Supporting pre-service teachers' development: what can we learn from case studies of three experienced school-based mathematics mentors

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Despite international interest on research into the preparation of pre-service mathematics teachers, the role of school-based subject mentors remains an under-explored area in the mathematics teacher education and professional development in general. In this paper, an exploratory study based on a multiple case approach that sought three experienced school-based mathematics mentors' views of their own roles in developing the pre-service teachers' knowledge for teaching mathematics is presented. With a particular focus on the specialised content knowledge (SCK) category from Ball et al.'s (2008) conceptualisation of mathematics knowledge for teaching, thematic analysis of the interview data indicates that development of pre-service teachers' such knowledge is influenced by and depends on mentors' own personal construct of subject specific mentoring. For pre-service teachers to fully benefit from their teaching practice, an explicit model of subject-specific mentoring is needed.

Keywords: Pre-service teachers, Subject mentors, Teacher education, Case study, Mathematics professional knowledge.

Background and context of the study

This paper sets out to highlight the important role school-based subject mentors play in the preparation of pre-service secondary teachers, role which has been overlooked by national and international research into the mathematics teacher education and professional development in general, and mentoring literature in particular. The small study reported in this paper is part of a larger study which sets out to investigate and compare the practices of subject specific mentors of pre-service teachers in five subjects across three countries (Finland, Sweden, and England).

In the following, I will start by describing the England, UK, context and clarify the various terminology specific to teacher education in this country, of relevance to this study. In England, pre-service secondary teachers (also referred to in literature as student-teachers) undertake a year-long postgraduate course called Post-Graduate Certificate of Education (PGCE) immediately or some years after having studied for a subject specific undergraduate degree. During this course, pre-service teachers spend almost a third of their course in two different placement secondary schools (pupils aged 11 to 18). Such placements are an essential part of pre-service teachers' education as it gives them opportunities to apply and transform their theoretical knowledge into practice, while learning how to teach their subject.

To support them while on a school placement, pre-service teachers are allocated a mentor, who is one of the teachers in the subject specific department in the placement school. These 'school-based subject mentors' have an influential role to play in the training and education of pre-service teachers,

through supporting them to learn about themselves, learn about teaching and develop new sets of skills to support learners learn the subject, and above all to become reflective practitioners.

Subject specific mentoring

School-based subject mentors are usually experienced teachers recognised by their schools as 'expert' subject teachers and put forward for the mentoring role. No other formal preparation is required by these teachers towards fulfilling the mentoring role. From one teacher education provider to another, various support is put in place for such mentors' preparation. A review of the mentor provision in England, but also worldwide, highlighted that there is an ever-increasing demand for new mentors in schools and a demand for support for mentors that is subject specific. In mathematics for example, the ACME survey (2015) clearly noted and recommended that "Mentors need to be confident in their own subject knowledge, be recognised expert teachers of the subject and also have the skills to mentor." (p. 19) in order to cater for the developmental needs of their mentees. However, nationally and internationally support for mentors is sparse and rather generic, at the expense of subject specific support (ACME, 2015; Barrera-Pedemonte, 2016), while the mentoring issues discussed and reported in the literature are mostly of a generic nature, i.e. more concerned with general teaching situations rather than with subject-specific teaching or teaching after initial training (e.g. Martin, 1996) and with mentors' roles such as providers of socio-emotional support and socializing new teachers (Achinstein & Davis, 2014).

Ingersoll and Strong (2011) warned of "a need to critically assess the empirical research on teacher induction to determine its scope and merit and the conclusions that may be drawn from it." (p. 204). However, little is still known about how subject teachers transition to subject mentors, how they think about the knowledge, skills and values needed by novice teachers in order to develop into great subject teachers. Despite international interest, mentoring programmes often do not hold robust ideas about subject-specific mentoring. Various calls for research to address the gap in the literature for which there is little research evidence, namely what is the key role of school-based mentors in the development of pre-service teachers in relation to the specific subject knowledge and its teaching have remained unanswered. Most studies in the mentoring literature seem to follow the long tradition by focusing on generic aspects of mentoring, which have led over the years to a lack of an understanding of what subject specific best practice in mentoring entails and looks like.

Although in mathematics such attempts have been made, current mentoring literature clearly indicates that the use of different terminology, various conceptualisations and applications make it difficult for practitioners to talk about subject specific mentoring and for researchers to synthesise what is already known. "Mentoring can be haphazard and left to chance, with mentors and mentees claiming significant differences in their mentoring experiences" warned Ganser (1996) (cited in Hudson et al., 2012, p. 2). Indeed, a significant body of research (e.g., Ball et al., 2008; Guerriero & Deligiannidi, 2017) has clearly indicated that beginning teachers need knowledge of how to teach their subject, through exploring how understanding of subject matter interacts with other kinds of knowledge that influences teaching and learning in classrooms, indicating that there is a need to specialise mentoring practices in specific subject areas in order to cater for the developmental needs of the pre-service teachers.

This study was thus conceived to be exploratory in nature, where research was conducted to study an aspect of teacher education that has not been explicitly defined nor tackled before. Exploratory research "tends to tackle new problems on which little or no previous research has been done" (Brown, 2006, p. 43). While the research to date usually focusses either on pre-service teachers' perspectives of their mentors' role and practices, or on the ideal mentors' qualities and professional knowledge, in this study we 'turn the tables' and focus on the underexplored school-based mentors' perspectives about the knowledge, skills and values a pre-service subject teacher need to develop while in a placement school. In this paper, we thus explore a different perspective to what is commonly found in the literature, namely one that acknowledges and emphasises the importance of understanding the diversity of views and perspectives that school-based subject mentors bring to teacher education.

Because this research is exploratory in nature, the study reported in this paper was undertaken with the aim of learning about how school-based mathematics mentors think about and approach the subject specific aspects of their mentoring practices. The literature reviewed was thus used to guide the research question, namely: What are school-based mathematics mentors' views and how do they conceive their role in developing the pre-service teachers' knowledge for teaching mathematics? For maintaining conceptual clarity in this paper, the nomenclature 'pre-service teachers', 'novice teachers' and 'mentees' are used interchangeably to refer to those studying to become teachers.

Conceptual frameworks and study design

Since the focus of this exploratory study was on the development of pre-service teachers' knowledge for teaching, given the little that is known in the literature about how subject mentors help novice teachers develop into expert subject teachers, some direction in framing this study is provided by the knowledge and practice base for content teaching put forward by Shulman (1987), who suggested that discipline-specific knowledge is particularly important for teachers who specialise in teaching a particular subject matter. Drawing on Shulman's work, Ball et al. (2008) developed the Mathematical Knowledge for Teaching (MKT) framework, which is the result of empirical research seeking to understand what mathematical knowledge teachers need in order to teach mathematics. Within MKT, there are two main categories of knowledge for teaching: (1) CK - Content (Subject-matter) Knowledge consisting of common mathematical knowledge and skills used in settings other than teaching (CCK), specialised content knowledge for teaching mathematics (SCK), and horizon content knowledge (HCK) which is an awareness of how distinct mathematical topics are related to each other; and (2) PCK - Pedagogical Content Knowledge, which is knowledge of content and students (KCS), knowledge of content and teaching (KCT) and knowledge of content and curriculum (KCC).

This exploratory study was aimed at investigating schools-based mentors' views of their roles in developing the various pre-service teachers' MKT categories. However, in this short paper we report on one such category of knowledge only, namely pre-service teachers' SCK, which is understood to consist of those mathematical knowledge and skills needed by a teacher to practice effective teaching, and which a mathematician does not necessarily need. SCK involves unpacking of one's mathematical knowledge and re-packaging it in pedagogically appropriate ways, which, while critical for teaching, it is challenging to develop by pre-service teachers.

Methods

To answer the research question, this study used a multiple case study approach, with cross-case analysis carried across the three cases. Data were collected through interviews for which a protocol was developed, tested out and agreed on. Apart from seeking background information on the teaching and mentoring experience, the interview questions were designed to elicit responses in relation to the following areas: mentors' reasons for becoming a mentor; how they transitioned from being a mathematics teacher to a mathematics mentor; how mentoring impacted on their own classroom practice and what professional development they had or could benefit from. Mentors' views of the kind of knowledge, skills and values and aspects of the subject they teach that they aim to instill in mentees' development were also sought, and this constitutes the focus of data analysis for this paper.

The participants' voices were used to gain an insight and understanding into their accumulated mentoring knowledge and experience. All interviews were conducted online, via Zoom and support was sought for a full transcription. Ethical approval to carry out the research was gained from the researcher's institution; informed consent was gained from respondents and data was securely stored. All data collected in this study were confidential; no participant or schools were identified. Given the time capacity for this small-scale research, only three school-based mathematics mentors were interviewed. The selection of the mentors for this study was made purposefully, as the intention was to tap into expert mentors' wisdom of practice. Two (2) mentors working in the researcher's university' partnership schools (students aged 11-18) and one (1) other mentor teaching in an Adult Education College (students aged 16 to 18) in a different metropolitan city in England were thus involved in this study. The first criterion for selecting the mentors was that the mentors had to be involved in mentoring work on a regular basis. A second criterion was the perceived competence and recognition of their experience and expertise, with the intent to choose someone who was viewed to be performing their work as a subject-specific mentor to a high standard.

Table 1: Participants' background information

Participants' pseudonyms	Background information of the participants	Gender
Sahana	Teaching mathematics for 20 years in the same secondary school (students aged 11 to 16) in inner London; Mentoring pre-service mathematics teachers for over 15 years; Head of Mathematics department since 2020;	Female
Leon	Teaching mathematics for just over 5 years in the same secondary school (students aged 11 to 18) in inner London; Mentoring pre-service mathematics teachers for 5 years;	Male
Emily	Teaching mathematics for just over 5 years in an Adult Education College (students aged 16 to 18), elsewhere in England; Mentoring pre-service teachers of mathematics, but also of other subjects for 5 years.	Female

Important to note is that Sahana and Leon, who both work with the same teacher training provider, were both awarded the 'Lead Mentor' status, a scheme introduced in the last five years in recognition of: the school-based mentors' outstanding practice in teaching subjects in schools; their involvement with the PGCE team to develop the training course; and also, their central role in supporting and developing new mentors each year.

Data analysis

The analysis of data was conducted first vertically, then horizontally (Miles & Huberman, 1994) and themes that best described the similarities and differences that characterised the mentoring practice experiences of the three participants were established. Vertical analysis meant that data was analysed case by case, where each mentor's interview was thematically analysed separately, and mentors' profiles were written.

The reflexive approach to thematic analysis (Braun & Clarke, 2019) was employed. Such an approach recognizes the researcher's active role in knowledge production through generating codes that represent the researcher's interpretations of meanings in the data. Themes were constructed by reading and interpreting the data inductively, keeping an open mind to look for emphasis, language and recurring points made. The recorded video interviews with transcripts were watched a number of times, and emergent themes were included in a table, with supporting data for each participant, as exemplified in Table 2.

Table 2: Themes identified from the data

Theme	How theme 'emerged'
Sahana's views of her mentees' knowledge of learners	Mentees: • "assume all learners find mathematics like they did"; • "enjoy the subject, they understand it very well… but not everybody does"; • "feel about pupils 'This person can never learn it' ".

Once thematic analysis of each case study was carried out, horizontal analysis was performed (also known as comparative or cross-case analysis (Miles & Huberman, 1994)). During cross-case analysis, themes that best described the similarities and differences that characterised the mentors' practice experience and views about their role in developing the pre-service teachers' knowledge for teaching mathematics of the three participants were established. The three separate thematic analyses of the mentors were then combined into a single table, to allow comparison of themes not just across the three cases, but also across the five different subjects in this international project, for which researchers followed a similar approach to data coding.

A number of emergent themes were identified in the data analysis, such as motivation to taking on the mentoring role, approaches to mentoring; mentor-mentee relationship; own experience as a learner of mathematics; own views about what makes a good teacher, as well as school-based mentors' views about their role in developing mentees' knowledge for teaching.

Results

In the following, I shall focus on reporting on school-based subject mentors' views about their roles in supporting the development of their mentees' specialised content knowledge (SCK).

Mentor's views about their roles in supporting development of pre-service teachers' SCK

Sahana, Leon and Emily talked in different ways about the mathematics knowledge pre-service teachers need in order to plan lessons and teach, and their roles in supporting mentees' development in this respect. In Sahana's view, all her mentees' subject knowledge should be very good, and they should all be 'mathematicians', otherwise 'I feel that if they don't know the subject themselves, it's

very difficult for them to deliver it effectively'. Sahana is aware however of the 'trap' her mentees could fall into, that of assuming that their students will too find mathematics easy and enjoyable, hence 'in danger' of 'not trying' when realizing that this is not always the case. This may explain while for many years as a mentor Sahana planned everything for her mentees, down to the fine details, to avoid them falling into the 'trap': 'so I found that I ended up doing a lot of the work for them; spoon-feeding, doing a lot of work for them'. However, more recently Sahana has started focusing on 'push[ing] the development of pedagogy', a priority in the development of her mentees, which she further explains as consisting of helping mentees 'work with the mathematics they know' to plan for teaching.

Emily too thinks that knowledge of the subject to teach is a very important aspect of her mentees' professional knowledge base for teaching. In her schools however (an Adult Education College), mentees do not have a good mathematics background. In Emily's words, her mentees 'are a page ahead of the students'. As a result, she encourages them to enroll on an advanced mathematics course, which she reported that her mentees usually find quite challenging. Apart from asking the mentors to attend this course, Emily further 'tailors' her mentoring by seeking support external outside of the school 'we had somebody from [an examination board] come in to do some subject specific work, with the mentees'. In Emily's view, 'it's very, very important for every mentee to develop their subject knowledge if they're not there yet', and the most important thing that she has learnt over the five years of mentoring was that mentees need to do this themselves.

Leon, the third mathematics mentor involved in this exploratory study, made it quite clear in the interview that his main priority when mentoring pre-service teachers is the development of their subject knowledge. Leon encourages his mentees to engage with the mathematics specific topics, as a starting point for the lesson planning and preparation 'in the beginning I was very focused on […] how to deal with the behaviour management, or how you use many whiteboards, and it was all very generic, but I find […] the moment we start talking about the mathematics itself, I find that they [mentees] make a lot more progress and the lessons are actually sharper because they [mentees] are less worried about how it looks and more worried about the content itself'. To support his mentees, Leon thinks that modelling how to be a teacher is an important part of his mentor's role, and he justified his own approach of 'telling, directing, and showing' his mentees how to teach a mathematics topic: 'Just tell them how you teach, and then, if they don't do it that way, you can discuss about why and how they did it. But they have something to work from.'. Leon starts his mentoring conversations by focusing on the mathematics content 'Always!' and he teaches his mentees that 'lessons planning should start with the mathematics, then the rest will follow.'

Some conclusions and discussion

The research question investigated in the study presented in this paper was: What are school-based mathematics mentors' views of their role in developing the pre-service teachers' SCK? Data analysis revealed similarities, but also differences in the three mathematics mentors' views. It was evident that all three mentors placed a great emphasis on the specialist content knowledge of their mentees. They all considered necessary that the mentees have a good knowledge of the subject they teach, which

provides the basis for further development of SCK. However, the mentors seem to have different approaches to supporting their mentees develop SCK.

Sahana expects that all her mentees have strong subject knowledge, which she assumes that to be the case for all of her mentees. As a result, the focus of her mentoring is on supporting mentees use their mathematics knowledge to plan for plan for lessons 'pitched at the right level, for the right audience'. Literature (Wang & Odell, 2002) has indeed shown that many subject specific mentors assume that mentees have learned the subject content in undergraduate studies or teacher education programs, hence little attention is given to the development of this component of mentees' professional knowledge base for teaching. However, many novice teachers enter the teaching with little preparation, as it is the case of Emily's mentees. Due to her school context (an Adult Education College), Emily is aware of the need for her mentees to improve on and widen their subject knowledge. In her mentor role, Emily sees herself more as a mediator, and believes that the strength of her approach to mentoring consists of supporting her mentees to 'want to learn the subject matter', and 'take ownership of things in teaching the subject', and 'getting them to take risks'. This is contrast with Leon's approach, who believes that it is his relationship with the subject, as a mathematician, but also as a mathematics education researcher, that make him a great subject mentor. As a result, in his mentor role Leon has the same expectations of all of his mentees, namely 'to know the mathematics', and he supports them 'to think hard' about how to teach it.

This paper showcases three school-based mathematics mentors' views about their role in the development of their mentees' SCK. Such research is needed indeed. Porter et al. (2001) cited in Achinstein and Davis (2014) reminded researchers "we know little about what how and what mentors think about their role in supporting the development of their mentees into effective and expert content teachers." (p. 107).

Although limited to a handful of school-based mentors, Yin (1989) suggests that case studies are powerful in providing opportunities to generate hypotheses and build theory, which is what this present study achieved in relation to the knowledge base needed by school-based subject mentors. It highlights a need for school-based mentors to be not only successful, expert and experienced mathematics teachers, but to also understand and learn how to best support the development of their mentees' knowledge, skills and values needed in order to develop into great subject teachers. This new focus on school-based mentors' perspective opens novel possibilities to mentoring theory and practice, and ultimately to the development of pre-service mathematics teachers.

The long term aims of larger international study this smaller exploratory study is part of is to scrutinize the differences but also those common aspects of mentoring in various subjects in each country, with a view to put forward an explicit model of subject specific mentoring to support school-based mentors, who are mostly left to just get on with the mentoring role.

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