none of the options listed

Original application and ethics approval

Original UEA ethics review body.

EDU S-REC (School of Education and Lifelong Learning Research Ethics Subcommittee)

Original UEA ethics application reference number. 2020_5_NM_IB

Original approved ethics application.

Original ethics approval letter/email.

Amendment type

Type of amendment

Change to research protocol

Is this amendment related to Covid-19? Yes

Change research protocol

Fully describe any changes and upload revised documentation if there are wording changes to the original application.

I am PT PhD student in my fourth year of studies (Irene Biza is my primary supervisor), and my study title is ‘Teacher Education in Further Education: The role of mentoring in further education mathematics student teachers’ mathematical and pedagogical knowledge development.’

I have completed the planned data collection during the academic year 2020-21 in which I collected data from student teachers using lesson observation, questionnaires, documents, and interviews. I also collected data by interviewing mentors of the student teachers I observed. However, due to the pandemic I did not manage to have the number of participants I expected in terms of mentors’ participation. For this reason, in consultation with my supervisor, I am planning to expand my fieldwork with more mentors (including those whose student teachers were not observed) using a questionnaire similar in structure to the one used for student teachers (but the MathTASK activities might be different) and follow up interviews. This expansion of the fieldwork will involve the following two adaptations of the existing ethics documents:

Adaptation of the teacher questionnaire PIS to mentor questionnaire PIS

Adaptation of the mentor (who student teachers were observed) interview PIS to any mentors (regardless of whether their student teachers were observed or not) interview PIS.

Attach any documentation which relates to the changes described.

Attached files

ETHICS Documentation.pdf

EDU ETHICS APPROVAL LETTER 2020_5_NM_IB (1).pdf

PIS questionnaire mentors 16 Oct.docx

PIS interview mentors 16 Oct.docx

Mentor interview guide 16 Oct.docx

UNIVERSITY OF EAST ANGLIA

SCHOOL OF EDUCATION AND LIFELONG LEARNING RESEARCH ETHICS COMMITTEE

APPLICATION FOR ETHICAL APPROVAL OF A RESEARCH PROJECT

This form is for all staff and students across the UEA who are planning educational research. Applicants are advised to consult the school and university guidelines before preparing their application by visiting https://www.uea.ac.uk/research/our-research-integrity and exploring guidance on specific types of projects https://portal.uea.ac.uk/rin/researchhttps://portal.uea.ac.uk/rin/research-integrity/research-ethics/research-ethics-policyintegrity/research-ethics/research-ethics-policy. The Research Ethics page of the EDU website provides links to the University Research Ethics Committee, the UEA ethics policy guidelines, ethics guidelines from BERA and the ESRC, and guidance notes and templates to support your application process: https://www.uea.ac.uk/education/research/researchhttps://www.uea.ac.uk/education/research/research-ethicsethics.

Applications must be approved by the Research Ethics Committee before beginning data generation or approaching potential research participants.

Staff and PGR (PhD, EdD, and EdPsyD) should submit their forms to the EDU REC Administrator (edu.support@uea.ac.uk) and Dr Kate Russell (Kate.russell@uea.ac.uk) at least two weeks prior to each meeting.

Undergraduate students and other students must follow the procedures determined by their course of study.

APPLICANT DETAILS	
Name:	*Natheaniel Machino*
School:	*Education and Lifelong Learning*
Current Status:	*PhD Student*
UEA Email address:	**N.Machino@uea.ac.uk**
If PGR, MRes, or EdD/EdPsyD student, name of primary supervisor and programme of study: **Primary supervisor:** *Dr Irene Biza* ***Programme of Study:*** *PhD in Education (Mathematics)*	
If UG student or MA Taught student, name of Course and Module: *N/A*	

The following paperwork must be submitted to EDU REC **BEFORE** the application can be approved. Applications with missing/incomplete sections will be returned to the applicant for submission at the next EDU REC meeting. Please combine the forms into **ONE** PDF	
Required paperwork	**✓ Applicant Tick to confirm**
Application Form (fully completed)	✓
Participant Information sheet and Consent Form (EDU template appropriate for nature of participants i.e. adult/parent/carer etc.)	✓
Other supporting documents (for e.g. questionnaires, interview/focus group questions, stimulus materials, observation checklists, letters of invitation, recruitment posters etc)	✓

2. PROPOSED RESEARCH PROJECT DETAILS:	
Title:	*Teacher Education in Further Education: The effectiveness of the mentor system of training mathematics student teachers in the Further Education and Skills sector.*
Start/End Dates:	*1 October 2018 – 30 September 2025*

3. FUNDER DETAILS (IF APPLICABLE):	
Funder:	*N/A*
	Has funding been applied for? YES NO Application Date:
	Has funding been awarded? YES NO
	Project code if known:
Will ethical approval also be sought for this project from another source? NO	
	If “yes” what is this source?

4. APPLICATION FORM FOR RESEARCH INVOLVING HUMAN PARTICIPANTS:

Please use the guidance notes to support your application as this can clarify what the committee needs to see about your project and can avoid any unnecessary requests for further information at a later date.

Briefly outline, using lay language, your research focus and questions or aims (no more than 300 words).

This research design is based on the assumption that by the time of data collection which starts in September 2020, face to face teaching in further education (FE) colleges should have resumed. If online teaching continues, the design will change.

My study is about the effectiveness of the mentor system of training mathematics student teachers in the Further Education and Training sector (FE). Effectiveness is seen in relation to how mentoring is related to student teachers' mathematical and pedagogical knowledge development. The aim of my study is to develop better and deeper insights into how mentoring of mathematics student teachers in FE works. The insights are intended to contribute to the improvement of mentoring of FE student teachers in general and those learning to teach mathematics in particular. This study will help define mentoring with specific reference to mathematics student teachers in FE. The study will most likely recommend how mentoring can be effectively carried out to improve teaching and learning of mathematics at FE. The recommendations might be transferable to other subjects and vocational courses taught in FE colleges, as well as the secondary and primary school sectors. The study attempts to clarify mentoring in FE which is not clearly defined and is carried out in different and often conflicting ways. The study also attempts to cover the gap of shortage of literature of the mentoring of mathematics student teachers in FE.

This study seeks to answer these research questions;
How does student teachers' mathematical and pedagogical knowledge develop during the teacher training course?
How is mentoring related to such student teachers' mathematical and pedagogical knowledge development?

Briefly outline your proposed research methods, including who will be your research participants and where you will be working (no more than 300 words).

- **Please provide details of any relevant demographic detail of participants (age, gender, race, ethnicity etc)**

The main participants will be student teachers enrolled on the in-service teacher training course – a larger number (around 40 student teachers) at the questionnaire phase and around 10 student teachers in the subsequent longitudinal study. The student teachers will be teachers employed by the training colleges. The course leads to Professional or Post Graduate Certificate in Education (PGCE) or Diploma in Teaching in the Lifelong Learning Sector (DTLLS). The student teachers will be on the generic course, but with specialization in mathematics teaching. Although my main focus will be the student teachers, other participants will include the student teachers' mentors and the student teachers' students; one class per student teacher. The students are expected to be between 16 and 19 years of age and of mixed ability. The participants will be recruited from 15 colleges in Essex and East London, which is convenient to me as I leave and work in Essex in an area very close to East London. Student teachers, mentors and students in the participating colleges are of different cultural backgrounds.

I will use mathtasks, fictional classroom situations from mathematics teaching with a set of questions for teacher reflection on such situations. Student teachers will be invited to respond to mathtasks in writing. The KQ is used to analyse the student teachers' responses, and this will reflect the mathematical and pedagogical knowledge development over the three mathtasks the student teachers are going to respond to over the duration of their training. Also, student teachers *will be observed in teaching, with video or audio recording with field notes taking or taking field notes only. Students' participation during lessons and how the student teachers respond is very important in capturing, using the KQ, the student teachers' mathematical and pedagogical knowledge. Meetings between student teachers and their mentors will be observed, with video or audio recording with field notes taking or field notes taking only. Mentors and student teachers will be interviewed separately using a semi-structured approach. Mentor meeting minutes and observation reports will be collected with the aim of triangulating data collected using mathtasks, classroom observations, mentor meeting observations and interviews.*

To start the data collection process, I will send a questionnaire, with the first mathtask embedded in it (see

Appendices G.1 and H on application form) to all student teachers in the participating colleges. Then, data collection will take place in three cycles that will repeat the following structure: mathtask; classroom observation; observation of mentor meeting; interview with student teacher; interview with mentors; and document collection. The cycles will be spread across teacher training period which is one year for full time and two years for part time.

4.3 Briefly explain how you plan to gain access to prospective research participants. (no more than 300 words).

Who might be your gatekeeper for accessing participants?

If children/young people (or other vulnerable people, such as people with mental illness) are to be involved, give details of how gatekeeper permission will be obtained. Please provide any relevant documentation (letters of invite, emails etc) that might be relevant

Is there any sense in which participants might be 'obliged' to participate – as in the case of pupils, friends, fellow students, colleagues, prisoners or patients – or are volunteers being recruited?

My research participants are student teachers, mentors and students from 15 sampled colleges in Essex and East London. To access the participants, I need to get access to the colleges; therefore, I will email the gate keepers who are the principals. I will phone reception requesting the gate keepers' emails. I will email the gate keepers using the official college emails requesting permission to carry out my research in their colleges. I will explain the aim of the study, the research process and the reason for selecting their colleges (see Appendix G.1). In the emails, I will also request names and emails of heads of mathematics departments(HoDs). I will communicate with HoDs (see Appendix G.2) and through them I will email student teachers the link to an online questionnaire (see Appendix H) with the mathtasks embedded in it. The participants of the remaining parts of the study (around 10 students teachers) will be recruited from those who will respond to the online questionnaire and express their interest to participate (see Appendix G.3). Selection will be according to the responses: preliminary analysis with KQ will indicate a potential range of pedagogical and mathematical knowledge and the selected participants will reflect this knowledge. Also, having participants with a range of experience and from different institutions is preferable.

4.4 Please state who will have access to the data and what measures will be adopted to maintain the confidentiality or anonymity of the research subject and to comply with data protection requirements e.g. how will the data be anonymised? (No more than 300 words.)

Only I and my primary supervisor will have access to the raw data. The data will be securely stored, and participants identity will not be disclosed. The participants will be assigned pseudonyms. The data will be stored in a password protected computer, which I am the only user. As a backup, the data will also be stored in my online UEA OneDrive account. The study may be published, and the participants will not be identified. The data will be kept for ten years then destroyed. The sample of participants will be small and this may risk their anonymity; however, they will be recruited from different institutions the names of which will not be revealed.

4.5 Will you require access to data on participants held by a third party? In cases where participants will be identified from information held by another party (for example, a doctor or school) describe the arrangements you intend to make to gain access to this information (no more than 300 words).

The research study does not require access to data on participants held by a third part. I will collect mentoring reports from mentors themselves, subject to mentors' and student teachers' consent. I will also seek permission from college principals to access mentor documents; observation reports and mentor meetings minutes. (see Appendix H: PCF- Principals). The mentors and the student teachers are employed by the colleges which in-service train the student teachers; therefore, there is no third party involved.

4.6 Please give details of how consent is to be obtained (no more than 300 words).

Identify here the method by which consent will be obtained for each participant group e.g. through information sheets and consent forms, oral or other approach. Copies of all forms should be submitted alongside the application form (do not include the text of these documents in this space).

- **How and when will participants receive this material and how will you collect forms back in?**

After gaining access to the colleges and getting emails of heads of mathematics departments (HoDs), I will email the HoDs a letter (see Appendices G.2 & G. 3) with an online link to the questionnaire (see Appendix H) to distribute to student teachers. Student teachers will complete the questionnaire and the responses will come to me only via the online survey. The student teachers will consent to take part in the first mathtask and provide their names and emails if they want to take part in further activities of the research. I will analyse the responses to the mathtasks, using the knowledge quartet (KQ) framework, and select the potential participating student teachers so that the sample will have student teachers with different mathematical and pedagogical knowledge and also having participants with a wide range of experience and from different institutions. Analysis of the questionnaire data will also provide a first impression on FE trainee teachers' pedagogical and mathematical knowledge on the teaching of fractions, a common mathematical topic in GCSE mathematics that has been reported in the literature as challenging for the students.

When the selection of participating student teachers is complete, I will then visit the colleges. to meet the potential participants; student teachers and mentors and give them the information sheets and consent forms, explaining my research and answer any question(s). I will make a second visit to collect consent forms from student teachers and mentors and select participating classes of students and distribute information sheets and consent forms to students and explain my research and answer any question(s). The student teachers will collect the consent forms from their students which I will collect during my first data collection visit.

FE student teachers are mostly in-serviced. They are trained by the college while teaching at the same college. There are some who are trained at university and come to the college for placement. I will be studying those who are following the in-service training only.

4.7 If any payment or incentive will be made to any participant, please explain what it is and provide the justification (no more than 300 words).

No payment or incentive will be made.

4.8 What is the anticipated use of the data, forms of publication and dissemination of findings etc.? (No more than 300 words.)

The primary use of the data collected is for my PhD thesis. The findings of the study will be presented at conferences. I will also publish the research findings in journals. There are possibilities the finding might be published as a chapter(s) in a book or as a book. In these publications, the identities of the participants will not be revealed

4.9 Findings of this research/project would usually be made available to participants. Please provide details of the form and timescale for feedback. What commitments will be made to participants regarding feedback? How will these obligations be verified? If findings are not to be provided to participants, explain why. (No more than 300 words.)

Student teachers and mentors will have the opportunity to review interview, lesson and mentor meeting observation transcripts, if they wish by ticking the appropriate box on the consent form. I will email transcripts to participants who will have shown interest in reviewing them. At the end of the study, a summary of the findings will be emailed to the student teachers and the mentors who will have indicated that on consent forms. All
participants will be made aware that the thesis will be available online upon completion.

4.10 Please add here any other ethical considerations the ethics committee may need to be made aware of (no more than 300 words).

Are there any issues here for who can or cannot participate in the project?

If you are conducting research in a space where individuals may also choose not to participate, how will you ensure they will not be included in any data collection or adversely affected by non-participation? An example of this might be in a classroom where observation and video recording of a new teaching strategy is being assessed. If consent for all students to be videoed is not received, how will you ensure that a) those children will not be videoed and/or b) that if they are removed from that space, that they are not negatively affected by that?

I will email the HoDs a letter with a link to a questionnaire (see Appendices G3 & H) to distribute to student teachers. Distributing the tasks through the HoDs might be taken as coercing the student teachers. The responses will come to me via the survey and the HoDs will not know who has and who has not completed the tasks, and it will be emphasized that the information provided will not be available to anyone.

I will give students information sheets and consent forms and their teachers (the student teachers) will be responsible for collecting them and this might be seen as a way of coercing the students into taking part, but even if the teachers are not involved, it is the same students who will be taught during the classroom observation, and the teachers will know who has consented and who has not. The students will be assured that there are no consequences for not participating.

I collect data by observing students in lessons. Students in college are above 16 so they can consent without parental approval. There are possibilities that not all students are going to consent to be video or audio recorded. If any students do not consent to be video recorded and consent to be audio recorded, together with the teacher, we will try to seat the students out of camera focus. In case there are students who do not consent to take part in the research, I will record the times of their contributions and edit the videos and/or audio recordings and remove their contributions. I will video-record or audio-record the class only if more that 70% of the class consents, alternatively I will observe the class and keep field notes. If the number of students who do not consent to take part in the research is more that 30%, I will consider changing the participating class.

4.11 What risks or costs to the participants are entailed in involvement in the research/project and how will you manage that risk?

Are there any potential physical, psychological or disclosure dangers that can be anticipated? What is the possible harm to the participant or society from their participation or from the project as a whole?

What procedures have been established for the care and protection of participants (e.g. insurance, medical cover, counselling or other support) and the control of any information gained from them or about them?

There is no cost involved as I will visit the participants and observe them at their college. There might be giving up free time as interviews and completing mathtasks are not part of their schedules. The potential risk which is anticipated is a challenge to participants' professional development, which can be caused by interviews. This can be minimised by being sensitive and alert to the reaction of participants during interviews. If an interviewee shows signs of discomfort during an interview, the question can be left out or changed, or the whole interview might be stopped. Participants are also made aware that it is their right not to answer some or all questions and to withdraw from the research at any point before the final analysis and their contributions will be removed. I will make it clear to the participants that I am not involved to the training programme they attend and that their participation (or not) to the study will not affect their training.

4.12 What is the possible benefit to the participant or society from their participation or from the project as a whole?

In my study student teachers complete mathtasks which I will analyse to investigate the development of their mathematical and pedagogical knowledge. Mathtasks are classroom situation-specific scenarios which are hypothetical but grounded on learning and teaching issues that previous research and experience have highlighted as seminal and are likely to occur in practice. By responding to the tasks student teachers benefit by reflecting on how to respond to situations they are likely to face in the classroom.

The student teachers are interviewed after classroom observation. These interviews will help the student teachers to reflect on their actions while teaching and this might have positive impact on their teaching. Mentors are also going to be *interviewed. This also helps them reflect on their mentoring strategies and how this impact on student teachers' mathematical and pedagogical development.*

The research project, which aims to develop insights into mentoring of mathematics student teachers in FE, is likely to trigger debates into this often not so talked about area. This might ultimately improve the practice of mentoring in FE. The publications from the study will add knowledge on mentoring to the already existing body of knowledge while covering the gap of lack of literature on mentoring mathematics student teachers.

4.13 Comment on any cultural, social or gender-based characteristics of the participants which have affected the design of the project or which may affect its conduct. This may be particularly relevant if conducting research overseas or with a particular cultural group

- **You should also comment on any cultural, social or gender-based characteristics of you as the researcher that may also affect the design of the project or which may affect its conduct**

There are no cultural, social or gender-based characteristics of participants which have affected the design of my research or will affect the conduct. My study is conducted in Essex and East London FE colleges which are multicultural, with teachers and students from different cultural and social backgrounds.

4.14 Does your research have environmental implications? Please refer to the University's Research Ethics Guidance Note: Research with a Potential Impact on the Environment for further details. Identify any significant environmental impacts arising from your research/project and the measures you will take to minimise risk of impact.

Not applicable

4.15 Will your research involve investigation of or engagement with terrorist or violent extremist groups? Please provide a full explanation if the answer is 'yes.'

No

4.16 Please state any precautions being taken to protect your health and safety? This relates to all projects and *not just* those undertaken overseas.

What health and safety or other relevant protocols need to be followed e.g. a DBS for work in schools? Have you completed this?

If you are travelling to conduct your research, have you taken out travel and health insurance for the full period of the research? If not, why not.

If you are travelling overseas, have you read and acted upon FCO travel advice (https://www.gov.uk/foreign-travel-advice)? If not, why not. If acted upon, how?

Provide details including the date that you have accessed information from FCO or other relevant organization

If you are undertaking field work overseas you are required to submit a Risk Assessment Form with your application. This is even if you are a researcher 'going home' to collect data (check EDU REC website).

I am a teacher in a Further Education and Skills college, and I have a DBS. I will follow the safeguarding, health and safety procedures of the colleges I will be conducting my study in.

I teach in one of the participating colleges but I do not have any relationship with any of the other participating colleges. I might have some participants from the college I work in. To address potential ethical issues of recruiting participants from my institution I will take the following actions:
I will be recruiting participants from my institution using the same way as for participants from other institutions.
I will be sensitive to those who choose not to volunteer to participate, and I will reassure them that not participating in the study will not affect our relationship.
My relationship with the participants may make them open up more during interviews. I will maintain confidentiality- avoid discussing the participants' involvement in the study in staffrooms and with other colleagues.
I will maintain institutional anonymity to protect participants identity.
I am not part of the assessment of student teachers as I am not involved in teacher education and I am not a mentor. However, I may have some information about the inside participants, like their performance. I will minimize the use of such information, and only use it with consent.
There is a possibility that I will come across what might be considered to be 'poor mentoring.' I will not discuss this with anyone. I will record it, keep it confidentially and will not share it with anyone. I will try to interpret the characteristics of such mentoring in the analysis of the data and report the findings in my study without being judgemental and by avoiding deficit language. In the interview I will listen to mentor's reflections on certain observation again without being judgemental. If they ask for feedback I will share my interpretations with them as they would be filtered through my analysis.

4.17 Please state any precautions being taken to protect the health and safety of other researchers and others associated with the project (as distinct from the participants or the applicant).

Not applicable

4.18 The UEA's staff and students will seek to comply with travel and research guidance provided by the British Government and the Governments (and Embassies) of host countries. This pertains to research permission, in-country ethical clearance, visas, health and safety information, and other travel advisory notices where applicable. If this research project is

being undertaken outside the UK, has formal permission/a research permit been sought to conduct this research? Please describe the action you have taken and if a formal permit has not been sought please explain why this is not necessary/appropriate (for very short studies it is not always appropriate to apply for formal clearance, for example).

The research is conducted in the UK

4.19 Are there any procedures in place for external monitoring of the research, for instance by a funding agency?

Not applicable

5. DECLARATION:

Please complete the following boxes with YES, NO, or NOT APPLICABLE:

I have read (and discussed with my supervisor if student) the University's Research Ethics Policy, Principle and Procedures, and consulted the British Educational Research Association's Revised Ethical Guidelines for Educational Research and other available documentation on the EDU Research Ethics webpage and, when appropriate, the BACP Guidelines for Research Ethics.	✓
I am aware of the relevant sections of the GDPR (2018): https://ico.org.uk/forhttps://ico.org.uk/for-organisations/guide-to-the-general-data-protection-regulation-gdpr/organisations/guide-to-the-general-data-protection-regulation-gdpr/ and Freedom of Information Act (2005).	✓
Data gathering activities involving schools and other organizations will be carried out only with the agreement of the head of school/organization, or an authorised representative, and after adequate notice has been given.	✓
The purpose and procedures of the research, and the potential benefits and costs of participating (e.g. the amount of their time involved), will be fully explained to prospective research participants at the outset.	✓
My full identity will be revealed to potential participants.	✓
Prospective participants will be informed that data collected will be treated in the strictest confidence and will only be reported in anonymised form unless identified explicitly and agreed upon	✓
All potential participants will be asked to give their explicit, written consent to participating in the research, and, where consent is given, separate copies of this will be retained by both researcher and participant.	✓

In addition to the consent of the individuals concerned, the signed consent of a parent/carer will be required to sanction the participation of minors (i.e. persons under 16 years of age).	**N/A**
Undue pressure will not be placed on individuals or institutions to participate in research activities.	✓
The treatment of potential research participants will in no way be prejudiced if they choose not to participate in the project.	✓
I will provide participants with my UEA contact details (*not* my personal contact details) and those of my supervisor (if applicable), in order that they are able to make contact in relation to any aspect of the research, should they wish to do so. I will notify participants that complaints can be made to the Head of School.	✓
Participants will be made aware that they may freely withdraw from the project at any	
time without risk or prejudice.	✓
Research will be carried out with regard for mutually convenient times and negotiated in a way that seeks to minimise disruption to schedules and burdens on participants	✓
At all times during the conduct of the research I will behave in an appropriate, professional manner and take steps to ensure that neither myself nor research participants are placed at risk.	✓
The dignity and interests of research participants will be respected at all times, and steps will be taken to ensure that no harm will result from participating in the research	✓
The views of all participants in the research will be respected.	✓
Special efforts will be made to be sensitive to differences relating to age, culture, disability, race, sex, religion and sexual orientation, amongst research participants, when planning, conducting and reporting on the research.	✓
Data generated by the research (e.g. transcripts of research interviews) will be kept in a safe and secure location and will be used purely for the purposes of the research project (including dissemination of findings). No-one other than research colleagues, professional transcribers and supervisors will have access to any identifiable raw data collected, unless written permission has been explicitly given by the identified research participant.	✓
Research participants will have the right of access to any data pertaining to them.	✓
All necessary steps will be taken to protect the privacy and ensure the anonymity and non-traceability of participants – e.g. by the use of pseudonyms, for both individual and institutional participants, in any written reports of the research and other forms of dissemination.	✓

I am satisfied that all ethical issues have been identified and that satisfactory procedures are in place to deal with those issues in this research project. I will abide by the procedures described in this form.

Name of Applicant:	*Natheaniel Machino*
Date:	22/04/2020

PGR/EdD/EdPsyD/MRes Supervisor declaration (for PGR/EdD/EdPsyD/MRes student research only)

I have discussed the ethics of the proposed research with the student and am satisfied that all ethical issues have been identified and that satisfactory procedures are in place to deal with those issues in this research project.

Name of PGR Supervisor:	*Dr Irene Biza*
Date:	22/04/2020

MA taught/Undergraduate Supervisor declaration (for MA Taught/Undergraduate student research only)

I confirm that I have read and discussed the ethics of the proposed research with the student and am satisfied that all ethical issues have been identified and that satisfactory procedures are in place to deal with those issues in this research project. I also confirm that all of the relevant documents are appropriate to conduct the proposed research.

Name of Supervisor:	
Date:	

APPENDIX 10.A : Information sheets and consent forms

Natheaniel Machino
PhD Researcher
[22/04/2020]

Faculty of Social Sciences
School of Education

University of East Anglia
Norwich Research Park

Norwich NR4 7TJ
United Kingdom

Email: N.Machino@uea.ac.uk

Tel: +44 (0) 7963706329

Web:www.uea.ac.uk

Teacher Education in Further Education: The effectiveness of the mentor system of training mathematics student teachers in the Further Education and Training sector.

PARTICIPANT INFORMATION STATEMENT – Student teacher

(1) What is this study about?

You are invited to take part in a research study about the effectiveness of the mentor system of training mathematics student teachers in the Further Education and Training sector (FE). The aim of the study is to develop better and deeper insights into how mentoring of mathematics student teachers in FE works, and these insights might contribute to future mentoring practices. You have been invited to participate in this study because you are training to teach mathematics at FE. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the study. Please read this sheet carefully and ask questions about anything that you don’t understand or want to know more about.

Participation in this research study is voluntary. By giving consent to take part in this study you are telling us that you:

- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.
- ✓ You have received a copy of this Participant Information Statement to keep.

Who is running the study?

The study is being carried out by **Natheaniel Machino**, a PhD student at the University of East Anglia, who is supervised by Dr Irene Biza.

What will the study involve for me?

Your participation in this study will involve you responding to MathTASK based questionnaires (thereafter called mathtasksk) which are classroom situation-specific scenarios which are hypothetical but grounded on learning and teaching issues that previous research and experience have highlighted as seminal and are likely to occur in practice The study will also involve you being observed by me while teaching, observed in the mentor meetings and being interviewed, and your mentor meeting minutes and observation reports being collected, three times over the duration of your training.

With your agreement (by ticking the appropriate box in the consent form), the lessons will be audio or video recorded and the mentoring meetings will be audio or video recorded. I will also be taking down notes. I will also interview you asking questions related to your lesson and about how you are being mentored. The interview, with your consent, will be audio recorded with note taking or note taking only. With your consent, by ticking the appropriate box, I will collect your mentor meeting minutes and lesson observation reports from your mentor. You will be free to view my notes and transcripts on the observed lessons and meetings, and interviews.

How much of my time will the study take?

Each mathtask takes approximately 20 minutes to complete. Since there are three tasks, about one hour is spend on tasks. An interview also takes approximately 20 minutes and there are three interviews which takes one hour. Teaching sessions and mentoring meetings will follow the normal schedule with no alterations. This means you will use two hours of your time for the study.

Do I have to be in the study? Can I withdraw from the study once I've started? Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate or not will not affect your current or future relationship with the researcher, anyone else at the University of East Anglia or at your college. Also, it will not affect your progress in the teacher training programme. If you decide to take part in the study and then change your mind later, you are free to withdraw at any time. You can do this by emailing me at N.Machino@uea.ac.uk.

You are free to stop the interview at any time. Unless you say that you want me to keep them, any recordings will be erased and the information you will have provided will not be included in the study results. You may also refuse to answer any question(s) that you do not wish to answer during the interview. If you decide at a later time to withdraw from the study your information will be removed from my records and will not be included in any results, up to the point I have analysed and published the results.

Are there any risks or costs associated with being in the study?

Besides giving up your time, I do not expect that there will be any costs associated with taking part in this study. Some of the interview questions might challenge your professional views. To reduce this, you should be aware that it is your right not to answer some or all questions and to withdraw from the interview at any point, if you feel you are uncomfortable with the questions.

Are there any benefits associated with being in the study?

You will complete mathtasks. Mathtasks are classroom situation-specific scenarios which are hypothetical but grounded on learning and teaching issues that previous research and experience have highlighted as seminal and are likely to occur in practice. By responding to the mathtasks, you benefit by reflecting on how to respond to situations that you are likely to meet in the classroom, and this will help improve your teaching. You will be interviewed after classroom observation. These interviews will help you to reflect on your actions while teaching, and this is likely to have positive impact on your teaching.

The research project, which aims to develop insights into mentoring of mathematics student teachers in FE, is likely to trigger debates into this often not so talked about area. This might ultimately improve the practice of mentoring student teachers in FE, especially those training to teach mathematics.

What will happen to information about me that is collected during the study? By providing your consent, you are agreeing to me collecting personal information about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise. Data management will follow the 2018 General Data Protection Regulation Act and the University of East Anglia Research Data Management Policy (2019).

Your information will be stored securely and will only be disclosed with your permission, except as required by law. Study findings will be presented at conferences and published in journals and may be published as a chapter in a book or as a book. In this instance, data will be stored for a period of 10 years and then destroyed.

What if I would like further information about the study?

When you have read this information, I will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact me at N.Machino@uea.ac.uk

Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell me that you wish to receive feedback by ticking the relevant box on the consent form. This feedback will be in the form of a one-page summary of the analysed data. You will receive this feedback after the completion of my studies and the thesis available.

What if I have a complaint or any concerns about the study?

The ethical aspects of this study have been approved under the regulations of the University of East Anglia's School of Education and Lifelong Learning Research Ethics Committee.

If there is a problem, please let me know. You can contact me via the University at the following address:
Natheaniel Machino
School of Education and Lifelong Learning
University of East Anglia
NORWICH NR4 7TJ
Email: N.Machino@uea.ac.uk

If you would like to speak to someone else, you can contact my supervisor: Dr Irene Biza.
School of Education and Lifelong Learning
University of East Anglia
NORWICH NR4 7TJ
Email: I.biza@uea.ac.uk
Telephone: 01603591741

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the interim Head of the School of Education and Lifelong Learning, Professor Nalini Boodhoo at N.Boodhoo@uea.ac.uk.

(12) OK, I want to take part – what do I do next?

You need to fill in one copy of the consent form and I will come and collect it during my visit to your college. Please keep the letter, information sheet and the 2nd copy of the consent form for your information.

This information sheet is for you to keep

PARTICIPANT CONSENT FORM (1st Copy to Researcher)

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.

The researchers have answered any questions that I had about the study and I am happy with the answers.

I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.

I understand that I can withdraw from the study at any time.

I understand that I may stop the interview at any time if I do not wish to continue, and that unless I indicate otherwise any recordings will then be erased and the information provided will not be included in the study. I also understand that I may refuse to answer any questions I don't wish to answer.

I understand that I may stop participating in an observation at any time if I do not wish to continue. I also understand that it will not be possible to remove my data unless the observation is videoed or I am individually identified in some way.

I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.

I understand that the results of this study may be published, but these publications will not contain my name or any identifiable information about me. I consent to:

- **Completing mathtasks** **YES** ☐ **NO** ☐
- **Classroom observation** **YES** ☐ **NO** ☐

- **Classroom observation with video recording** **YES** ☐ **NO** ☐

- **Classroom Observations with audio recording** **YES** ☐ **NO** ☐
- **Mentor meeting observation** **YES** ☐ **NO** ☐
- **Mentor meeting observation with audio recording** **YES** ☐ **NO** ☐
- **Mentor meeting observation with video recording** **YES** ☐ **NO** ☐
- **Interviews** **YES** ☐ **NO** ☐
- **Interviews with audio recording** **YES** ☐ **NO** ☐
- **Reviewing transcripts** **YES** ☐ **NO** ☐

Mentor meeting minutes and observation reports collecting YES ☐ **NO** ☐

Would you like to receive feedback about the overall results of this study?

YES ☐ **NO** ☐

If you answered **YES**, please indicate your preferred form of feedback and address:

Postal: ____

Email: ____

....

Signature

....

PRINT name

....

Date

PARTICIPANT CONSENT FORM (2nd Copy to Participant)

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

✓ I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.

✓ The researchers have answered any questions that I had about the study and I am happy with the answers.

✓ I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.

✓ I understand that I can withdraw from the study at any time.

✓ I understand that I may stop the interview at any time if I do not wish to continue, and that unless I indicate otherwise any recordings will then be erased and the information provided will not be included in the study. I also understand that I may refuse to answer any questions I don't wish to answer.

✓ I understand that I may stop participating in an observation at any time if I do not wish to continue. I also understand that it will not be possible to remove my data unless the observation is videoed or I am individually identified in some way.

✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.

✓ I understand that the results of this study may be published, but these publications will not contain my name or any identifiable information about me.

I consent to:

- **Completing mathtasks** **YES** ☐ **NO** ☐
- **Classroom observation** **YES** ☐ **NO** ☐
- **Classroom observation with video- recording** **YES** ☐ **NO** ☐
- **Classroom Observations with audio recording** **YES** ☐ **NO** ☐
- **Mentor meeting observation** **YES** ☐ **NO** ☐
- **Mentor meeting observation with audio recording** **YES** ☐ **NO** ☐
- **Mentor meeting observation with video recording** **YES** ☐ **NO** ☐
-
- **Interviews** **YES** ☐ **NO** ☐
- **Interviews with audio recording** **YES** ☐ **NO** ☐

Reviewing transcripts **YES** ☐ **NO** ☐

Mentor meeting minutes and observation reports collecting **YES** ☐ **NO** ☐

Would you like to receive feedback about the overall results of this study?

YES ☐ **NO** ☐

If you answered **YES**, please indicate your preferred form of feedback and address:

Postal: ____

Email: ____

....

Signature

....

PRINT name

....

Date

APPENDIX 10.B : Information sheets and consent forms

Natheaniel Machino **Faculty of Social Sciences**

PhD Researcher School of Education

[22/04/2020] University of East Anglia

Norwich Research Park

Norwich NR4 7TJ

United Kingdom

Email: N.Machino@uea.ac.uk

Tel: +44 (0) 7963706329

Web:www.uea.ac.uk

Teacher Education in Further Education: *The effectiveness of the mentor system of training mathematics student teachers in the Further Education and Training sector.*

PARTICIPANT INFORMATION STATEMENT – *Mentor*

(1) What is this study about?

You are invited to take part in a research study about the effectiveness of the mentor system of training mathematics student teachers in the Further Education and Training sector (FE). The aim of the study is to develop better and deeper insights into how mentoring of mathematics student teachers in FE works, and these insights might contribute to future mentoring practices. You have been invited to participate in this study because you are a mentor of mathematics student teacher(s) who have agreed to participate to this study. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the study. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary. By giving consent to take part in this study you are telling me that you:

✓ Understand what you have read.

✓ Agree to take part in the research study as outlined below.

✓ Agree to the use of your personal information as described.

✓ You have received a copy of this Participant Information Statement to keep.

Who is running the study?

The study is being carried out by **Natheaniel Machino**, a PhD student at the University of East Anglia, who is supervised by Dr Irene Biza.

What will the study involve for me?

Your participation in this study will involve observe you in meetings with your mentee. With your agreement (by ticking the appropriate box in the consent form), the meetings will be audio or video recorded. I will also be taking down notes. I will also interview you asking questions related to the general performance of student teachers on mathtasks, observed lessons and how you mentor the student teacher. The interviews may be audio recorded with notes taking or notes taking only. You will be free to view my notes and transcripts of the observed lessons and meetings, and interviews. Additionally, I will collect your observation reports and minutes of mentor meetings that regard your mentee.

(4)How much of my time will the study take?

Each interview will last about 20 minutes and there are three interviews, meaning a total of one hour of your time. Teaching sessions and mentoring meetings will follow the normal schedule with no alterations.

Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate or not will not affect your current or future relationship with the researcher, or anyone else at the University of East Anglia and your college.

If you decide to take part in the study and then change your mind later, you are free to withdraw at any time. You can do this by emailing me at N.Machino@uea.ac.uk

You are free to stop the interview at any time. Unless you say that you want me to keep them, any recordings will be erased and the information you will have provided will not be included in the study results. You may also refuse to answer any question(s) that you do not wish to answer during the interview. If you decide at a later time to withdraw from the study your information will be removed from my records and will not be included in any results, up to the point I have analysed and published the results.

Are there any risks or costs associated with being in the study?

Besides giving up your time, I do not expect that there will be any costs associated with taking part in this study. Some interview questions might challenge your professional views. To reduce this, you should be aware that it is your right not to answer some or all questions and to withdraw from the interview at any point, if you feel you are uncomfortable with the interview.

Are there any benefits associated with being in the study?

Taking part in the study is likely to generate reflections on your mentoring strategies. The interview after observing the student teacher's lessons and in the mentor meetings, is likely going to bring some insights into different mentoring strategies.

The research project, which aims to develop insights into mentoring of mathematics student teachers in FE, is likely to trigger debates into this often not so talked about area. This might enhance the practice of mentoring student teachers in FE leading to improved teaching and learning of mathematics, other subjects and vocational courses.

What will happen to information about me that is collected during the study?

By providing your consent, you are agreeing to me collecting personal information about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise. Data management will follow the 2018 General Data Protection Regulation Act and the University of East Anglia Research Data Management Policy (2019). Your information will be stored securely and will only be disclosed with your permission, except as required by law. Study findings will be presented at conferences and published in journals and may be published as a chapter in a book or as a book. In this instance, data will be stored for a period of 10 years and then destroyed.

What if I would like further information about the study?

When you have read this information, I will be available to discuss it with you further and answer any question(s) you may have. If you would like to know more at any stage during the study, please feel free to contact me at N.Machino@uea.ac.uk

Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell me that you wish to receive feedback by ticking the relevant box on the consent form. This feedback will be in the form of a one-page summary of the analysed data. You will receive this feedback after the completion of my studies and the thesis available

What if I have a complaint or any concerns about the study?

The ethical aspects of this study have been approved under the regulations of the University of East Anglia's School of Education and Lifelong Learning Research Ethics Committee.

If there is a problem, please let me know. You can contact me via the University at the following address: Natheaniel Machino

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: N.Machino@uea.ac.uk

If you would like to speak to someone else, you can contact my supervisor:

Dr Irene Biza.

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: I.biza@uea.ac.uk

Telephone: 01603591741

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the interim Head of the School of Education and Lifelong Learning, Professor Nalini Boodhoo at N.Boodhoo@uea.ac.uk.

(12) OK, I want to take part – what do I do next?

You need to fill in one copy of the consent form and I will come and collect it during my visit to your college. Please keep the information sheet and the 2nd copy of the consent form for your information

This information sheet is for you to keep

PARTICIPANT CONSENT FORM (1st Copy to Researcher)

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

✓ I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.

✓ The researchers have answered any questions that I had about the study and I am happy with the answers.

✓ I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.

✓ I understand that I can withdraw from the study at any time.

✓ I understand that I may stop the interview at any time if I do not wish to continue, and that unless I indicate otherwise any recordings will then be erased and the information provided will not be included in the study. I also understand that I may refuse to answer any questions I don't wish to answer.

✓ I understand that I may stop participating in an observation at any time if I do not wish to continue. I also understand that it will not be possible to remove my data unless the observation is videoed or I am individually identified in some way.

✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.

✓ I understand that the results of this study may be published, but these publications will not contain my name or any identifiable information about me.

I consent to:

- **Mentor meeting observation** **YES** ☐ **NO** ☐
- **Mentor meeting observation with audio recording** **YES** ☐ **NO** ☐
- **Mentor meeting observation with video recording** **YES** ☐ **NO** ☐
- **Interviews** **YES** ☐ **NO** ☐
- **Interviews with audio recording** **YES** ☐ **NO** ☐
- **Reviewing transcripts** **YES** ☐ **NO** ☐
- **Providing mentor meeting minutes and observation reports** **YES** ☐ **NO** ☐
- **Would you like to receive feedback about the overall results of this study?**
  YES ☐ **NO** ☐

If you answered **YES**, please indicate your preferred form of feedback and address:

Postal: ____

Email: ____

....

Signature

....

PRINT name

....

Date

PARTICIPANT CONSENT FORM (2nd Copy to Participant)

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

✓ I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.

✓ The researchers have answered any questions that I had about the study and I am happy with the answers.

✓ I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.

✓ I understand that I can withdraw from the study at any time.

✓ I understand that I may stop the interview at any time if I do not wish to continue, and that unless I indicate otherwise any recordings will then be erased and the information provided will not be included in the study. I also understand that I may refuse to answer any questions I don't wish to answer.

✓ I understand that I may stop participating in an observation at any time if I do not wish to continue. I also understand that it will not be possible to remove my data unless the observation is videoed or I am individually identified in some way.

✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.

✓ I understand that the results of this study may be published, but these publications will not contain my name or any identifiable information about me .

I consent to:

- **Mentor meeting observation** **YES** ☐ **NO** ☐
- **Mentor meeting observation with audio recording** **YES** ☐ **NO** ☐
- **Mentor meeting observation with video recording** **YES** ☐ **NO** ☐
-
- **Interviews** **YES** ☐ **NO** ☐
- **Interviews with audio recording** **YES** ☐ **NO** ☐
- **Reviewing transcripts** **YES** ☐ **NO** ☐
- **Providing mentor meeting minutes and observation reports** **YES** ☐ **NO** ☐
- **Would you like to receive feedback about the overall results of this study?**

  YES ☐ **NO** ☐

If you answered **YES**, please indicate your preferred form of feedback and address:

Postal: ____

Email: ____

…………………………………………………………

Signature

……………………………… ……………………………………………

PRINT name

……………………………………………………………………

Date

APPENDIX C: Information sheets and consent forms

Natheaniel Machino
PhD Researcher
[22/04/2020]

Faculty of Social Sciences
School of Education

University of East Anglia
Norwich Research Park
Norwich NR4 7TJ
United Kingdom

Email: N.Machino@uea.ac.uk

Tel: +44 (0) 7963706329

Web:www.uea.ac.uk

Teacher Education in Further Education: *The effectiveness of the mentor system of training mathematics student teachers in the Further Education and Training sector.*

PARTICIPANT INFORMATION STATEMENT – *Student*

(1)What is this study about?

You are invited to take part in a research study about the effectiveness of the mentor system of training mathematics student teachers in the further education and Training sector (FE). The aim of the study is to develop better and deeper insights into how mentoring of mathematics student teachers in FE works, and these insights might contribute to future mentoring practices. You have been invited to participate in this study because you are a student studying mathematics in an FE college taught by a student teacher who had agreed to participate to this study. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the study. Please read this sheet carefully and ask questions about anything that you don’t understand or want to know more about.

Participation in this research study is voluntary. By giving consent to take part in this study you are telling me that you:

✓ Understand what you have read.

✓ Agree to take part in the research study as outlined below.

✓ Agree to the use of your personal information as described.

✓ You have received a copy of this Participant Information Statement to keep.

Who is running the study?

The study is being carried out by **Natheaniel Machino**, a PhD student at the University of East Anglia, who is supervised by Dr Irene Biza.

What will the study involve for me?

I will observed your teacher and you in your mathematics lesson on three different occasions this year. With your agreement (by ticking the appropriate box in the consent form), the lessons will be audio or video recorded. I will also be taking down notes. My focus is going to be your teacher, but there might be occasions when I would like to capture the interaction of the teacher with students.

(4)How much of my time will the study take?

This study does not take any of your time as you will be observed in your timetabled lessons.

Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate or not will not affect your current or future relationship with the researcher, anyone else at the University of East Anglia , your college or your teacher. If you do not want to be participate in the general classroom observations, I will make sure that the audio/video will not capture you and I will not include data from your contribution when this is possible.

If you decide to take part in the study and then change your mind later, you are free to withdraw at any time *and I will not include data from your contribution when this is possible*. You can do this by emailing me at N.Machino@uea.ac.uk

Are there any risks or costs associated with being in the study?

There will be no risks or costs associated with taking part in this study.

Are there any benefits associated with being in the study?

Taking part in the study is likely going to improve your learning of mathematics as it is likely going to improve the teaching.

The research project, which aims to develop insights into mentoring of mathematics student teachers in FE, is likely to trigger debates into this often not so talked about area. This might improve the mentoring of your teachers leading to improvement of teaching and learning of mathematics in FE.

What will happen to information about me that is collected during the study?

By providing your consent, you are agreeing to me collecting personal information about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise. Data management will follow the 2018 General Data Protection Regulation Act and the University of East Anglia Research Data Management Policy (2019).

Your information will be stored securely and will only be disclosed with your permission, except as required by law . Study findings will be presented at conferences and published in journals and may also be published as a chapter in a book or as a book. In this instance, data will be stored for a period of 10 years and then destroyed.

What if I would like further information about the study?

When you have read this information, I will be available to discuss it with you further and answer any question(s) you may have, during my visit to your college. If you would like to know more at any stage during the study, please feel free to contact me at N.Machino@uea.ac.uk

Will I be told the results of the study?

You have the right to receive feedback about the overall results of this study. You can tell me that you wish to receive feedback by ticking the relevant box on the consent form. This feedback will be in the form of a one-page summary of the analysed data. You will receive this feedback after the completion of my studies and the thesis available.

What if I have a complaint or any concerns about the study?

The ethical aspects of this study have been approved under the regulations of the University of East Anglia's School of Education and Lifelong Learning Research Ethics Committee.

If there is a problem, please let me know. You can contact me via the University at the following address: Natheaniel Machino

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: N.Machino@uea.ac.uk

If you would like to speak to someone else, you can contact my supervisor:

Dr Irene Biza.

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: I.biza@uea.ac.uk

Telephone: 01603591741

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the interim Head of the School of Education and Lifelong Learning, Professor Nalini Boodhoo at N.Boodhoo@uea.ac.uk.

(12) OK, I want to take part – what do I do next?

You need to fill in one copy of the consent form and give it to your mathematics teacher and I will come and collect it during my visit to your college. Please keep the information sheet and the 2nd copy of the consent form for your information.

This information sheet is for you to keep

PARTICIPANT CONSENT FORM (1st Copy to Researcher)

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

✓ I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.

✓ The researchers have answered any questions that I had about the study and I am happy with the answers.

✓ I understand that being in this study is completely voluntary and I do not have to take part. ✓ My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.

✓ I understand that I can withdraw from the study at any time.

✓ I understand that I may stop participating in an observation at any time if I do not wish to continue. I also understand that it will not be possible to remove my data unless the observation is videoed or I am individually identified in some way.

✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to.

✓ I understand that information about me will only be told to others with my permission, except as required by law.

✓ I understand that the results of this study may be published, but these publications will not contain my name or any identifiable information about me

I consent to:

• **Classroom observation**	**YES** ☐	**NO**	☐
• **Classroom observation with audio-recording**	**YES** ☐	**NO**	☐
• **Classroom observation with video-recording**	**YES** ☐	**NO**	☐

....

Signature

....

PRINT name

....

Date

PARTICIPANT CONSENT FORM (2nd Copy to Participant)

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

✓ I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.

✓ The researchers have answered any questions that I had about the study and I am happy with the answers.

✓ I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.

✓ I understand that I can withdraw from the study at any time.

✓ I understand that I may stop participating in an observation at any time if I do not wish to continue. I also understand that it will not be possible to remove my data unless the observation is videoed or I am individually identified in some way.

✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.

✓ I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.

I consent to:

- **Classroom observation** **YES** ☐ **NO** ☐
- **Classroom observation with audio-recording** **YES** ☐ **NO** ☐
- **Classroom observation with video-recording** **YES** ☐ **NO** ☐

....

Signature

....

PRINT name

....

Date

APPENDIX D: Indicative sample of interview questions

D.1. Student teachers.

How often are you observed and have mentor meetings?

What aspects of the mentor meetings help you as a teacher? Please give examples.

With your mentor, do you discuss how to respond to students contribution during lessons? Please give examples.

Do you think the mentor helps you improve your teaching?

Is there any further support that your mentor would offer?

Are there any areas that you would like to improve in your teaching? Please elaborate

How can your mentor assist you in improving the areas you mentioned earlier?

Discussion on the lesson observed.

Discussion on the mathtask

D.2. Mentors

Does your mentee improve as a teacher due to your mentoring?

What are your mentoring strategies?

Are you involved in evaluating the performance of your mentee?

Discussion on the specificities of the lesson observed.

Discussion on highlights of responses given to mathtask (without mentioning responses of specific mentees)

APPENDIX E: Indicative sample of lesson observation protocol

Knowledge Quartet ***Domains and subdomains***	**What students say and do**	**What the teacher say and do**
Foundation 1.Awareness of purpose *2.Identifying errors* *3. Overt subject knowledge 4. Theoretical underpinning of pedagogy* *Use of terminology* *Use of textbooks* *Reliance on procedures*		
Transformation *Choice of representation* *Teacher demonstration* *Choice of example* *(mis)use of instructional materials*		
Connection *Decisions about sequencing*; *Making connections between procedures 3. Making connections between representations 4. Making connections between concepts*. *5. Anticipation of complexity* 6. Recognition of conceptual appropriateness		
Contingency *1. Deviation from agenda* *2. Responding to student ideas*		
Use of opportunities. *Teacher insight during instructions* *Responding to the (un)availability of tools and resources*		

Adapted from Dimensions and contributory codes (Rowland & Turner, 2017 p. 106)

APPENDIX F: Indicative sample of mentor meeting observation guide

What the mentor says.	**What the student teacher says.**

APPENDIX G: Recruiting participants

G.1 Draft email to gate keepers

Dear Principal

I am a PhD student at the School of Education and Lifelong Learning at the University of East Anglia. I am carrying out a research on the role of mentoring in the training of mathematics student teachers in the further education and training sector (FE). I am looking for FE colleges which are interested in taking part in my study, and I am approaching you because your college trains FE teachers.

The aim of my study is to develop better and deeper insights into how mentoring of mathematics student teachers in the Further Education and Skills (FE) sector works. The insights are intended to contribute to the improvement of mentoring of FE student teachers in general and those learning to teach mathematics in particular. The study involves inviting mathematics student teachers to reflect in writing on fictional classroom situations; observing student teachers lessons and mentor meetings; and interviewing student teachers and mentors. I will also collect mentor meeting minutes and observation reports of the observed lessons, with your consent. Data collection will take place three times during the training of the student teachers.

If you are willing to allow me access to your college, can you please help me with the name and email address of your mathematics head of department through whom I will invite student teachers to participate to my study.

Kind regards.

Natheaniel Machino

G.2 Draft email to heads of mathematics departments

Dear HoD (mathematics)

I am a PhD student at the University of East Anglia, and I am carrying out a research on the role of mentoring in the training of mathematics student teachers in the further education and training sector (FE) I have been given permission by the principal to carry out my research study in your department.

The aim of my study is to develop better and deeper insights into how mentoring of mathematics student teachers in the Further Education and Skills (FE) sector works. The insights are intended to contribute to the improvement of mentoring of FE student teachers in general and those learning to teach mathematics in particular. The study involves inviting mathematics student teachers to reflect in writing on fictional classroom situations; observing student teachers lessons and mentor meetings; and interviewing student teachers and mentors. I will also collect mentor meeting minutes and observation reports of the observed lessons. Data collection will take place three times during the training of the student teachers.

Can you please forward the letter attached with a questionnaire link to the student teachers in your department? I am happy to visit your college and explain my study once I have received the completed tasks from the student teachers and have shown interest in the study.

Kind regards,

Natheaniel Machino

G.3 Statement accompanying the mathtask questionnaire

[ON THE FRONT SCREEN PARTICIPANTS WILL SEE THE FOLLOWING]

Dear mathematics student teacher

I am a PhD student at the University of East Anglia and I am carrying out a study about the role of mentoring in the training of mathematics student teachers in the Further Education and Training sector (FE). Especially, I am investigating how mentoring of mathematics student teachers is related to the development of student teachers' mathematical and pedagogical knowledge essential for important and difficult for the students areas of the curriculum. This is the first phase of the study and I am inviting you to participate in this study because you are a teacher student in FE.

Your participation involves responding to an anonymous questionnaire in which you will write your thoughts on a classroom situation in which students discuss about the addition of fractions. You will be also asked to respond to a few questions about yourself and your experience. Your response to the questionnaire will take approximately 15-20 minutes.

Participation to the study is voluntary and by providing your consent, you are agreeing your information to be used only for the purposes of my PhD research and publications of its findings. Data management will follow the 2018 General Data Protection Regulation Act and the University of East Anglia Research Data Management Policy (2019).

The questionnaire responses will be anonymous. Only if you want to participate in the

following stages of the study you will have the chance to add your contact details at the end of the questionnaire.

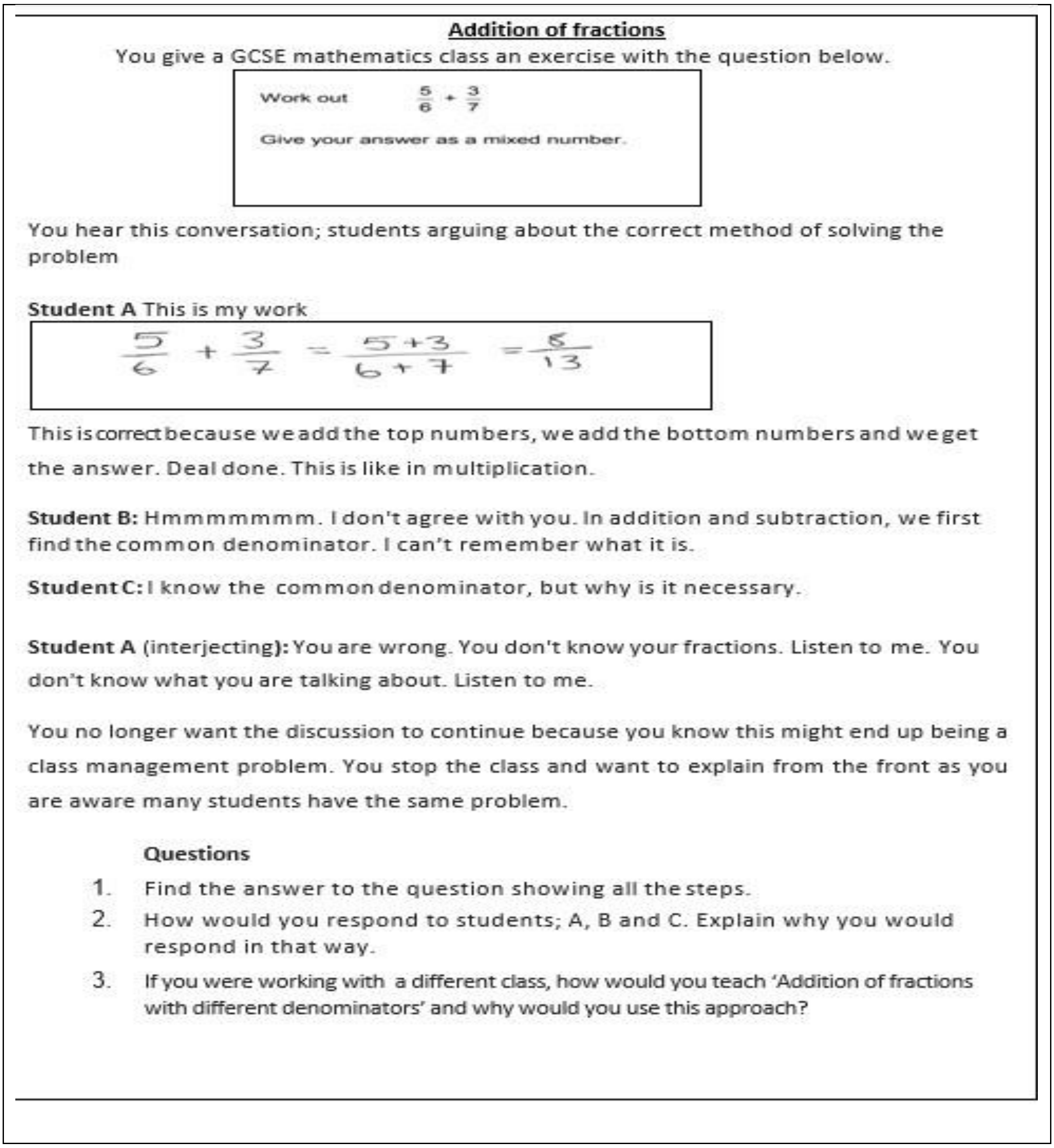
For further information, click HERE [This link will lead you to a full information sheet – see

Appendix I] or write to me at N.Machino@uea.ac.uk

[IF THEY SELECT NO, A MESSAGE WILL APPEAR SAYING "THANK YOU FOR CONSIDERING YOUR PARTICIPATION TO THE STUDY”

IF THEY SELECT YES, THE QUESTIONNAIRE WILL APPEAR]

Section A Mathtask 1



Addition of fractions

You give a GCSE mathematics class an exercise with the question below.

Work out $\frac{5}{6} + \frac{3}{7}$

Give your answer as a mixed number.

You hear this conversation; students arguing about the correct method of solving the problem

Student A This is my work

$$\frac{5}{6} + \frac{3}{7} = \frac{5+3}{6+7} = \frac{8}{13}$$

This is correct because we add the top numbers, we add the bottom numbers and we get the answer. Deal done. This is like in multiplication.

Student B: Hmmmmmmm. I don't agree with you. In addition and subtraction, we first find the common denominator. I can't remember what it is.

Student C: I know the common denominator, but why is it necessary.

Student A (interjecting)**:** You are wrong. You don't know your fractions. Listen to me. You don't know what you are talking about. Listen to me.

You no longer want the discussion to continue because you know this might end up being a class management problem. You stop the class and want to explain from the front as you are aware many students have the same problem.

Questions

1. Find the answer to the question showing all the steps.
2. How would you respond to students; A, B and C. Explain why you would respond in that way.
3. If you were working with a different class, how would you teach 'Addition of fractions with different denominators' and why would you use this approach?

Write your responses below. For question 1 (or all the questions), you can work on a piece of paper, take a photo and paste it below..

Section B : Background information Indicate your gender

●

Female

○

Male

○

Prefer not to say

Indicate your age group

○

Less than 25

○

26 - 35

○

36 - 45

○

46 and above

What is your highest qualification?

○

GCSE

○

A Level

○

Certificate or Diploma

○

Bachelor’s degree

○

Master’s degree

○

Doctorate

●

Other

For how long have you been teaching in FE

○

Less than 5 years

○

6 - 10 years

○

11 - 15 years

○

More than 16 years

What was your job before joining FE and for how many years have you been doing that?

Do you consider yourself to have a disability?

- ○ yes
- ○ no

Section C: THANK YOU and what’s next

THANK YOU for taking part in this part of the study. The next part involves you completing two more mathtasks, being observed teaching and in mentor meetings and being interviewed three times. If you would like to continue in the study, please write your name and email below and I will contact you with more information.

○

I would like to continue

●

I don't want to continue

Please write your name and email below.

APPENDIX H: Information sheet for gatekeepers

Natheaniel Machino
PhD Researcher
[22/04/2020]

Faculty of Social Sciences
School of Education

University of East Anglia
Norwich Research Park
Norwich NR4 7TJ
United Kingdom

Email: N.Machino@uea.ac.uk
Tel: +44 (0) 7963706329
Web:www.uea.ac.uk

Teacher Education in Further Education: *The effectiveness of the mentor system of training mathematics student teachers in the Further Education and Training sector.*

PARTICIPANT INFORMATION STATEMENT – Principal

(1) What is this study about?

You are invited to take part in a research study about the role of mentoring in the training of mathematics student teachers in the Further Education and Training sector (FE). Especially, I am investigating how mentoring of mathematics student teachers is related to the development of student teachers' mathematical and pedagogical knowledge essential for important and difficult for the students areas of the curriculum. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the study. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary. By giving consent to take part in this study you are telling us that you:

✓Understand what you have read.

✓Agree to take part in the research study as outlined below.

✓Agree to the use of your personal information as described.

✓You have received a copy of this Participant Information Statement to keep.

Who is running the study?

The study is being carried out by **Natheaniel Machino**, a PhD student at the University of East Anglia, who is supervised by Dr Irene Biza.

What will the study involve for me?

Your participation involves allowing me to access and use mentoring documents; mentor meeting minutes and observation reports about mathematics student teachers in your college..

(4) How much of my time will the study take?

The study will be conducted in your college, but it will not take any of your time.

(5) Do I have to be in the study? Can I withdraw from the study once I've started?

Participation to the study is voluntary and by providing your consent, you are agreeing the information in the documents to be used only for the purposes of my PhD research and publications of its findings. Your decision whether to allow me permission to access and use the mentoring documents or not will not affect your current or future relationship with the researcher and anyone else at the University of East Anglia or at your college.

(6) Are there any risks or costs associated with being in the study?

I do not expect that there will be any risks or costs associated with taking part in this study..

Are there any benefits associated with being in the study?

The participating student teachers in your college will benefit by reflecting on how to respond to situations that they are likely to meet in the classroom, and this may inspire their reflection on their teaching.

The research project, which aims to develop insights into mentoring of mathematics student teachers in FE, is likely to trigger debates into this often not so talked about area. This might ultimately improve the practice of mentoring student teachers in FE, especially those training to teach mathematics.

What will happen to information about me that is collected during the study?

By providing your consent, you are agreeing to me collecting personal information about the student teachers and their mentors for the purposes of this research study. The information will only be used for the purposes outlined in this Participant Information Statement. Data management will follow the 2018 General Data Protection Regulation Act and the University of East Anglia Research Data Management Policy (2019).

The information will be stored securely and will only be disclosed with the mentors and student teachers' permission, except as required by law. Study findings will be presented at conferences and published in journals and may be published as a chapter in a book or as a book. In this instance, data will be stored for a period of 10 years and then destroyed.

What if I would like further information about the study?

When you have read this information, I will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact me at N.Machino@uea.ac.uk

Will I be told the results of the study?

I will be able to provide you feedback about the overall results of this study only if you contact me with this request. Please email me at N.Machino@uea.ac.uk and tell me that you wish to receive feedback. This feedback will be in the form of a one-page summary of the analysed data. You will receive this feedback after the completion of my study and when the thesis will be available.

(11) What if I have a complaint or any concerns about the study?

The ethical aspects of this study have been approved under the regulations of the University of East Anglia's School of Education and Lifelong Learning Research Ethics Committee.

If there is a problem, please let me know. You can contact me via the University at the following address:

Natheaniel Machino

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: N.Machino@uea.ac.uk

If you would like to speak to someone else, you can contact my supervisor:

Dr Irene Biza.

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: I.biza@uea.ac.uk

Telephone: 01603591741

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the interim Head of the School of Education and Lifelong Learning, Professor Nalini Boodhoo at N.Boodhoo@uea.ac.uk.

(12) OK, I want to take part – what do I do next?

You need to fill in one copy of the consent form and I will come and collect it during my visit to your college. Please keep the information sheet and the 2nd copy of the consent form for your information

PARTICIPANT CONSENT FORM (1st Copy to Researcher)

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.

The researchers have answered any questions that I had about the study and I am happy with the answers.

I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.

I understand that I can withdraw from the study at any time.

I consent to provide access to:

- Mentor meeting minutes and observation reports YES ☐ NO ☐

……………………………………………………………

Signature

………………………………………

………………………………………………

PRINT name

………………………………………………………………………………

Date

PARTICIPANT CONSENT FORM (2nd Copy to Participant)

I, ………………………………………………………………………… [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

✓I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

✓I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.

✓The researchers have answered any questions that I had about the study and I am happy with the answers.

✓I understand that being in this study is completely voluntary and I do not have to take part. ✓My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.

✓I understand that I can withdraw from the study at any time.

I consent to provide access to:

- Mentor meeting minutes and observation reports YES ☐ NO ☐

....

Signature

....

PRINTname

....

Date

APPENDIX I : Information sheet for questionnaires

Natheaniel Machino
PhD Researcher
[22/04/2020]

University of East Anglia

Norwich Research Park

Norwich NR4 7TJ

United Kingdom

Faculty of Social Sciences
School of Education

Email: N.Machino@uea.ac.uk
Tel: +44 (0) 7963706329
Web:www.uea.ac.uk

Teacher Education in Further Education: The effectiveness of the mentor system of training mathematics student teachers in the Further Education and Training sector.

PARTICIPANT INFORMATION STATEMENT – Student teacher

(1) What is this study about?

You are invited to take part in a research study about the role of mentoring in the training of mathematics student teachers in the Further Education and Training sector (FE). Especially, I am investigating how mentoring of mathematics student teachers is related to the development of student teachers' mathematical and pedagogical knowledge essential for important and difficult for the students areas of the curriculum. This is the first phase of the study and I am inviting you to participate in this study because you are a teacher student in FE. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the study. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary. By giving consent to take part in this study you are telling us that you:

Understand what you have read.

Agree to take part in the research study as outlined below.

Agree to the use of your personal information as described.

You have received a copy of this Participant Information Statement to keep.

Who is running the study?

The study is being carried out by **Natheaniel Machino**, a PhD student at the University of East Anglia, who is supervised by Dr Irene Biza.

What will the study involve for me?

Your participation involves responding to an anonymous questionnaire in which you will write your thoughts on a classroom situation in which students discuss about the addition of fractions. You will be also asked to respond to a few questions about yourself and your experience.

(4) How much of my time will the study take?

Your response to the questionnaire will take approximately 15-20 minutes.

Do I have to be in the study? Can I withdraw from the study once I've started?

Participation to the study is voluntary and by providing your consent, you are agreeing your information to be used only for the purposes of my PhD research and publications of its findings. Your decision whether to participate or not will not affect your current or future relationship with the

researcher, anyone else at the University of East Anglia or at your college. Also, it will not affect your progress in the teacher training programme. If you decide to take part in the study and then change your mind later, you are free to withdraw at any time. You can do this by emailing me at N.Machino@uea.ac.uk .

If you decide at a later time to withdraw from the study your information will not be possible to be removed from my records as the questionnaire does not record your identity.

Are there any risks or costs associated with being in the study?

Besides giving up your time, I do not expect that there will be any costs associated with taking part in this study..

Are there any benefits associated with being in the study?

You will benefit by reflecting on how to respond to situations that you are likely to meet in the classroom, and this may inspire your reflection on your teaching.

The research project, which aims to develop insights into mentoring of mathematics student teachers in FE, is likely to trigger debates into this often not so talked about area. This might ultimately improve the practice of mentoring student teachers in FE, especially those training to teach mathematics.

What will happen to information about me that is collected during the study?

By providing your consent, you are agreeing to me collecting personal information about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise. Data management will follow the 2018 General Data Protection Regulation Act and the University of East Anglia Research Data Management Policy (2019).

Your information will be stored securely and will only be disclosed with your permission, except as required by law. Study findings will be presented at conferences and published in journals and may be published as a chapter in a book or as a book. In this instance, data will be stored for a period of 10 years and then destroyed.

What if I would like further information about the study?

When you have read this information, I will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact me at N.Machino@uea.ac.uk

Will I be told the results of the study?

As the questionnaire is anonymous, I will be able to provide you feedback about the overall results of this study only if you contact me with this request. Please email me at N.Machino@uea.ac.uk and tell me that you wish to receive feedback. This feedback will be in the form of a one-page summary of the analysed data. You will receive this feedback after the completion of my study and when the thesis will be available.

What if I have a complaint or any concerns about the study?

The ethical aspects of this study have been approved under the regulations of the University of East Anglia's School of Education and Lifelong Learning Research Ethics Committee.

If there is a problem, please let me know. You can contact me via the University at the following address:

Natheaniel Machino
School of Education and Lifelong Learning
University of East Anglia
NORWICH NR4 7TJ
Email: N.Machino@uea.ac.uk

If you would like to speak to someone else, you can contact my supervisor:

Dr Irene Biza.

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: I.biza@uea.ac.uk

Telephone: 01603591741

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the interim Head of the School of Education and Lifelong Learning, Professor Nalini Boodhoo at N.Boodhoo@uea.ac.uk.

(12) OK, I want to take part – what do I do next?

Return to the main screen and select YES in the consent option.

You can download and keep this information sheet

Natheaniel Machino
PhD Researcher
[28/09/2021]

Faculty of Social Sciences
School of Education
University of East Anglia
Norwich Research Park
Norwich NR4 7TJ
United Kingdom

Email: N.Machino@uea.ac.uk

Tel: +44 (0) 7963706329

Web: www.uea.ac.uk

Teacher Education in Further Education: *The role of mentoring in further education mathematics student teachers' mathematical and pedagogical knowledge development.*

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study about the role of mentoring in further education mathematics student teachers' mathematical and pedagogical knowledge development. The aim of the study is to develop better and deeper insights into how mentoring of mathematics student teachers in FE works, and these insights might contribute to future mentoring practices. You have been invited to participate in this study because you are (or you were) a mentor of mathematics student teacher(s) in FE. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the study. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary. By giving consent to take part in this study you are telling me that you:

A Understand what you have read.

A Agree to take part in the research study as outlined below.

A Agree to the use of your personal information as described.

A You have received a copy of this Participant Information Statement to keep.

Who is running the study?

The study is being carried out by **Natheaniel Machino**, a PhD student at the School of Education and Lifelong Learning of the University of East Anglia. This study will take place under the supervision of Dr Irene Biza.

What will the study involve for me?

Your participation in this part of the study will involve you completing a questionnaire on *Microsoft Forms* and, if you wish, a follow up interview. The questionnaire responses will be anonymous. If you want to participate in the interview stages of the study you will have the chance to add your contact details in a different form, so your identity will not be connected to your responses.

How much of my time will the study take?

Completing the questionnaire will take about 30 minutes and the interview, if you decide to participate, approximately 20 minutes.

Do I have to be in the study? Can I withdraw from the study once I have started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate or not will not affect your current or future relationship with the researcher, or anyone else at the University of East Anglia or your professional institution.

If you decide to take part in the study, you can withdraw your consent up to the point that your data is fully anonymised. You can do this by emailing me at N.Machino@uea.ac.uk

What are the consequences if I withdraw from the study?

If you decide to take part in the study and then change your mind, you are free to withdraw at any time before you have submitted the questionnaire. Once you have submitted it, your responses cannot be withdrawn because they are anonymous and therefore, we will not be able to tell which one is yours.

(7)Are there any risks or costs associated with being in the study?

Aside from giving up your time, some questions might challenge your professional views. To reduce this, you should be aware that it is your right not to answer some or all questions (you can just type NO RESPONSE in the answer area) and to stop responding the questionnaire at any point, if you feel you are uncomfortable with the questions.

Are there any benefits associated with being in the study?

Taking part in the study is likely to generate reflections on your mentoring strategies and it is likely going to bring some insights into different mentoring strategies. The research project, which aims to develop insights into mentoring of mathematics student teachers in FE, is likely to trigger debates into this often not so talked about area. This might enhance the practice of mentoring student teachers in FE leading to improved teaching and learning of mathematics, other subjects and vocational courses.

What will happen to information about me that is collected during the study?

Your personal data and information will only be used as outlined in this Participant Information Sheet, unless you consent otherwise. Data management will follow the Data Protection Act 2018 (DPA 2018) and UK General Data Protection Regulation (UK GDPR), and the University of East Anglia's Research Data Management Policy.

The information you provide will be stored securely and your identity will be kept strictly confidential, except as required by law. Study findings may be published, but you will not be identified in these publications if you decide to participate in this study.

What if I would like further information about the study?

When you have read this information, I will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact me at N.Machino@uea.ac.uk

Will I be told the results of the study?

You are not able to receive feedback about the overall results because the data collected is anonymised.

What if I have a complaint or any concerns about the study?

If there is a problem, please let me know. You can contact me via the University at the following address:

Natheaniel Machino

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: N.Machino@uea.ac.uk

[ETH2122-0140]

If you would like to speak to someone else, you can contact my supervisor at the following address: Dr Irene Biza.

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: I.biza@uea.ac.uk

Telephone: 01603591741

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the Head of the School of Education and Lifelong Learning, Professor Yann Lebeau at Y.Lebeau@uea.ac.uk

(13) How do I know that this study has been approved to take place?

To protect your safety, rights, wellbeing and dignity, all research in the University of East Anglia is reviewed by a Research Ethics Body. This research was approved by the EDU S-REC (School of Education and Lifelong Learning Research Ethics Subcommittee).

14) What is the general data protection information I need to be informed about?

According to data protection legislation, we are required to inform you that the legal basis for processing your data as listed in Article 6(1) of the UK GDPR is because this allows us to process personal data when it is necessary to perform our public tasks as a University.

In addition to the specific information provided above about why your personal data is required and how it will be used, there is also some general information which needs to be provided for you:

The data controller is the University of East Anglia.

For further information, you can contact the University's Data Protection Officer at dataprotection@uea.ac.uk

You can also find out more about your data protection rights at the Information Commissioner's Office (ICO).

If you are unhappy with how your personal data has been used, please contact the University's Data Protection Officer at dataprotection@uea.ac.uk in the first instance.

OK, I want to take part – what do I do next?

If you are happy and consent to take part in the study please access the questionnaire at this website by following the link below:

https://forms.office.com/Pages/ResponsePage.aspx?id=lYdfxj26UUOKBwhl5djwkH2RNBiU33ZDusPojCcQRiBURFMxR1RBVlZPRURJTDk2MFdKNFhUT0RRVi4u

and answer the questions. By submitting your responses you are agreeing to the researcher using the data collected for the purposes described above. Please keep the information sheet for your information.

Further information

This information was last updated on 28th September 2021.

This information sheet is for you to keep

Natheaniel Machino
PhD Researcher
[28/09/2021]

Faculty of Social Sciences
School of Education
University of East Anglia
Norwich Research Park
Norwich NR4 7TJ
United Kingdom

Email: N.Machino@uea.ac.uk

Tel: +44 (0) 7963706329

Web: www.uea.ac.uk

Teacher Education in Further Education: *The role of mentoring in further education mathematics student teachers' mathematical and pedagogical knowledge development.*

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study about the role of mentoring in further education mathematics student teachers' mathematical and pedagogical knowledge development. The aim of the study is to develop better and deeper insights into how mentoring of mathematics student teachers in FE works, and these insights might contribute to future mentoring practices. You have been invited to participate in this study because you are (or you were) a mentor of mathematics student teacher(s) in FE. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the study. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary. By giving consent to take part in this study you are telling me that you:

A Understand what you have read.

A Agree to take part in the research study as outlined below.

A Agree to the use of your personal information as described.

A You have received a copy of this Participant Information Statement to keep.

Who is running the study?

The study is being carried out by **Natheaniel Machino**, a PhD student at the School of Education and Lifelong Learning of the University of East Anglia. This study will take place under the supervision of Dr Irene Biza.

What will the study involve for me? Your participation in this part of the study will involve you being interviewed. The interview will be on Microsoft Teams and recorded. You will be free to view my notes and transcripts of the interview.

How much of my time will the study take?

The interview will take approximately 20 minutes.

Do I have to be in the study? Can I withdraw from the study once I have started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate or not will not affect your current or future relationship with the researcher, or anyone else at the University of East Anglia or your professional institution.

If you decide to take part in the study, you can withdraw your consent at any point. You can do this by emailing me at N.Machino@uea.ac.uk

What are the consequences if I withdraw from the study?

You are free to stop the interview at any time. Unless you say that you want us to keep them, any recordings will be erased and the information you have provided will not be included in the study results. You may also refuse to answer any questions that you do not wish to answer during the interview. If you decide at a later time to withdraw from the study your information will be removed from our records and will not be included in any results, up to the point I have analysed and published the results and this would include the submission of the thesis for assessment purposes.

Are there any risks or costs associated with being in the study?

Aside from giving up your time, some interview questions might challenge your professional views. To reduce this, you should be aware that it is your right not to answer some or all questions and to withdraw from the interview at any point, if you feel you are uncomfortable with the interview.

Are there any benefits associated with being in the study?

Taking part in the study is likely to generate reflections on your mentoring strategies and it is likely going to bring some insights into different mentoring strategies. The research project, which aims to develop insights into mentoring of mathematics student teachers in FE, is likely to trigger debates into this often not so talked about area. This might enhance the practice of mentoring student teachers in FE leading to improved teaching and learning of mathematics, other subjects and vocational courses.

What will happen to information about me that is collected during the study?

Your personal data and information will only be used as outlined in this Participant Information Sheet, unless you consent otherwise. Data management will follow the Data Protection Act 2018 (DPA 2018) and UK General Data Protection Regulation (UK GDPR), and the University of East Anglia's Research Data Management Policy.

The information you provide will be stored securely and your identity will be kept strictly confidential, except as required by law. Study findings may be published, but you will not be identified in these publications if you decide to participate in this study.

What if I would like further information about the study?

When you have read this information, I will be available to discuss it with you further and answer any questions you may have about the study. If you would like to know more at any stage during the study, please feel free to contact me at N.Machino@uea.ac.uk

Will I be told the results of the study?

You have the right to receive feedback about the overall results of this study. You can tell me that you wish to receive feedback by ticking the relevant box on the consent form. This feedback will be in the form of a one-page summary of the analysed data. You will receive this feedback after the completion of my studies and the thesis available

What if I have a complaint or any concerns about the study?

If there is a problem, please let me know. You can contact me via the University at the following address:

Natheaniel Machino

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: N.Machino@uea.ac.uk

If you would like to speak to someone else, you can contact my supervisor at the following address:

Dr Irene Biza.

School of Education and Lifelong Learning

University of East Anglia

NORWICH NR4 7TJ

Email: I.biza@uea.ac.uk

Telephone: 01603591741

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the Head of the School of Education and Lifelong Learning, Professor Yann Lebeau at Y.Lebeau@uea.ac.uk

(13) How do I know that this study has been approved to take place?

To protect your safety, rights, wellbeing and dignity, all research in the University of East Anglia is reviewed by a Research Ethics Body. This research was approved by the EDU S-REC (School of Education and Lifelong Learning Research Ethics Subcommittee).

14) What is the general data protection information I need to be informed about?

According to data protection legislation, we are required to inform you that the legal basis for processing your data as listed in Article 6(1) of the UK GDPR is because this allows us to process personal data when it is necessary to perform our public tasks as a University.

In addition to the specific information provided above about why your personal data is required and how it will be used, there is also some general information which needs to be provided for you:

The data controller is the University of East Anglia.

For further information, you can contact the University's Data Protection Officer at dataprotection@uea.ac.uk

You can also find out more about your data protection rights at the Information Commissioner's Office (ICO).

If you are unhappy with how your personal data has been used, please contact the University's Data Protection Officer at dataprotection@uea.ac.uk in the first instance.

OK, I want to take part – what do I do next?

You need to fill in one copy of the consent form and email it to N.Machino@uea.ac.uk . Please keep the letter, information sheet and the second copy of the consent form for your information.

Further information

This information was last updated *on 28th September 2021.* If there are changes to the information provided, you will be notified by email.

This information sheet is for you to keep

PARTICIPANT CONSENT FORM (First Copy to Researcher)

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

I have read the Participant Information Sheet, which I may keep, for my records, and have been able to discuss my involvement in the study with the researcher if I wished to do so.

The researcher has answered any questions that I had about the study and I am happy with the answers.

I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researcher or anyone else at the University of East Anglia and your professional organisation now or in the future.

I understand that I may stop the interview at any time if I do not wish to continue, and that unless I indicate otherwise any recordings will then be erased and the information provided will not be included in the study results. I also understand that I may refuse to answer any questions I don't wish to answer.

I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.

I understand that the results of this study will be used for a thesis assessment and may be published but that the thesis and any publications will not contain my name or any identifiable information about me.

I consent to:

Audio-recording YES o NO o
Video-recording YES o NO o
Reviewing transcripts YES o NO o

Would you like to receive feedback about the overall results of this study?

YES o NO o

If you answered **YES**, please indicate your preferred form of feedback and address: o Postal:

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____

o Email:____

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Signature

……………………………………………………………………………

PRINT name

……………………………………………………………………………

Date

PARTICIPANT CONSENT FORM (Second Copy to Participant)