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Policy supported out-of-field mathematics teacher professional development and professionality: possibilities for mathematics teachers and teachers of mathematics

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Citation:

BOYLAN, Mark, ADAMS, Gill and BIRKHEAD, Amy (2026). Policy supported out-of-field mathematics teacher professional development and professionality: possibilities for mathematics teachers and teachers of mathematics. Professional Development in Education: 2668006. [Article]

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Professional Development in Education

ISSN: 1941-5257 (Print) 1941-5265 (Online) Journal homepage: www.tandfonline.com/journals/rjie20

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To cite this article: Mark Boylan, Gill Adams & Amy Birkhead (07 May 2026): Policy supported out-of-field mathematics teacher professional development and professionality: possibilities for mathematics teachers and teachers of mathematics, Professional Development in Education, DOI: 10.1080/19415257.2026.2668006

To link to this article: https://doi.org/10.1080/19415257.2026.2668006

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Published online: 07 May 2026.

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PROFESSIONAL DEVELOPMENT IN EDUCATION
https://doi.org/10.1080/19415257.2026.2668006

RESEARCH ARTICLE

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Policy supported out-of-field mathematics teacher professional development and professionality: possibilities for mathematics teachers and teachers of mathematics

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ABSTRACT

In education systems where out-of-field secondary mathematics teachers have become more prevalent, policy responses have included funding programmes to address these teachers' professional development needs. We examine the implications of programme design for the professionality of out-of-field teacher participants by analysing and comparing three government supported professional development programmes that have been implemented over the last 20 years, two in England and one in Ireland. We review research-based reports of these programmes by analysing the explicit or implicit ways that different professionalities for teaching mathematics are supported. We do this principally through analysing the forms of knowledge, agency and sociality integral to the programmes, supported by considering the programmes' modes of professional learning, and material and systemic arrangements. The application of the theoretical frameworks provides a model for the analysis of other programmes. The analysis draws attention to how policy supported programmes offer the potential to extend teachers' existing professional identity to also embrace being a mathematics teacher or alternatively positioning them as technicians who teach mathematics.

ARTICLE HISTORY
Received 15 December 2025
Accepted 16 April 2026

KEYWORDS
Out-of-field teachers; mathematics teachers; professional development; policy

Introduction

Out-of-field teachers are increasingly important in many education systems (Hobbs and Porsch 2021). One policy response is to fund tailored professional development programmes. Such policy-supported programmes vary across many dimensions, such as length, accreditation, types of professional learning experiences and in the balance of content between subject and pedagogical knowledge (Price *et al.* 2019, Barker *et al.* 2024, Rutgers *et al.* 2025). Here, we examine the consequences for mathematics teacher professionality of different choices available to policymakers and those they fund to design and implement out-of-field professional development. We contend that analysis of these programmes indicates that these policy-supported choices position out-of-field teachers as either on a trajectory to becoming 'in-field' or to

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remaining out-of-field. Our claim is based on a comparative analysis of three policy supported professional development programmes for secondary out-of-field mathematics teachers, framed against the international background of policy-supported mathematics professional development (e.g., Hobbs and Porsch 2021, Barker *et al.* 2024). In England, two such programmes, implemented over the last 20 years, are the Mathematical Development Programme for Teachers (MDPT) from 2009 to 2012, and a more recent programme, Specialist Knowledge for Teaching Mathematics (SKTM), since 2021. The two programmes represent contrasting approaches to out-of-field professional development from the same education system. In Ireland, the Professional Diploma in Mathematics for Teaching (PDMT) has been supported since 2012, which provides an example of an alternative policy choice in a contrasting policy context.

These programmes have some common features, for example, a concern with developing both pedagogical and subject pedagogical knowledge and a shared context of shortages of mathematics specialist teachers (see, Ní Ríordáin and Hannigan 2009, Worth 2023). However, the programmes also have important differences, as will be shown. These differences are related to the three policy contexts in which each was developed.

Analysing a variety of research output types, we consider how each programme creates possibilities for the development of different forms of professionality, principally through differences in the *knowledge*, *agency* and *sociality* available to participants. These three features, in turn, supported by *modes of professional learning* and the *material and systemic arrangements* of the programmes. We identify how far the programmes position teaching as a professional or technical endeavour (Winch *et al.* 2015), and this is rooted in the wider systemic contexts of how teaching is positioned as a profession in relation to the education policy context and drivers in England (Boylan *et al.* 2023, Ellis 2023) and Ireland (Walsh 2024).

Our focus in this paper is on the design of the programmes and the policy choices that are implicated. We do not compare outcomes of the three programmes as the sources available do not allow for this across all three programmes; the outcomes of the PDMT have been reported in multiple research outputs but not to the same extent for MDPT and not yet for SKTM, the newest programme. Our critique of the programme designs should not be read as criticism of the programme designers or delivering organisations. As policy-led programmes, the programmes were shaped by policy context and policymakers' requirements and willingness to fund types of activity. Without these constraints, the programmes designs would likely have been different.

Before continuing, our analysis and arguments should be read with a consideration of our positionality as university-based mathematics teacher educators. We promote the development of mathematics teachers as agentic, critical subject professionals. This positioning shapes our analysis. We may not fully value less ambitious and more limited approaches to supporting out-of-field mathematics teachers that might address the more immediate desires of both policymakers and some teachers. Additionally, one of us was an evaluator of a pilot of the MDPT programme in England, and currently we are engaged in an evaluation of the SKTM programme, although the analysis presented in this article is based on published descriptions of the SKTM programme rather than evaluation data (see Boylan *et al.* 2025). Our relationship is closer to the programmes in

England and we are 'insiders' to the context in contrast to our 'outsider' understanding of Ireland's PDMT only from secondary sources.

In the next section, we discuss possibilities for different professionalities of out-of-field mathematics teachers including their heterogeneous relationships to teaching mathematics. We then summarise policy drivers and responses that shape support for out-of-field mathematics teachers before describing the three programmes of interest. Sections follow on methods and the theoretical framework that underpin our analysis before the analytical and comparative description of important features of the programmes applying the theoretical framework. We then discuss how policy choices are contextualised and conclude by considering implications of our analysis and arguments.

Out-of-field teachers: heterogeneity, identity and professionality

Out-of-field secondary mathematics teachers are heterogenous. Attributes that vary across out-of-field mathematics teachers include mathematical knowledge, mathematical pedagogical learning, experience of teaching and learning mathematics, and beliefs about teaching and learning in mathematics and more widely (Lane and Ní Ríordáin 2020). For example, the extent of prior study of mathematics can vary considerably from none beyond secondary school to mathematics study as part of university degrees. In one survey in England, 75% of non-specialist mathematics teachers had a relevant qualification beyond high school or university entrance level, such as engineering or science (Darlington 2017).

Out-of-field teachers reasons for teaching mathematics may influence engagement in professional learning. Some may positively choose to teach mathematics in preference to their original subject, some only teach out-of-field because of restricted opportunities to teach their original subject, and others are directed to do so (Darlington 2017). An important temporal dimension has both a past and future aspect: how long out-of-field teachers have taught and will teach mathematics. Out-of-field mathematics teachers may have temporary, short term, and long-term status (Goos *et al.* 2024).

As well as these attributes, professional and personal teacher identity is important for understanding engagement in, and outcomes of, out-of-field professional learning (Hobbs 2013, Bosse and Törner 2015). Teacher identity in general, and mathematics teacher identity specifically, are complex both as theoretical constructs and as empirical phenomena. The relationship between being a teacher and being a mathematics teacher may be conceptualised in different ways (Bosse and Törner 2015, Lutovac and Kaasila 2018), with mathematics teacher identity being a subject-related sub-identity (Bosse and Törner 2015) or a specific mathematics-related teacher identity (Lutovac and Kaasila 2018). An alternative conception lies behind an understanding of out-of-field teaching as a boundary crossing event (Hobbs 2013). This view emphasises the sociocultural and the ongoing process of being part of a discursive community of subject teachers. Empirically, it may be that the extent to which a secondary teacher identifies as a teacher first and a teacher of a subject second, or the other way round, varies from individual to individual, influenced by both system-wide and school contexts, and is dynamic, potentially changing over time.

Considering context, in England, for example over the last 10 years various reforms to initial teacher education have introduced a 'core content framework'

that emphasises a generic pedagogy over disciplinary knowledge and practice. This is now extended to policy-supported post-qualification professional development (Hordern and Brooks 2024). These changes in England are implicated in a move towards a more managerial teacher professionalism where uniformity, accountability and compliance are key (Sachs 2003, Evetts *et al.* 2009) and position teachers as technicians (Winch *et al.* 2015) in a delivery model of education. Winch *et al.* (2015) contrasts teachers as technicians with teachers as professionals whose technical know-how is complemented with critical reflection and disciplinary situated insight gathered through practice and engagement with peers. These different conceptions of professionalism and professionality can be distinguished by differences in knowledge and teachers' relationship to knowledge, agency and forms of sociality or how teachers relate to each other as professionals. More individually focused 'controlled professionalism' contrasts with an alternative of activist professionalism where teachers work together collectively for system-wide change (Sachs 2016). Forms of professionalism are experienced individually by teachers in their professionality: the ideological, attitudinal, intellectual and epistemological stance in relation to the practice of teaching which influences their professional practice (Evans 2010).

Out-of-field teaching in mathematics, policy drivers and potential responses

Teaching out-of-field in secondary mathematics is an international issue due to shortages of qualified specialist teachers in many systems (Price *et al.* 2019, Hobbs and Porsch 2021, Rutgers *et al.* 2025). What counts as teaching out-of-field is contextually dependent on issues like qualification requirements for subject specialist recognition (Hobbs and Porsch 2021, Rutgers *et al.* 2025). Further, different definitions may be used in different surveys of the prevalence of out-of-field teaching, and these may also differ from qualification requirements (Goos *et al.* 2024). So, precise comparisons are challenging about the prevalence of out-of-field teaching in mathematics internationally. Nevertheless, in both England and Ireland out-of-field teaching in mathematics is significant. In England, 45% of surveyed senior leaders reported that at least some lessons in their schools are taught by non-specialist teachers (Worth 2023). In Ireland, before the MDPT was introduced, a national survey found 48% of teachers of secondary mathematics classes were teaching the classes out-of-field (Ní Ríordáin and Hannigan 2009).

The issue of teacher supply is one that is of policy concern internationally (See *et al.* 2020) and this extends to out-of-field teaching. Policy responses addressing the issue are often not the result of a linear or cyclical model of policy formation following the identification of an issue by policymakers. Rather, policies result from interplay between coalitions of stakeholders and policy-intermediaries seeking to influence policymakers and funders (Boylan *et al.* 2023). Some of the policy drivers and influences that shape responses are:

- arguments associating workforce qualification with educational outcomes (e.g., Goos *et al.* 2024)
- concerns that schools serving disadvantaged communities have more out-of-field teaching than others (Worth 2023, Goos *et al.* 2024)

- mathematics educators and mathematical professional and learned societies concerns (Smith 2004, Schueler *et al.* 2015, Goos *et al.* 2024)
- policy-intermediaries identifying requirements and professional learning needs of teachers (e.g., Smith 2004)
- indirect pressure from school leaders to have competent teachers in the classroom and to address the challenges out-of-field teachers experience (Du Plessis *et al.* 2017).

Additional to reported policy drivers, there are potential parental concerns about teacher quality which also may influence stakeholders. Anecdotally, some schools in England appear reluctant to inform parents if a teacher lacks a teaching qualification in the subject they teach.

Given out-of-field teacher heterogeneity and the different drivers and influences, policy responses to provide professional development for out-of-field teachers vary. Programmes may variously 'upskill', 're-certify' or allow teachers to 'gain approval' to teach another subject (Hobbs and Porsch 2021). From the perspective of policymakers, the finer grained and complex understanding of identity needed to understand the outcomes of programmes may be of less interest than a much coarser lens of teacher supply.

Against this background, we address these questions:

(1) What relationships to teaching mathematics and what forms of professionality do the MDPT, SKTM and PTMD programmes support?
(2) How do these possibilities relate to each programme's context?

Methodology

Sources

Our analysis is based on secondary sources of published research reports, evaluation reports and an evaluation protocol. We had previously engaged with several sources for other activities, for example, PDMT was a case study in an international horizon scan of mathematics education policy (Adams and Boylan 2023). We used the programme names as the search terms to identify other sources.

A limitation of our analysis is that material available on the programmes is uneven; quantity and depth of available sources differ across the programmes. The MDPT was relatively short lived and published research consists of an evaluation of pilot programmes and reports from teacher educator researchers' involved in the delivery of the programmes. One feature of the MDPT is that the detail of content and delivery by providers was not centrally proscribed, thus we only have detail on some and not all instances of the programme. For the SKTM, our main source was an evaluation protocol describing the programme in detail but not implementation in practice or participant responses and outcomes. In contrast, the PDMT has existed since 2012, and a substantial research programme has developed by multiple researchers. This research programme includes reports on implementation and outcomes. For PDMT, we selected sources after initial review that included detail of the programme design. However, the current programme design may vary from this. Table 1 provides references to the sources with a description of these.

Table 1. Key sources.

Programme	Sources
PDMT	Case studies of OOF teacher professional development for in-service teachers in Republic of Ireland, England and Australia with comparisons, contribute to a framework for effective professional development (Faulkner *et al.* 2019). Analysis of design principles of PDMT in Ireland, focusing on affordances of blended learning (Goos *et al.* 2020). Research on changes in PDMT participants' beliefs and practices and relation to programme and school influences (Lane and Ní Ríordáin 2020).
MDPT	Evaluation report of the pilots of the MDPT (Boylan and Hardy 2008) and the of pre-service and in-service subject knowledge provision (Holland *et al.* 2009). An exploration of MDPT teachers' identity, using a case study approach with participants in one cohort of one programme (Crisan and Rodd 2011). Doctoral thesis examining mathematics teachers' conceptions of understanding mathematics in depth, with MDPT and other teachers (Stevenson 2013) and a further examination of identity changes from the same instances of the MDPT (Stevenson 2016) A study of the MDPT design and mathematics teacher identity (Crisan and Rodd 2017). Case studies of out-of-field teacher professional development for in-service teachers in Republic of Ireland, England and Australia with comparisons, contributing to a framework for effective professional development (Faulkner *et al.* 2019).
SKTM	Evaluation protocol with a detailed description of the SKTM programme (Boylan *et al.* 2025). Overview of the programme by the provider (NCETM 2025)

Analysis

We analysed the programmes in two ways. First, we used a modified form of the Template for Intervention Description and Replication (TIDieR) checklist as applied to evaluation in education (Humphrey *et al.* 2016). This supported a comprehensive comparative description of each programme. We modified the template to remove two items focused on planned and actual implementation strategies as implementation evaluation was out of scope. We added an item to note relevant contextual features. This modified checklist is shown in Figure 1, with our addition in italics.

To analyse the relationship between programme design and teacher professionality, we applied a theoretical framework to the initial descriptive analysis. The development of this framework was iterative by considering:

- constructs used in a theorisation of professionality and its relationship to professional development and learning as described earlier, constructs used in a review of research on professional development labelled 'transformative' (Boylan *et al.* 2023).
- those applied in research on out-of-field teacher professional development or in previous comparison of programmes (e.g., Faulkner *et al.* 2019).

Consequently, we identified three core dimensions of out-of-field professional learning that support varied forms of professionality: knowledge, agency and sociality. These three dimensions of professionality are enacted through the modes of professional learning – the forms and types of professional learning activity – and through the material and systemic arrangements through which professional learning is implemented.

The second stage of iterative framework development followed applying the broad categories found in Boylan *et al.* (2023) or Faulkner *et al.* (2019) and identifying the need to refine the detail and sub-components. Consequently, we

1. Brief name
2. Why: rationale, theory and/or goal of essential elements of the intervention
3. Who: recipients of the intervention
4. What: physical or informational materials used in the intervention
5. What: procedures, activities and/or processes used in the intervention
6. Who: intervention providers/implementers
7. How: mode of delivery
8. Where: location of the intervention
9. When and how much: duration and dosage of the intervention
10. Tailoring: adaptation of the intervention
11. *Contextual features relevant to programme content, processes and materials*

Figure 1. Adapted TIDieR checklist, modified from (Humphrey *et al.* 2016).

Table 2. Sources of the analysis framework

Initial sources for the analysis framework	Additional sources for the analysis framework
(Boylan *et al.* 2023): framework used to analyse transformative professional learning (Kennedy 2014): models of professional development programmes including relationship of participant to professional learning (Sachs 2011): Model of purposes of professional development as metaphors (Sachs 2016): examination of the forms of professional learning and of professionalism (Faulkner *et al.* 2019): comparison of OOF teacher development programmes	(Ball *et al.* 2008): categorisation of types of knowledge for teaching mathematics (Boeskens *et al.* 2020): OECD teacher professional learning study including categorisation of types of professional learning (Boylan and Adams 2024; Ellis *et al.* 2021) – categories of professional development provider (Winch *et al.* 2015): forms of knowledge, teacher professional learning and types of professionality (Eteläpelto *et al.* 2013: synthesis of research on teacher agency including in the context of professional learning Margolis 2016): study of hybrid teacher leaders who lead professional development

drew on additional frameworks and models developed in literature on teacher professional learning. Table 2 describes these different sources of the framework for analysis.

Table 3, below, summarises key aspects of these three features used in analysis drawing on the sources identified in Table 2. Although the dimensions are distinct, they are interconnected. Examples of this interconnectivity are discussed later through examples from the three programmes.

Aspects of these components of professional learning processes and systems that were considered in the analysis of the programmes are summarised in Table 4.

Table 3. Dimensions of professionality and out-of-field teacher professional learning.

Dimension	Aspects and sources
Knowledge	Knowledge for teaching mathematics and specifically subject content knowledge and pedagogical content knowledge (Ball *et al*. 2008); and epistemic relationship to mathematics – how mathematics is viewed as a body of knowledge
	Generic teacher knowledge and skills, for example development of critical reflection and capacity to use research and research own practice (Winch *et al*. 2015)
	Credit bearing and accredited knowledge (Kennedy 2014)
Agency	Degree of professional agency – exercised when professional subjects and/or communities influence, make choices and take stances on their work and professional identities' (Eteläpelto *et al*. 2013, p. 61) including from a life-long learning perspective
	Agentic professional development and learning including identifying priorities and means for professional learning (Sachs 2011, Kennedy 2014)
	Individual versus relational and collective agency (Eteläpelto *et al*. 2013, p. 61)
Sociality	Individually orientated or collaborative professional learning relationships across formal professional learning activity, work-based learning and in the profession more widely (Boylan *et al*. 2023; Sachs 2016);

Table 4. Professional learning processes and systems.

Dimension	Aspects and sources
Modes of professional learning	Models and purposes of professional learning from transmissive to transformative e.g., training, cascade, coaching and mentoring, practitioner research (Kennedy 2014, Boylan *et al*. 2023)
	On site and off site formal and informal professional learning activities (Boeskens *et al*. 2020).
Material and systemic arrangements	Professional learning organisational providers (Boeskens *et al*. 2020)
	Funding and leadership by local/regional authorities, by universities or other providers (Boylan and Adams 2024) and their relationship to the state (Ellis *et al*. 2021)
	Professional learning facilitators – those leading the professional development, professional teacher educators, teachers and hybrid teacher leaders (Margolis 2016)

In summary, the analytical process was iterative between the key sources and the development of the framework. Additionally, as a research team, we rotated lead responsibility for analysis for the different programmes across different phases and writing to develop a shared interpretation.

The three programmes

In this section, we describe the three programmes' key features. To avoid repetition, when describing the programme features, we do not link specific sources as references. The sources that inform these descriptions are provided in Table 1.

England – MDPT

The MDPT was piloted in 2007–09 in three universities after commissioning by a government agency and then offered by 12 providers with universities central to provision. The programme was amended in 2011 and replaced shortly after. Teachers participated in the MDPT if they had taught for more than a year after qualifying in another subject or in the primary phase, had no university level mathematics study, and were teaching mathematics to 11–16-year-olds in a state-funded school. Participants needed support from their headteacher and schools identified a school-based mentor to support them. Schools were provided with funds to cover participants' time out of school.

Typically, training took place over 15 months or four English school terms – consisting of 30 days out of school and 10 school-based days to complete pedagogical tasks. Each provider designed the specific content for the course within a common frame of a focus on teaching the secondary mathematics curriculum. Although gaining academic credit was not a primary focus, such credits were used to assess successful completion with 40 UK credits at final year undergraduate level available. This is equivalent to about 1/3 of a year's undergraduate study. The total time commitment was 300 hour based on training days, and 400 hours equivalent based on credits. Participants' QTS did not change on completion however, they were eligible for a £5000 payment, if they met attendance requirements and gained credits.

England – SKTM

Following the MDPT, a similar programme was funded, the Subject Knowledge Enhancement plus (SKE+), with a reduced time commitment. This was replaced by the Teacher Subject Specialism Training (Croft and Fisher 2017). The SKTM started in 2021 was developed by the National Centre for Excellence in Teaching Mathematics (NCETM), a government funded organisation and delivered through a network of Maths Hubs – local school-led clusters for professional development support. From 2014, the NCETM consolidated its advocated approach to teaching mathematics under the label of 'teaching for mastery'. The NCETM manages the programme providing centrally produced resources, training for the SKTM professional development facilitators – 'cohort leads' who work for local maths hubs responsible for recruitment and delivery.

Eligible SKTM participants are teachers of secondary mathematics whose teaching qualification is in another subject or phase. Potential participants are nominated to take part by subject and school leaders. The programme consists of 6 days or equivalent professional development, taking place over at least two school terms with school-based tasks undertaken in between. The content focuses on subject and subject pedagogical knowledge for teaching the 11–16 mathematics curriculum. Attendance and engagement are recognised through a certificate of completion. Participants may opt to undertake formal academic assessment at Masters level associated with this programme, gaining a 60-credit Postgraduate Certificate in Educational Practice in Mathematics.

Ireland – PDMT

As noted in the description of sources, it may be that the current programme differs in some respects from the description in the sources we drew on. The development of the PDMT followed the rollout of a new curriculum for post primary mathematics, aimed at enhancing students' understanding of concepts and their problem-solving skills. The Irish Government Department of Education and Skills (DES) funded the PDMT from 2012. The programme was developed by a consortium of Irish higher education institutions and delivered by mathematics lecturers, mathematics tutors and mathematics teacher educators. The PDMT was designed for post-primary teachers teaching mathematics in a second-level school in Ireland who were qualified second-level teachers

registered with the Teaching Council in a discipline other than mathematics lacking the required qualifications for teaching mathematics.

The programme utilised a blended learning design, intended to meet the demand that it be accessible to teachers across Ireland. It is a 2-year, part-time course, with attendance at evening, weekend and summer sessions, rather than during the school day. The Diploma comprises ten mathematics content modules and two mathematics pedagogy modules, delivered through a blended learning programme. The mathematics content modules comprised 30 hour blocks in 6-week sessions (24 lectures, 6 tutorials), each worth 6 ECTS credits. The two mathematics pedagogy modules, completed over the course of 1 year were formed of 5 × 3 hour workshops plus a week-long summer school (6 and 9 ECTS credits). Successful completion of the programme 75 ECTS credit programme led to the addition of mathematics to teachers' teaching council registration.

Out-of-field mathematics teacher programmes and professionality

We now apply the analytical framework of dimensions of professionality and professional learning processes and systems to compare the three programmes.

Knowledge

All three programmes' design explicitly focus on subject knowledge and pedagogical subject knowledge (Ball *et al.* 2008). However, the amount of content across the three programmes differs. The PDMT content is aligned with the requirements for initial teacher education to teach secondary mathematics, which includes an expectation of study of relatively advanced mathematical topics such as multi-variable calculus and non-Euclidean geometry (Teaching Council 2022). The SKTM's focus is on the mathematical content of core curriculum topics for students aged 11–13. As noted, the content of individual MDPT programmes was designed by each provider within a broad framework of supporting out-of-field mathematics teachers to teach mathematics 11–16.

A common feature of MDPT programmes was focusing on interconnections in mathematics in some cases conceptualised as developing a profound understanding of fundamental mathematics (Stevenson 2008). One instance of the MDPT was structured around significant mathematics themes 'Infinities, Uncertainties, Structures and Spaces' rather than the school curriculum (Crisan and Rodd 2011, Faulkner *et al.* 2019). Thereby encouraging out-of-field teachers to rethink their relationship to mathematics. In both the MDPT and PDMT, the amount of and form of mathematics studied could offer this potential. The SKTM also appears to have a concern for this epistemic relationship to mathematics, although in the case of SKTM to do this a positive experience of doing mathematics is emphasised and engagement with representations and models – one of the components of the mastery approach.

Again, due to alignment with the Teacher Standards and requirements for gaining university credits, the PDMT also addresses a range of teacher knowledge and skills, notably engagement in practitioner research. The PDMT is also fully credit bearing with knowledge gained leading to additional qualification as a mathematics specialist teacher. The MDPT also offered accreditation of learning, although to a lesser extent, this accreditation was tied to an incentive payment upon completion. For both the PDMT

and MDPT knowledge was assessed through standard approaches to university study. The SKTM certificates participation and engagement rather than assessment of learning.

A common feature of all three programmes is doing mathematics. However, what type of engagement with mathematics is encouraged and how this is accessed may vary depending on the extent to which engagement with mathematics is intended to develop knowledge that could be applied through a generic pedagogy, or as foundational for development of disciplinary pedagogy (e.g., in the PMDT Goos *et al.* 2020).

Central to knowledge and epistemic concerns are the sources of knowledge. Universities were central for the MDPT and PDMT in contrast to the SKTM. However, this surface difference obscures the conceptualisation of teacher knowledge in all cases drawn from mathematics education research. Considering the two programmes in England, the view of mathematics teaching and learning embedded in the programmes sits within a long-standing consensus within the mathematics education community in England (Compton and Boylan 2023).

The constructs of subject knowledge and pedagogical subject knowledge are well established in mathematics education (e.g., Ball *et al.* 2008) and, as noted, all three programmes centred these forms of knowledge in programme aims. Other aspects of the knowledge included in the three programmes are less well formulated in mathematics education research. Specifically, the programmes potentially foster knowledge about the nature of mathematics as an interconnected and meaningful subject – this in contrast to long standing concerns with how school mathematics is experienced (e.g., Ingram *et al.* 2026). By providing participants with a potentially different experience of mathematical activity to previous ones, the programmes also imply or make explicit that there are different ways to teach and learn mathematics. Thus, the programmes have the potential to develop not only subject knowledge and subject pedagogical knowledge but knowledge about the nature of mathematics and knowledge about different ways to teach mathematics.

Agency

We focus on agency (Eteläpelto *et al.* 2013) in relation to teachers' participation. The extent to which teachers choose to participate in the programme differed, with teachers in Ireland choosing to apply for the PDMT. In England, recruitment to the MDPT was mainly via schools and colleges, with headteachers support required; for the SKTM, recruitment was aimed specifically at school leaders, suggesting that teachers may have had less agency in deciding whether to participate. Linked to these choices is the structure of the professional learning, with the PDMT taking place out of school hours. The MDPT had supply cover fully funded. The SKTM does not have supply cover funding and, depending on the delivery model, may take place during the school day, outside of the school day or a mixture of these timings.

The professional development supported teacher choice. For example, on the PDMT, one of the pedagogy modules requires participants to complete a supervised action research project on their practice in the classroom. The aim to have individual agency in learning and assessment on the MDPT was harder to achieve in practice, but there was still some scope for professional experimentation. The SKTM programme of workbooks and slides may leave limited scope for teachers to tailor CPD to meet own needs, although there was some scope for teachers to develop school-based tasks.

PDMT providers have agency over content and delivery and MDPT providers had freedom to develop programme locally, designing their own curriculum. In the SKTM, materials are produced centrally by the NCETM, with flexibility for local leaders to select activities.

Sociality

Opportunities for teachers on the PDMT to build relationships were supported attendance at lecture and tutorial venues around Ireland, a week-long summer institute on mathematics pedagogy at the end of year 1 (Faulkner *et al.* 2019, p. 276) and blended learning collaboration. The 2-year programme supported sustained relationships. Professional collaboration within school contexts was restricted by limits on course places imposed by the DES, resulting in prioritising teachers from as many schools as possible taking part, rather than enabling two or more teachers from the same school to participate at the same time (Goos *et al.* 2020).

As noted, the MDPT had local university-led design. In one course 'establishing a strong learning community and shared ethos was a key design principle enabled by a residential, encouragement to identify with wider mathematics education community through subject associations, including funding attendance at conferences' (Stevenson 2013, p. 68). At another, the programme comprised 'three interrelated parts: face-to-face contact sessions based at university, directed work arising immediately from the taught contact sessions and school-based work where teachers relate the university-based experiences to their own practice' (Faulkner *et al.* 2019, p. 283). They were supported in this by university and school-based mentors. All courses utilised 'collaborative learning and small group work', aiming to model good pedagogical practice (Holland *et al.* 2009). As with the other two programmes, the SKTM encourages collaboration with cohort peers, however the shorter duration of the programme of 6 days over 1 year may limit this.

Modes of professional learning

The SKTM professional learning is organised around 18 modules of participant materials that are used across the 6 days (or equivalent) of programme events. These are supported by presentation materials used by the professional development facilitators – the cohort leads. Participants work individually or collaboratively on mathematical tasks, and the cohort leads share and model approaches to teaching the mathematical content and guide discussion and reflection. Approximately, five school-based tasks selected by cohort leads are provided for participants. Although interactive and collaborative, using the NCETM's 'work group' model, the professional learning has aspects of a training model (Kennedy 2014) due to being brief relative to the amount of content. In the SKTM, the participants' mathematics subject leaders are encouraged to provide additional support through mentoring, but this is not obligatory. The MDPT had considerably longer time spent in off-site activity (30 days rather than 6 days), funded support for school-based activity and a requirement that schools identified a mathematics teacher as a mentor. The greater time available on the MDPT compared to the SKTM, and working with the same group of OOF teachers on a regular basis, potentially supported a more collaborative professional learning community (Sachs 2016).

The PDMT shared with SKTM and MDPT a blend of mathematical study, explanation and modelling by experienced mathematics educators and opportunities for reflection. In the PDMT, a distinctive feature was a designed blended learning approach. Further, to achieve certification, participants undertook a substantial practitioner research project.

Material and systemic arrangements and resources

Here, we add to the earlier descriptions of the programmes to consider the nature of the organisations designing and delivering the three programmes. We discuss the influence of this on other aspects of the programmes in sections that follow. All three programmes were government funded but the level of funding per participant clearly differs greatly given the different length of programmes.

Both programmes in England have some links with the NCETM, the main policy actor in mathematics teacher professional development (Boylan and Adams 2024). Drawing on Ellis, Mansell, and Steadman's (2021) shadow state typology, the NCETM is a co-created structure, indicative of the multiple and complex relationships between the state and various enterprises – including entrepreneurs, scholarly enterprises and enterprising charities (Boylan and Adams 2024).

The PDMT in Ireland was run by a scholarly enterprise, a university consortium with a cross-consortium leadership team with two full time staff. School involvement was limited to confirmation of eligibility by the principal. Under the terms of the DES contract, a Monitoring Group comprising DES officials from the Teacher Education Section, the Schools' Inspectorate and members of the course team monitors the programme. Google was a partner in the programme and provided the online platform (Faulkner *et al.* 2019, p. 276).

The MDPT was designed and delivered by universities with 'freedom to design their own curriculum', with as noted one provider avoiding structuring the course around the National Curriculum (Crisan and Rodd 2011). All participants registered with the NCETM and used NCETM self-evaluation tools to identify needs and track learning (Stevenson 2013).

The SKTM is funded by DfE and developed and run by the NCETM via maths hubs. Maths Hubs identify Cohort Leads (experienced mathematics teachers and subject leaders who have undertaken the NCETM's Professional Development Lead Programme) to lead the professional development. Some Cohort Leads lead more than one cohort.

Mathematics teachers and teachers of mathematics

Having analysed the programmes, we now turn back to the questions that we sought to address about the relationships to teaching mathematics and to professionality that the programmes supported and how these relate to the different contexts.

The MDPT and the PDMT

The MDPT and PDMT designs both support the development of mathematics teacher subject identity and professionality with the potential for participants to move from being out-of-field to becoming 'in field', that is to lead to or strengthen a sense of being a mathematics teacher. This is most obviously the case for the PDMT given it leads to

additional recognition. However, the MDPT also offered this possibility, although this might be more dependent on the motivation and engagement of individual participants.

The two programmes have many similarities but have some differences that may be context dependent but are worth considering in the design of similar programmes that likewise aim for supporting a professional orientation. The MDPT had a strong emphasis on the importance of engagement in the on-site professional community of teachers in schools with a subject mentor being a key feature. This reflected a context in which subject mentoring was a key aspect of initial teacher education. The PDMT had a more extensive and common body of professional knowledge that aligns with the requirements for other secondary mathematics teachers. Arguably, this reflects a more general stronger policy commitment in Ireland to mathematics teachers as disciplinary professionals than in England. The MDPT content was more varied and less extensive than in Ireland, but this reflects the policy environment and the positioning of teachers increasingly as technicians with beginning teachers 'trained' rather than educated, at least as framed in policy.

SKTM

The SKTM has less time commitment from participants and is a more malleable form (Kennedy 2014) of professional development. The programme itself is unlikely to support the development of a strong subject specialist professionality. However, this may depend on the motivation of individual participants and existing professionality in their school contexts. If participants' orientation is more technician orientated or if that is the culture in their school setting then the programme activity, being relatively limited, is unlikely to change that. Conversely, a participant who has a more professional orientation or is in a school setting that does provide additional mentoring and a collaborative professional learning environment could develop a fuller mathematics subject teacher professionality.

At the same time, the more limited SKTM is arguably a reasonable policy response to address the needs of teachers required to do some teaching of mathematics or reluctant teachers of mathematics. So, a positive feature of the SKTM is that it provides some professional development to support teachers who may not seek to become 'in-field' teachers or to become dual qualified.

Possibilities for different professionalities

The programmes offer different opportunities for participants' relationship to teaching mathematics: professional learning for being a mathematics teacher and being a teacher who teaches mathematics. This latter construct encompasses, for example, being a physical education teacher who teaches mathematics or a languages teacher who teaches mathematics and so on. A programme aimed at being a mathematics teacher suggests a trajectory towards being 'in-field'; one aimed at being a teacher who teaches mathematics to remaining out-of-field. However, rather than a binary, with only two possibilities, a continuum is possible with some out-of-field teachers engaging in processes of more complex and hybrid identity construction. Second, regardless of design, participants' actual trajectories will depend on their professional and personal identity, goals and motivations, for example, even if a programme is designed to retool, participants may engage in more transformative ways.

Figure 2 indicates potential relationships that the three programmes offer to mathematics teaching and to teacher professionality generally. However, outcomes for participants will vary given their heterogeneity and related to this how they choose to participate. Thus, Figure 2 indicates possible destinations rather than destinies that will manifest simply due to participating in programmes. This is an important feature of the SKTM programme and its positioning in Figure 2 reflects that the programme design supports all four destinations.

However, the positioning of the SKTM ellipse as being located more in the lower two quadrants than the upper two reflects that the design focuses more on supporting teachers who teach mathematics than, through the programme alone, supporting the development of a mathematics teacher professionality. The primary reason for this lies in the material and systemic arrangements and resources of the SKTM programme, specifically the limited time available to the professional development providers and the participants – substantially lower than for the MDPT and PDMT. The amount of resource committed in policy to the latter two programmes also supports accreditation of learning that allows for a wider range of types of knowledge to be developed and importantly formal recognition of this learning. Connected to these two programmes are designed possibilities for socialisation into a mathematics teacher community, albeit through different routes. In MDPT, a school-based mentor was a requirement of the programme. In the PDMT, extended residential experiences also support induction into a professional community.

The different possibilities for professionality echo different purposes of professional development programmes. Upskilling resonates with retooling (Sachs 2011), that may be achieved by transmissive models of professional development (Kennedy 2014). Such

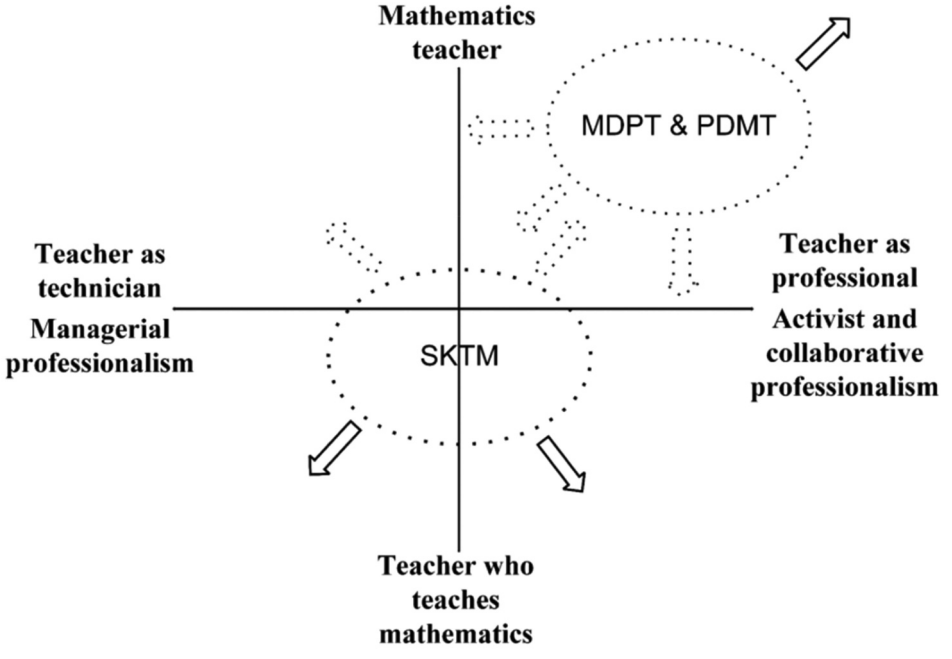

Figure 2. Teaching mathematics and professionality: possible relationships.

approaches might be appropriate for out-of-field teachers who are expected to teach mathematics only for a short time. Alternatively, if a teacher is re-certified to teach mathematics, then not only will they have engaged with the same or similar content as other mathematics teachers but also potentially have engaged in significant additional learning from the experience of crossing boundaries (Hobbs 2013). In such cases, professional learning may be more transformative (Kennedy 2014) as teachers re-imagine (Sachs 2011) both what teaching is and who they are as teachers.

These different possibilities for professionality do not arise only from of individual aspects of the programmes but through their interconnections. For example, we described different forms of knowledge that the programmes foster. Some of these also enhance agency. Knowing that there are different ways to teach mathematics supports teacher agency; including this knowledge embeds the potential for professional rather than technical learning (Winch *et al.* 2015) and transformative learning rather than retooling (Sachs 2011). Collaborative professional learning supports the potential for collective agency (Eteläpelto *et al.* 2013) and potentially socialisation into belonging in a community of mathematics teachers.

Out-of-field mathematics teacher professional development: policy contexts and teacher professionality

The programmes' different possibilities for mathematics teacher professionality are rooted in their policy contexts. At the time MDPT was introduced, universities still had a dominant role in teacher education provision. The introduction of the MDPT was part of the implementation of a recommendation of one of a series of government commissioned reports into mathematics education (Smith 2004). This report demonstrated that universities were seen both by policy intermediaries and policymakers as trusted and important vehicles for implementating teacher education policy and improving workforce quality. That the government at the time commissioned and then implemented the recommendations of an independent expert group that were not dependent on government funding indicates a relatively deliberative policy process. Qualified teacher status (QTS) was shaped by generic teaching standards rather than any subject specific required content. Therefore, subject specialist status was dependent on the initial teacher education route.

In the period after the MDPT, there were a series of reforms to teacher education with an increasing centralisation and control of the content, and the development of a marketised delivery model with a reduced role for universities (Ellis 2023) and the development of more complex means to develop and implement policy, viewed variously as shadow state (Ellis *et al.* 2021) or network governance through statification of markets (Boylan and Adams 2024). The existing relatively high regulation of schools was amplified in teacher education that was in the process of being reconstructed as 'teacher training' with a mandated core content framework closely controlled and monitored by the government ministry (Ellis 2023). These changes broadly favoured a managerialist form of teacher professionalism (Sachs 2003). The reduction in the amount of time for policy supported out of field professional development programmes from 40 days (MDPT) to 6 days (SKTM) exemplifies how teaching and teachers are constructed in policy. Further, the length of the SKTM programme is also influenced by perceptions of the amount of time schools are willing to allow teachers to engage in professional development in the context of a technicist model of training.

In contrast, the PDMT exemplifies a different policy environment and that is marked by a more classic, liberal or social democratic view of teaching and teacher professionalism. The Irish General Teaching Council (IGTC), established in 2006, regulates standards in the profession and defines qualified mathematics teacher status. It is comprised of elected teacher, higher education and other stakeholder representatives, with those nominated by the government in the minority. Funding for the PDMT required it to fulfil the requirements set by the ITGC for secondary mathematics teacher qualification.

Conclusion

We have analysed the three programmes in terms of dimensions of professionality and process and systems to consider the consequences of design choices; the application of the theoretical framework we have used in our analysis provides a model for comparing other out-of-field teacher programmes, potentially other professional development programmes and could inform future programme design and implementation.

The MDPT and PDMT programmes offer the opportunity for participants to develop knowledge, skills and identity centred on becoming and being a mathematics teacher. In contrast, the SKTM is focused more on being a teacher who teaches mathematics. A notable difference between the MDPT and PDMT from the SKTM is the role of universities. Our analysis suggests that as or more important than who leads the professional development is the wider positioning of the teaching profession in the two countries. In England, political micro-management of the teaching profession and teacher education has increased. In Ireland, there is an independent, influential professional body in the Teaching Council. We have also drawn attention to the different level of resource committed by policymakers to the different programmes, and this has implications in other education systems for addressing out-of-field teaching (Hobbs and Porsch 2021, Goos *et al.* 2024).

Looking across the three programmes, one policy implication for Ireland (and other systems aiming to address out-of-field mathematics teachers' professional development) is to have more of a tiered or stepped approach with an introductory programme similar to the SKTM aimed at temporary or short term out-of-field mathematics teachers that can be built on through a programme like PDMT or MDPT over a longer period of time. Policy supported programmes for out-of-field mathematics teachers aside, similar issues may arise in relation to other subjects or for more informal professional development that might be provided in schools in the absence of formal programmes. Regardless, comparison of the three programmes draws attention to the impact of policy supported decisions in extending teachers' existing professional identity to also embrace being a mathematics teacher or alternatively positioning them as technicians who teach mathematics.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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