

Teaching A-level in Early Career: Induction, Support and Professional Learning

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Abstract

There is considerable interest within mathematics teacher education in mapping the career development of teachers. Although there is agreement that professional learning is embedded in workplace practice, there has been little attention to the effect of variations within the teaching profile. This paper focuses on pre-university mathematics and its contribution to teacher development in the early career stage. Our longitudinal multiple-case study mapped induction for A-level teaching in England, and identified opportunities and demands that led to professional learning. We found a common understanding of such teaching as a privilege. Teachers experienced rapidly reducing formal support, with little mentoring directed at reflective development of A-level teaching, and claimed this limited their growth as teachers. However, A-level teaching offered professional learning opportunities complementary to those offered by teaching of earlier mathematics: teachers came to better appreciate connections within mathematics, and the need for development of rigour and deep conceptual foundations, as well as deepening their own mathematical knowledge.

Introduction

At the beginning of their careers, new secondary teachers have little choice over the school classes they are allocated. Exposure to students of different ages, and on different courses, produces a range of demands recognised by experienced teachers but not necessarily by novices (Berliner, 2004). The early career stage may therefore prove to be less homogenous than it appears in overviews such as Feiman-Nemser (2001) or Winslow et al. (2009). We hypothesise that some early career teaching profiles have particular demands and

affordances. This paper examines one such profile, and reports how teaching pre-university mathematics contributes to overall teacher development. A case-study approach offers detail of the demands and learning opportunities offered by teaching A-level mathematics in the English policy context. We note implications for the support and development of teachers with a mathematics specialism and those teaching beyond their degree specialism.

Our focus on teaching pre-university mathematics arises from the comparative lack of attention this receives in initial teacher education (ITE), and an interest in how relevant pedagogic knowledge is applied or developed through subsequent workplace learning. England prepares secondary-school teachers through a variety of ITE routes (Tatto, Lerman, & Novotná, 2009). Although A-level is the standard English pre-university course for 16-18 year olds, it is not mandatory to include any preparation for teaching A-level. All routes have a minimum of 24 weeks spent on teaching placement, but there is usually caution in giving examination classes to unqualified teachers. Beginner teachers are thus predominantly familiar with the 11-15 age group. This profile starts to change in early career. Although we lack data by subject, surveys suggest that, two years after qualifying over 90% of teachers have a 15/16-year old examination group, and half teach 16-18 year olds (Tracey et al., 2008). Preparation for teaching A-level is thus relevant to nearly all secondary mathematics teachers in establishing what Ball, Thames and Phelps (2008) call 'horizon knowledge' of wider mathematical ideas, structures, and principles. Moreover, if teachers lack early experience of teaching A-level, they may struggle for opportunities to develop expertise. Ward-Penny et al (2013, p. p14) found that schools' decisions about teaching mathematics A-level were driven by a balance of inertia, established teachers' values, and result-seeking: some have a "fixed" teaching provision that can "delay or frustrate the impact which younger teachers with alternative preferences might have on the curriculum."

We found just one published study of how pre-service teachers have been inducted into A-level teaching and suggest this area has been under-researched: Butcher (1999, 2003) reports on an 11-18 HE-led route (now closed) with subject specialism in English. He characterised pre-qualification school-based mentoring

directed at post-16 teaching as “invisible”, leaving trainees to “sink or swim”. He concluded that learning to teach A-level may best be left for the early career stage, supported by in-service induction programmes. Our research takes up this focus but in the context of mathematics, and fifteen years later. In this study, we identified five teachers, from three mainstream routes into teaching mathematics, all of whom had been allocated A-level in their first year as ‘Newly Qualified Teachers’ (NQTs). We interviewed and observed them over a period of 20 months, investigating the questions ‘How are early career mathematics teachers inducted into teaching A-level?’ (RQ1) and ‘What are the effects on their development as teachers?’ (RQ2).

Theoretical Background

The dearth of literature focused on A-level preparation means we have drawn on several related areas to structure our field work and analysis, namely teachers’ career development, teacher knowledge frameworks, and professional learning.

Teaching careers are typically considered to have an early career phase of at least three years during which teachers establish their identity as a teacher and consolidate their classroom skills (Feiman-Nemser, 2001). There is considerable evidence that expert mathematics teachers’ skills differ from novices’. They use routines, recognise classroom patterns, deploy a range of representations and adapt their teaching more, improvising activities that build on students’ talk. Their expertise depends on knowing students’ likely responses to school mathematics tasks, personal relationships, and having already established students’ expectations for how they will behave and learn (Berliner, 2004; Livingston & Borko, 1990). Berliner (2004) quotes evidence to show that all this typically takes between 5-7 years to build – and only if a teacher deliberately works at it and has effective mentoring/coaching. From this perspective the early career period should focus on core teaching and learning, which may or may not be taken to include A-level teaching. Coldwell, Maxwell and McCaig (2010), surveying school leaders and early career teachers in England, have identified the predominance of this skill-honing approach to development: enacted by protecting early career teachers from out-of-classroom responsibilities to consolidate core teaching. They contrast it with an approach that plans staged exposure to a variety of professional roles, enacted by encouraging teachers to

build up a wide portfolio of teaching experiences, and allocating in-subject leadership from the NQT+1 year. Teaching A-level in early career may be justified within either approach: in our framework we therefore considered the nature of new teachers' induction into A-level, and the rationale given for it.

The literature concerning knowledge needed for teaching mathematics is considerable and contested. One distinction is between knowledge of mathematical content (MCK) and knowledge of pedagogy related to mathematics, dubbed pedagogical content knowledge (PCK) by Shulman (1986). Ball et al (2008) argue that MCK includes both horizon knowledge of connections within and beyond school mathematics, and specialist knowledge of mathematics for teaching. Teachers' PCK includes knowledge of the curriculum, of students and their mathematical thinking, and of teaching routines, tasks and representations. Empirical research has shown distinct effects of teachers' MCK and their PCK on student achievement but with no support for distinguishing effects of subcategories within either (Baumert et al., 2009). Nevertheless we found this framework enabled us to tease out how A-level teaching contributed to professional learning: in particular whether this was mediated by engagement with advanced mathematical content or older students.

While recognising the complexity of teacher development, our study required indications of reasonable expectations of beginning teachers. Although there are international reviews of teacher preparation systems aiming to map curricular progressions in knowledge (e.g. Schmidt, Burrough, Cogan, & Houang, 2016; Tatto et al., 2009), these proved less useful than studies that analysed teachers' classroom actions and accounts of their own learning (Feiman-Nemser, 2001; Rowland, Turner, Thwaites, & Huckstep, 2009). We have drawn particularly on McCormack, Gore & Thomas' (2006) study of 20 NQTs (teaching a range of subjects including mathematics). This mapped teachers' reported concerns and changes in pedagogic practice over four terms, using Feiman-Nemser's (2001) empirically-based framework that identifies 'central tasks of learning to teach'. They found teachers' earliest concerns were with gaining *contextual knowledge* of their students, curriculum and school and with *establishing classroom expectations*, but these faded in importance during the first year. A longer challenge was in setting realistic goals and differentiating tasks, because teachers' *knowledge of students* was still developing. The major and long-term areas of challenge

were in the emotional and reflective work of *establishing an identity* as a successful teacher, and in the professional work of *developing a repertoire* that connected their knowledge of organisational routines with what they valued as purposes of learning, freeing up attention so as to be able to deal productively with unexpected mathematical, pedagogical or management issues. We find these aspects of pedagogic practice compatible with the frameworks for MCK and PCK in mathematics discussed above, and useful in framing the opportunities and demands of A-level teaching within broader expectations of progression.

How NQTs learn is also a matter of research interest. Their professional learning is experienced as more informal and context-specific than their preservice training, dominated by collaborative or unplanned learning from colleagues (McCormack et al., 2006; Tracey et al., 2008). Horn (2005) investigates the social and situated nature of teacher workplace learning. She highlights three key resources: curriculum materials, 'reform slogans' that provisionally articulate teachers' understanding of intended change, and professional conversations that classify and frame classroom experience according to those goals. In Horn (2010) she repackages those conversations as 'replays and rehearsals' of the emotions and thinking around particular classroom episodes, which then support 're-envisioning of practice' in which teachers elaborate or revise their understanding of complex teaching situations. Desimone (2009, p. 182) also recommends "embedded professional development" as the basis for active, ongoing, subject-focussed learning but argues that experience alone does not ensure effective teacher learning. Instead, that depends on collaborative, expert-supported reflection that interacts with the participating teachers' beliefs. Thus, both Horn and Desimone highlight the necessity for mechanisms that, either formally or informally, mediate experience through collaborative reflective processes that move between classroom specifics and teachers' sense-making. Such opportunities underpin the pedagogies of ITE programmes in England, and continue into the NQT year as an entitlement to weekly sessions with a named teacher mentor. It is in this formalised mentor setting, as well as in contingent interactions, that we expected to find the combination of reflective conversations, valued resources and 'key messages' that induct teachers into A-level teaching.

Study

The study took a multiple case-study approach, in which we produced an “intensive, thick description and interpretation of the phenomenon” (Merriam, 1985), aiming to generate hypotheses about the role of teaching A-level in beginner teachers’ development. Each case is an NQT teaching some A-level mathematics. We recruited alumni from courses on which we had previously taught for ease of access to NQTs with the right teaching profile and also considering that familiarity would mitigate pressure on participants. Different routes into teaching were chosen to strengthen evidence by including “hypothesised variations” of mentoring and prior experience (Yin, Clarke, Cotner, & Lee, 2006, p. 114): two teachers (‘HE’ in Table 1) received relatively high university input and support for teaching placements during the training year; the other three had worked as teachers on reduced timetables alongside a training programme that was led either by a charity (Teach First; ‘TF’) or by the school (‘S’). The routes were deemed ‘outstanding’ by national ITE evaluators. Our selection of cases intended variation in degree subjects similar to the national profile; but we found only relatively well-qualified cases. All were employed in London state-funded schools, three in areas of economic disadvantage. Table 1 shows the profile of the early career participants (with pseudonyms) and the number of A-level modules taught in their NQT year and NQT+1 years (a full A-level comprises 6 modules). We note that only one has stayed in the same school for more than 2 years, and three have left state-funded education. This teacher turnover is slightly higher than the overall rate in London.

Table 1

| Teacher (by route) | Degree | Started teaching A-level in school in ... | Modules taught | NQT+1 | NQT+2 |
|--------------------|-------------|----------------------------------------------------|---------------------|------------------|--------------------|
| Anna HE | Mathematics | NQT year after some observation in QTS year | 1 (+1 in next year) | Same school | Independent school |
| David HE | Mathematics | QTS year | 3 (+2) | Same school | Same school |
| Calum S | Engineering | NQT year after substantial observation in QTS year | 3 (+2) | Same school | Independent school |
| Pam TF | Mathematics | QTS year | 5 (+1) | 6th form college | Same college |

| | | | | | |
|-----------|---------|----------|---|-----------------------|--------------------------------|
| Nadiya TF | History | NQT year | 2 | Teaching 11-16 abroad | Same school then left teaching |
|-----------|---------|----------|---|-----------------------|--------------------------------|

Data collection events included recording and transcribing five interviews with each early career (EC) teacher, and one with their Head of Department or NQT mentor; also three interwoven lesson observations, with foci arising from both interviews and the literature. For example, the last included review of prior learning, noted by Livingston and Borko (1990) as needing expert pedagogy. These methods are appropriate for “describing and understanding the complexities of professional development in a specific context, how beliefs and attitudes change, and the processes through which teachers change their instruction” (Desimone, 2009, p. 190). They took place termly over two school years, interspersed by two periods of analysis and a participant validation meeting. One participant left the country during the study, completing only one observation and four interviews (one remotely). Interviews 1 and 3 focussed on participants’ reflections on priorities, benefits and tensions in A-level teaching, their developing classroom practice and sources of support. Interviews 2, 4 and 5 focused on participants’ planning and pedagogic decisions in the observed lessons as indicators of their MCK, PCK and response to contingent events. These allowed us to strengthen the evidence for the teachers’ claims of professional learning: we sought confirming or disconfirming instances of practice in our, and the teachers’, interpretations of specific classroom events.

After two interviews, it was clear that participating in the research was itself having an effect on the teachers’ thinking about A-level teaching, in part because they reported limited other opportunities to reflect in depth. For this reason, and because of the purposive sampling, our cases cannot be considered typical of new teachers’ progress in A-level teaching. Instead they offer illustrations of how A-level teaching *can* develop in early career for teachers who are well-qualified via their chosen ITE routes; and indicate where they find support/challenge for further development.

Data were analysed thematically, as reported below. After each phase of data collection, the interviewing author wrote an individual case summary that was reviewed by the other author against the data. Revised

summaries were then reviewed collectively in order to make and test cross-case comparisons. The first phase generated hypotheses about teachers' initial induction, beliefs and challenges and was used to structure subsequent data collection. For example, concerns about using mathematical language precisely arose in this phase. Phase two generated cross-case descriptions and interpretations of experiences that were offered to three participants at a validation seminar, with an emphasis on testing the relevance of analytic themes, identifying shared/unique experiences, and asking teachers to comment on apparent tensions (for example, A-level teaching was initially said to need both more and less planning than earlier teaching). This meeting also permitted a longitudinal perspective as participants discussed how their views had changed since the NQT year. The final analytic phase used the validation meeting transcript as prompt to re-interrogate all the data, refining the findings and their significance.

Findings

We report the common discursive themes that featured in teachers' accounts, albeit with differing perspectives and at different times. We examine these under four framework headings: the rationales for including A-level teaching in early career (including how these changed over time), how induction was organised and support offered, and the dual roles that A-level teaching played in participants' professional learning, mediated firstly through smaller, more amenable classes and secondly through mathematical content.

Rationale for Teaching A-level in Early Career

In early interviews, the rationales offered by EC teachers for embarking on A-level teaching echoed closely those of their HoDs and mentors. A-level teaching was repeatedly framed as a "responsibility and privilege" whose allocation arises from a serendipitous match between the perceived strength of the teacher and current staffing needs. A-level was reported to be given only to particularly well-known and well-prepared NQTs (in terms of both subject knowledge and pedagogical skills), and indeed all our NQTs were known by the school from their training year. Only one teacher (David) had specifically requested A-level teaching; the others were pleased to be offered it and felt that it marked an accelerated progress towards a 'trusted

teacher' role. We characterise this rationale as bestowing/receiving *recognition* with A-level teaching. It fits the skill-honing model of teacher career by positioning A-level experience as a more risky and/or complex practice that requires strong foundational pedagogic skills. However, as we see below, there was little institutional articulation of what these prior or emerging skills should be.

We also found variations and challenges to this dominant rationale. Pam's mentor considered any delay unnecessary for confident mathematicians. She valued A-level teaching in early career as a protected, rich microcosm in which to learn in close-up about the interplays of teaching, learning and assessment. This is a variation of the skill honing model but one that includes A-level within core practices of teaching. Nadiya's mentor offered the contrasting rationale. He gave an A-level class to all NQTs in the team, explaining: "As a head of department I want to be involved in each key stage, and I would expect the same of the rest of the department." Calum's mentor also argued "the earlier you try different things, the more variety you have to choose from." Hence we identified the second rationale: that of staging *exposure* to all aspects of a teachers' role. Nadiya followed the TF route and her mentor's clear articulation of promoting multiple responsibilities fits the TF ethos, which has a particular commitment to developing leadership (so that trainees are viewed as sources of immediate potential) and relatively high turnover of teachers (so that roles need filling). By the end of the NQT year, teachers themselves described A-level teaching in terms that combined aspects of *recognition* (respect) with *exposure* to the full breadth of teaching roles:

"It's part of wanting to be a teacher who's got the whole big picture, the whole 11-18 thing, part of being able to put it all together and being respected by colleagues and by the students, rather than a teacher who's only got part of the picture and can only teach main school maths." (Anna, interview 3)

This quote illustrates a complementary rationale that teachers developed through the 20-month study: synthesising experience across teaching contexts to develop "the whole big picture" of mathematical and curricular knowledge. We elaborate this in the section below on professional learning.

Induction and Support

We use interview data to report on induction, by which we mean the aspects of school organisation intended to prepare new teachers for the A-level teaching context. We also identify the support that was offered by colleagues within or beyond that planned induction. Interviewees described a standard A-level induction experience as taking responsibility for the lesser share of a year 12 class, covering the pure mathematics content, while an experienced teacher takes the other lessons, including applied mathematics. In practice, three of our five teachers started with different content - Anna and Calum with applied mathematics and David adding Further Mathematics. This variation was ascribed to staffing gaps in these areas, and not problematized in the early interviews. All teachers were timetabled for the weekly mentor meeting, and most also had access to other teachers who had taught the same material. Three participants were also encouraged to attend external A-level-focussed professional development. However, the planned availability of in-school support translated into variable practice. Three out of five teachers reported that mentor meetings rapidly became less regular and structured, dissipating entirely by the end of the NQT year. Mentor support, though limited, was influential. Across the cases, mentors provided a similar orientation to A-level teaching in the form of two messages, given in the early months, that echoed through later reflections on A-level teaching. We summarise these as: 'year 12s are overgrown year 11s' and 'do all the questions/prepare thoroughly'. In the first message, teachers and mentors emphasised that A-level students, although apparently mature, needed the same engagement and monitoring strategies as younger students. All five teachers exemplified their professional learning by recounting how, despite this warning, they came to realise that they had over-estimated their students' mathematical knowledge and – even more visibly – the maturity of their learning habits. They felt a strong disappointment that older students, whom they felt to be “on your side”, had broken an unspoken pedagogic contract. For example, Pam recalled in the validation meeting: “I thought they were like university students. Intellectuals.” As in Butcher (1998), they showed evidence of mis-identifying A-level students with their own self-motivated selves. In these recounted episodes, mentors advised teachers to re-establish expectations by adopting into A-level the same routines they had established for younger students. This included disciplinary and managerial routines

(such as checking every homework), and routines focussed on managing tasks and assessment to allow responsive teaching. We interpret the repetition of this message as being a means for new teachers to negotiate what they, and the school, considered to be their teacherly responsibility for student progress. In Feiman-Nemser's terms, they are meeting the early concern to gain contextual knowledge of the school, but also starting to *establish an identity* as a successful teacher rather than a student. During the NQT+ 1 year, interviewees still returned to this message but with growing nuance. They started to critique performativity demands and develop their own position on how to balance supportive teaching with respect for older students' independence.

Turning to the second message, 'do all the questions/prepare thoroughly', all interviewees agreed that thorough preparation made better A-level lessons. In early interviews they reported that mentors advised them to 'do all the questions', which was understood as aimed primarily at increasing their confidence by reducing opportunities for mathematical uncertainty in the classroom. Interviewees initially treated this message as concerning only MCK. They connected it to the fear of failing to display the content knowledge that students require from teachers. Later, teachers broadened their idea of thorough preparation to include establishing knowledge about students' thinking, sometimes explicitly seeking colleagues' advice about what students would find difficult in the mathematics. This was consistent with a growing pedagogic appreciation, as we discuss below. Despite all the early career teachers repeating this mentor advice, they differed in whether they claimed they spent more, or less, time preparing for A-level than for younger classes. In the validation meeting they discussed this difference and why some deviated from what was taken as best advice:

"I feel like if I'm not prepared then I am worried that [the students] are going to ask me something and I'll be like, I really don't know. I don't want them to lose confidence in me as a teacher."

“I can't do everything, and if I didn't plan my key stage 3 or 4 well - chaos! *Yeah*. So I'd have to put my A-level class last - because they're not just going to riot if I don't ... don't plan the lesson that well”.

Outside these initial messages, we found support for teacher learning about A-level was largely informal and logistical. Three teachers reported finding difficulties in claiming their allocated time for mentor meetings due to colleagues' workload. Of the two whose meetings continued, Calum's focused largely on main school teaching so only one, Nadiya, a History graduate, used mentor meetings to discuss A-level mathematics content and “the actual pedagogy of the broader concepts.” Similarly, only Nadiya and Calum had formal monitoring observations of A-level teaching, although Pam later requested this.

Another potential source of induction support was through the teachers who shared these classes. Some interviewees reported fairly frequent informal conversations with their co-teacher. However, when looking back on the NQT year, they felt these had limited potential for learning, because they focused on liaison around organising and monitoring students. As Anna put it:

“We're so busy in the staffroom, we tend only to talk about the things it's necessary to talk about like exam arrangements and organisation and so on. So although I know [X] has taught [decision maths], we haven't really talked about that.” (Interview 5).

This does not mean these professional conversations were not valuable at the time: indeed they contributed to establishing the knowledge of local context that McCormack, Gore & Thomas (2006) identify as an early but passing concern of new teachers. Nevertheless, all five teachers reflected later that the school had not helped them to develop their A-level teaching. Two noted simply that the promised support was limited, since “it's just kind of assumed you can do A-level teaching” (Anna). However, two critiqued their mentoring for portraying only one possible approach to teaching: for example Nadiya characterised the school approach to A-level as “Chalk and talk. This is the example, and now you have a go” whereas she sought to “become a more engaged teacher.” David's criticism was that any school feedback on teaching examination classes was performativity-driven: “about as far from this (*interview 5*) conversation as it's possible to get....

other ideas just don't matter." Thus although induction mechanisms had initially been put in place, and had at least ensured that students progressed as expected and teachers knew which colleagues had A-level expertise, mentoring had not supported teachers' emerging needs as workplace learners, desirous of critiquing and experimenting with practice. Of course these teachers did develop pedagogic knowledge, as we outline below, but they received significantly less support as NQTs than they had expected.

Teachers' professional learning: attending to students' thinking and refining teachers' routines

Our analysis of interview and observation data showed that the opportunities and demands of A-level developed teachers' practice and reflection in two ways that did not occur to the same extent in other teaching. We argue that this is professional learning that can be considered germane, although not unique to, advanced mathematics teaching. Firstly, we report those claims for professional learning that we interpret as mediated by the mental space and time released by having smaller, amenable classes. Here, administrative and behaviour-centred concerns intrude less into considering the interplays of learning and teaching.

All teachers spoke of having opportunities in the A-level classroom to observe students' live attempts at problems. They could observe what students found difficult, appreciate how they developed mathematical reasoning, and notice representations and language that might differ from the teacher's own preferred approach. For example, after introducing radians at the board, Nadiya described the complexity of her thinking as she observed her students' strategies in matching radian and degree angles:

"It just felt like I hadn't made that explicit at all: that if I was looking at this, I would think about it all in terms of π as 180. So if it's a third π it's going to be 60 degrees. So ... I hadn't made that explicit and I thought actually I should make that clearer. And then but I thought I'll wait a minute because I felt like I'd only just started them, so I didn't want to interrupt it too early. And I wondered if anybody else would pick it up. But then I thought, actually no, it's quite good for them to know. And also get her to explain why, rather than it coming from me." (Interview 2)

Nadiya had an opportunity here to assess students' thinking, debate potential actions, decide how to adapt the task and its timing, and then assess again. Such adaptive learning opportunities were considered more possible in A-level classes. Teachers contrasted them with main school lessons, where they needed to stick to the lesson plan to maintain behaviour: "If you're being a bit more flexible it means your transitions are a bit more shaky.... Which is fine, if the class are on your side and behaving" (Pam, Interview 2).

Still mediated by smaller, amenable A-level classes, and as a result of attending to students' thinking, teachers articulated a deeper awareness of the limitations of extended exposition in lessons. Both David and Calum reflected that during the training year, they had already learnt how to provide structure and engagement in lessons for younger students, primarily for behavioural reasons. However, as NQTs, they repeated this process in the A-level context. In doing so they now perceived a stronger pedagogic rationale: keeping their own exposition concise allowed students (of any age) to do more mathematical thinking:

"It's as though I'd started again with the A-level teaching, although I suppose that's pretty much how it felt I was taught myself. But I was trying to prove something to myself, I really was. Now I use much the same techniques right through the school, just adjusted for the age group so if anything I leave the sixth formers to sweat a bit longer, because I know I won't get a riot" (Calum, interview 3)

Consistent with these self-reports, participants spoke of – and we observed – an increasing use of tasks that promoted student discussion and multiple approaches, intended to provide formative feedback. Teachers began to appreciate that even A-level students were not yet mature enough to communicate their own learning needs: Nadiya spoke of being challenged by their silences and David of their attempts to hide misunderstandings. Having identified this issue but appreciating the potential for learning *from* students about approaches to the mathematics, the teachers used routines and tasks they had met in main school teaching to encourage student communication and teach responsively. Those who attended external professional development had access to rich resources and ways of using them in class. Although they were not yet always able to exploit all the opportunities of such tasks, the early career teachers used them with

intent. For example, Calum used mini-whiteboards to survey A-level students' thinking and Anna, in the final observed lesson, built on student talk during a peer assessment exercise to highlight specific messages. They sought to assess what knowledge students brought to the lesson and what they understood from initial explanations, in order to adapt subsequent parts of the lesson – a skill of more expert teachers (Berliner, 2004). The context of A-level teaching thus provided a space for teachers to learn by diagnosing and adapting their own teaching. They perceived the purposes and benefits of discussion activities for formative assessment, and claimed to extend this throughout the school.

Another affordance of A-level classes was that teachers could refine their own behaviours in managing group and practical activities. Anna spoke of trying out classroom routines and materials, in terms of knowing both what to do and why:

“I've had the space with a small group, and relatively mature, to try out some things – you know, some of the resources I've used, the structures, I've gained confidence by using them and have then used similar structures adapted for main school, and I'm more confident about the organisation, the letting them get stuck and just asking the odd question to make them think, and that they gain quite a lot by arguing out.” (Anna, Interview 3)

Teachers also spoke, usually in the NQT+1 year, of getting to know A-level students as individual young people and learning how to manage their teacher persona within this less formal relationship. They claimed this supported them in forming similarly nuanced teacher relationships with younger age groups. A-level experiences thus started teachers on the path to building a personal repertoire (Feiman-Nemser, 2001) by: refining their teaching in response to students' thinking, creating a desired learning environment, and establishing the techniques and relationships to organise it smoothly.

Teachers' professional learning: Impact of the mathematics 'big picture'

The second way in which we identified advanced mathematics teaching contributing to teacher learning was mediated by teachers' engagement with the mathematics: as in Anna's quote above, all the teachers spoke

of the effects of gaining “a bigger picture” through teaching A-level. We identified some of this learning as related to mathematical knowledge (MCK). When teachers identified the skills needed to solve mathematical problems in order to phase the introduction of new ideas, or considered different ways of thinking about A-level topics, they appreciated new connections and distinctions between mathematical topics and representations. This then had implications for pedagogic development. Teachers reported that, as a direct consequence of reflecting on mathematics for teaching, they refined the language they used in class. For example, David reflected in interviews about the difference between saying “root” or “solution,” and pointed out to his class that numerical “factors” were connected to algebraic “factorising”. Nadiya, not a mathematics graduate, claimed the most significant impact was from the iterative interaction of PCK and MCK. She argued that the kind of language errors she made in other classes arose simply from unfamiliarity, just “saying the wrong thing” (for example pi instead of theta). She compared this with experiences of teaching advanced mathematics when she had realised that her use of language blurred conceptual distinctions: for example, until teaching radians, she had not distinguished the concept of angle from its measure in degrees. By re-examining her language for teaching, she deepened her MCK which led back to considering language use.

Increased mathematical knowledge also gave the teachers confidence and flexibility in the ways they listened to, and communicated with, students. Pam, in particular, who later specialised in post-16 teaching, explained that she found the A-level syllabus more connected and coherent than the 11-16 syllabus. This meant that she could find ways of differentiating explanations for individual students, a skill she considered vital for successful and enjoyable teaching.

‘Bigger picture’ thinking extended to perceiving mathematical relationships and progression within the school mathematics curriculum. Teachers used A-level content to enrich other lessons, for example using bin-packing with 11-year-olds as a context for problem solving and practising addition. They also began to critique and change their main school teaching from this perspective. Even by interview 1, all were aware of an increase in algebraic demand post-16: “that’s definitely something that I’ve learned for my main school

teaching, in just a few weeks – get the algebra solid, fluent, just like a natural language.” (Anna, Interview 1). Although they made this claim to learning, the observation data showed that they were not necessarily using strategies to improve students’ algebra, or seeking help from colleagues to do so. Calum was still pondering his approach almost a year later: “You almost can’t get them too fluent with the algebra. Though it’s sometimes difficult to motivate them when they think they know it – they don’t see why it needs to be any better than it is I suppose.”

The last significant pedagogic insight emerging from this ‘bigger picture’ was the importance of students’ mathematical reasoning. In each interview we asked teachers about similarities and differences in teaching between A-level and other classes. Over the two years, they increasingly viewed learning and teaching as a continuum from 11-18. This drew attention to school policies that prioritised younger students performing to ‘target’ on regular tests, whereas their A-level teaching experiences suggested that students often had not retained that learning and could not reason with it. The teachers responded to this systemic tension with understandable humility, and framed a purely personal goal to teach for conceptual understanding and for good mathematical habits. David illustrates this shift: initially, he had argued that A-level was a distinct phase of teaching. By interview 5 he spoke confidently about promoting conceptual teaching across all ages - “it’s what I’ve developed as my approach.” He reflected on techniques such as making links between precise and everyday language, and when he expected students to engage with rigour and depth:

“at first I might have thought ‘*this* is an A-level thing so it’s really important to understand all the bits and pieces’ but ... ‘*this* is year 7 so it’s OK to glaze over some things’. But now I’m less likely to shy away from really trying to say what underpins things or...using technical language...and I really try to emphasise ... it’s better to spend time on something that will build their understanding.”

Over time, we observed Pam, Anna and David set expectations for rigorous reasoning in their A-level teaching and attempt to convey that mathematicians wanted to prove results in order to understand *why* they were true. They and Calum explicitly linked the fact that they valued rigour to the mathematical

experiences in their degree courses. They also critiqued their own A-level teaching by reflecting on progression to university. This was notably different for Nadiya. For her, A-level teaching provided a much deeper knowledge of school mathematics, but not beyond. For example, she reflected that she preferred to learn one formula and manipulate it, whereas some of her students “just like to learn them all and then use it if they need to.” However she did not discuss how such differences related to mathematical processes such as abstracting for generality. All the teachers eventually expressed frustrations that the main school culture promoted “spoon-feeding” and that there were few opportunities for them to change or indeed question this approach.

Discussion

This longitudinal study of early career mathematics teachers shows how teachers’ knowledge-in-action and professional concerns changed as a result of experiences of planning and managing A-level teaching. It has exposed comparative perspectives: between A-level teaching and main-school teaching, and between potential support and actual support during their induction. In the paper we have foregrounded the contributions made by the demands and opportunities of A-level teaching. We should not ignore the time expended by some of these teachers in preparing advanced mathematics topics for teaching. There is considerable existing international consensus that early career teachers feel pressured, isolated and lacking in opportunities for growth (Winsløw et al., 2009), so that added pressure on their time and confidence is very pertinent. Nevertheless, the contribution of this paper is to trace how teachers have chosen to use the opportunities provided by A-level teaching, and have been required to meet its demands, and in doing so have developed as teachers.

The first research questions asked how teacher were inducted into A-level teaching. Our findings suggest that early career mathematics teachers’ induction operates through a combination of formal mentor meetings, class-sharing and identification of others who have taught the same material. However, this appeared to act, in effect, as a safety-net for students and schools rather than as a model for teacher learning. In several of our cases, perhaps because the teachers were deemed successful in A-level, the

planned induction dissipated rapidly. Two potentially disruptive features of A-level teaching were identified and indeed expected by mentors: that new teachers would over-estimate students' prior learning and learning skills, and that students' thinking would challenge their existing mathematical knowledge. Two key messages prepared teachers for these problems of early career and, we suggest, made it more possible for them to seek assistance when they arose. The focus here matches what Butcher (2003) and McCormack et al (2006) identified as the two immediate concerns of first year teachers: establishing behavioural expectations, and learning the school context and the sustained challenge of gaining knowledge of students and their thinking.

Beyond these two messages, three of the five teachers reported no further discussions aimed at understanding or improving their A-level teaching. In considering why this should be, we note the dominant rationale that A-level teaching is given in *recognition* of mathematical and teaching competence, and suggest this may make it more difficult for all concerned to articulate that EC teachers still have a lot to learn.

Although schools espouse a skill-honing career model, this was not evident in the actual approach to induction – at least in relation to A-level teaching. Three teachers who moved to different institutions during the study claimed seeking more enjoyable workloads and widening their opportunities for teaching A-level as contributory reasons. We argue therefore that attention to how schools induct teachers in this area is important for staff retention.

Induction does not have to be formal: we also considered the quality of the teachers' informal workplace learning. A-level teaching proved to be relatively isolated: related discussions with experienced colleagues did not take place in the same ad hoc way as for other teaching. When teachers did have protected mentor time, or external professional development, they were able to "rehearse" (Horn, 2005) teaching strategies and likely student responses to these, but otherwise teachers' opportunities to "replay" events were restricted – in some cases to the research interviews. There was some evidence that the key induction messages, 'year 12s are overgrown year 11s' and 'do all the questions/prepare thoroughly,' acted as "reform artefacts" (Horn, 2005). That is, they are slogans that focused attention on features of teaching identified by

mentors as probably needing attention, while simultaneously allowing negotiation about what the goals should be (in this case how teachers should support A-level learners acting independently, or what preparation is needed for teaching). Nevertheless, we suggest that, for these EC teachers at least, the fact that workplace learning was largely limited to conversations about shared classes meant that they missed opportunities for learning from colleagues experienced in teaching the same material. Of Horn's (2005) developmental resources of reflective conversations, reifying slogans and valued artefacts in relation to A-Level teaching, three teachers experienced the first two only at the very start of their career. Two participants experienced reflective A-level support over a sustained period. For the non-specialist, this modelled a single approach to A-level teaching and served mainly to enhance the foundations of her main school teaching. In consequence, only one received school-based support in moving towards "re-envisioning" A-level practice.

Our second research question concerned the effect of A-level teaching on participants' development as teachers. We identified claims to learning and changes in practice resulting from A-level experiences, and tested these through comparison over time, comparison with observed lessons, and group participant validation. Teachers claimed benefits from A-level beyond what mentors described as expected pleasure of variety or relief from difficult classes. We argue that teachers developed self-evaluation skills from having opportunities to focus on learners, to listen, experiment and assess what works and what doesn't, and because students themselves expected that teachers would adapt approaches mid-lesson if needed. Teachers envisaged a desired learning environment in which students shared responsibility for mathematical reasoning. They honed their resource- and activity-management skills with students who were tolerant of errors while routines became established. We have characterised all of these as mediated by having smaller, more amenable classes. We conjecture that similar learning could be encouraged in the English context by teaching Core Maths, a course for 16-18 year olds that focuses on contextualised problem-solving. However teachers' learning might have rather different foci in resit classes.

Our second characterisation of teacher learning was that it resulted from engagement with advanced mathematical content and teachers' appreciation that they and the students needed to use multiple, connected, valid ways of reasoning within such mathematics and understand why these were valued. They described this as appreciating the 'big curriculum picture.' Changes to practice we identified were: calling on a range of mathematical representations and verbal explanations, and matching these to student contributions in lessons. By the end of the second year, several teachers were able also to manage review lessons that distinguished between powerful, generalisable approaches and less important features of mathematical thinking. They began to argue that their main school teaching should emphasise understanding and fluency needed for progression, and to find strategies to promote this alongside securing students' expected progress on tests. Those remaining in teaching came to highlight precision, rigour and communication as mathematical values.

The English context is unusual in that mathematics is not compulsory post-16. In an international context, teachers may have more opportunities for teaching 16-18 year olds. While our aim here has been to trace in detail how learning took place in the English context, our analysis of those aspects that are attributable to the nature of the classes, or to the mathematics, allows interpretation in wider contexts.

A question underpinning this research was whether we could identify a distinctive role for teaching advanced mathematics classes within early professional learning. Our findings suggest that A-level and main school teaching are *complementary*, with differences being a matter of emphasis rather than clear distinction. Teachers used their A-level knowledge of curricular aims to inform their main school teaching, and they used their knowledge of routines and tasks for younger students to develop behaviour and encourage reasoning in the A-level classroom. They came to view the 11-18 curriculum as a continuum.

This paper has outlined the induction support that might be available to teachers and the effects on their pedagogy in expectations of behaviour, developing routines and gaining knowledge of students' thinking. We are mindful also that teachers develop emotionally and socially, and we expect that further analysis will show how A-level teaching contributes to these aspects of teacher learning and retention in the career.

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