

## ***Teaching mathematics out-of-field and the journey to obtaining mathematics teacher certification***

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### **ABSTRACT**

The misassignment of teachers, with respect to their qualification, results in teachers teaching mathematics out-of-field (OOF). OOF mathematics teaching is an international area of concern, with research documenting the existence of the practice in Australia, the United States, Germany and England, and the negative effects that the practice can have on teachers' lives, student learning and the professional standards of teaching. Research conducted in Ireland has demonstrated the prevalence of teachers being assigned to teach mathematics OOF in post-primary schools. In response to the issue of OOF mathematics teaching, the Irish government funded the Professional Diploma in Mathematics for Teaching (PDMT), a professional development programme for teachers teaching mathematics OOF, enabling them to obtain mathematics teacher certification. The content of the PDMT, then, adheres to the Teaching Council of Ireland's curricular requirements for teaching mathematics. This research employs the construct of first-person mathematics-related (1<sup>st</sup> PM-R) teacher identity to capture the learning trajectory of a participant on the PDMT. 1<sup>st</sup> PM-R teacher identity refers to the teacher's self-understandings in relation to mathematics teaching. These self-understandings are stories told by the teacher about themselves to a third party. This paper reports on the 1<sup>st</sup> PM-R teacher identity of Mary, a certified business studies and accounting teacher teaching mathematics OOF, whilst undertaking the PDMT. Thematic analysis and sociolinguistic tools were used to analyse interview data to obtain insights regarding Mary's 1<sup>st</sup> PM-R teacher identity, and the ways in which her 1<sup>st</sup> PM-R teacher identity was reshaped over her involvement in the PDMT. The findings suggest that professional development programmes have the capacity to impact 1<sup>st</sup> PM-R teacher identity, in particular, with regard to how the teacher believes they are seen by school management and their students' parents; however, other factors, such as colleagues and previous experience learning mathematics, may be more significant in shaping the teacher's 1<sup>st</sup> PM-R teacher identity in relation to their teaching practices. The findings from this research may have implications for the development of mathematics professional development programmes and the criteria for determining mathematics teacher certification.

### **KEYWORDS**

Teacher identity, professional development, out-of-field teaching, mathematics education

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## Introduction

In 2009, a research study by Ní Ríordáin and Hannigan (2009) discovered the widespread existence (48%) of teachers being assigned to teach mathematics in Irish post-primary schools without the requisite mathematics teacher certification. This practice of teacher mis-assignment, which results in teachers teaching mathematics out-of-field (OOF) (Ingersoll, 1999), has also been documented in Australia (Hobbs, 2013; Weldon, 2016), the US (Van Overschelde & Piatt, 2020), England (Crisan & Rodd, 2014), Germany (Bosse & Törner, 2015) and South Africa (Du Plessis et al., 2015). The growing prevalence of OOF teaching, then, is of growing concern to those who advocate for teacher professional standards, given that the practice of teacher mis-assignment largely ignores the perspective that to be an effective teacher one must obtain a credentialed level of content and pedagogical knowledge in a particular subject (McConney & Price, 2009). Therefore, across the various jurisdictions reporting on the incidence of OOF teaching, there have been a variety of approaches implemented to address the issue. For instance, a centralised approach in the US involved the Department of Education enacting policy to ensure that students were taught by ‘highly qualified’ mathematics teachers (e.g., No Child Left Behind), while at a more localised level in Australia, a Victorian university provided a mathematics professional learning programme for teachers teaching mathematics OOF (e.g., Vale et al., 2011). Ireland, too, has sought to address OOF mathematics teaching, and it is Ireland’s approach, the development of the State-funded, two-year, part-time, blended learning programme, the *Professional Diploma in Mathematics for Teaching* (PDMT), that is the focus of this paper.

The PDMT, established in 2012 by the Department of Education and Skills<sup>1</sup> (DES), is structured in line with the requirements of the Teaching Council to enable in-service teachers teaching mathematics OOF to add mathematics to their teacher certification. The programme, for which there is no fee incurred by the participants, was and continues to be delivered by a national consortium of Higher Education Institutions. To date, the DES has provided over €8 million in funding for the PDMT, accounting for three cohorts of teachers (approximately 1,100) graduating from the programme and catering for a further 300 teachers who are currently undertaking the programme. As a result of this investment in the PDMT, the latest research suggests that approximately 17% of the mathematics teacher workforce in Ireland are graduates of the programme, while the proportion of the workforce that are teaching OOF has reduced (~25%) (Goos et al., 2021). The PDMT then has changed the landscape of mathematics teaching in Ireland; yet, the impact of this programme on the lives and teaching practices of those involved requires further consideration, particularly given that the PDMT was established following the implementation of the reformed post-primary mathematics curriculum, Project Maths. This research paper provides some insights in this regard by documenting Mary’s journey, a business teacher with six years’ experience, who found herself teaching mathematics OOF and subsequently, opted to undertake the PDMT to formally add mathematics to her teacher certification. Prior to commencing her studies on the PDMT, Mary had been teaching mathematics in her school for one year, attended other professional development courses in mathematics and collaborated with fellow mathematics teachers in her school; thus, she had accumulated some experience and expertise in the subject area. Therefore, Mary, like other teachers teaching mathematics OOF, should not be viewed or researched from a deficit perspective (Törner, 2014); instead, a holistic approach, such as teacher identity, which encapsulates both cognitive and affective-motivational components should be employed (Hobbs, 2013).

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<sup>1</sup> In October 2020, the DES was renamed as the Department of Education.

The construct of mathematics-related teacher identity offers a viable approach for studying teachers, such as Mary, who are teaching mathematics OOF, given that their mathematics-related teacher identity is continuously negotiated and reshaped as their beliefs and attitudes interweave with their pedagogical content knowledge and content knowledge. This ongoing amalgam of cognitive and affective-motivational components shapes one's self-understandings in relation to mathematics teaching, otherwise termed, one's *first-person mathematics-related* (1<sup>st</sup> PM-R) *teacher identity*. This paper provides a short overview of 1<sup>st</sup> PM-R teacher identity, before detailing how Mary's 1<sup>st</sup> PM-R teacher identity was reconstructed over her time completing the PDMT. In doing so, this paper sheds light on how a professional development programme along with other factors shape teachers' self-understandings in relation to mathematics teaching.

## Teacher Quality and Teaching Quality

It is widely acknowledged that what teachers *know* and what teachers *do* impacts on students' learning. Unsurprisingly then the connection between what teachers know (teacher knowledge), what teachers do (teacher practices) and the subsequent learning that occurs (student learning) has been the focal point of mathematics educational research for numerous years. Yet, in spite of a plethora of research in this area, the links between mathematical knowledge, classroom teaching and learning outcomes remain unclear (Askew & Venkat, 2020). Therefore, research is still required to deepen our understanding of the connection between mathematics teacher knowledge and mathematics teachers' practices. To assist in researching the connection between teacher knowledge and teacher practice, Kaplan and Owings (2002) demarcate between *teacher quality* and *teaching quality*. Teacher quality refers to:

the inputs that teachers bring to the school, including their demographics, aptitudes, professional preparation, college majors, teacher examination scores, teacher licensure and certification, and prior professional experiences. (Kaplan & Owings 2002, p. 4)

Teacher quality then encapsulates a set of attributes, outlined by teacher certification criteria and developed through teacher education curricula and programmes, which predict that the teacher will be successful in the classroom (Goe, 2007). Therefore, teacher certification acts as the professional benchmark for teacher quality (Kaplan & Owings 2002), and provides those who are certified with the identity of a qualified teacher. This reflects an acquisitionist perspective of identity, in that it refers to something one *has* (Darragh, 2016). Teaching quality is concerned with "what teachers do with what they know to promote student learning inside the classroom" (Kaplan & Owings 2002, p.4). It includes creating a positive learning environment, choosing appropriate instructional goals and assessments, using the curriculum effectively and implementing varied instructional behaviours that assist students to learn to a high level. Teaching quality is manifested through identity enactment within the classroom, reflecting a participationist view of identity as something one *does* (Darragh, 2016).

## Teacher Identity

Identity, from the participationist perspective, can be conceptualised as "about 'doing' ways of being for self and others", and thus, is inextricably linked with practice (Watson, 2006, p. 509; Wenger, 1998). Given the link between identity and practice, it follows then that teacher identity is inextricably linked to the practice of teaching and subsequently, impacts on teaching quality. Teacher identity is then a unifying construct encompassing *who* one is as a teacher and *what* one does as a teacher. The significance of teacher identity for teaching is surmised by Sachs (2005):

Teacher professional identity then stands at the core of the teaching profession. It provides a framework for teachers to construct their own ideas of ‘how to be’, ‘how to act’ and ‘how to understand’ their work and their place in society. Importantly, teacher identity is not something that is fixed nor is it imposed; rather it is negotiated through experience and the sense that is made of that experience. (p. 15)

In the context of teaching mathematics OOF, when a teacher is assigned to teach mathematics without holding the requisite qualifications they must embark on a journey to develop a sense of *who* they are as a mathematics teacher and *what* they do as a mathematics teacher in their classroom. They must construct and, as the process of identification is continuously ongoing, reconstruct their sub-identity in relation to being a mathematics teacher. Bosse and Törner (2015) refer to this sub-identity as mathematics-related teacher identity.

### Mathematics-Related Teacher Identity

Mathematics-related teacher identity is, in Gee’s (1999) terms, a situated identity, given that it is enacted and recognised in social settings, such as the school and classroom. The recognition aspect of identity involves reflection as one continuously forms and reforms their self-understandings in relation to others (Holland et al., 1998). Self-understanding then refers to one’s situated subjectivity; it is the cognitive and emotional view that one has of oneself and one’s social world. By viewing self-understanding and social location in relation to each other, the self is culturally specific. In this way, one can have various self-understandings of who one is. Losano et al. (2017) conceptualise mathematics teacher professional identity as a set of self-understandings related to ways of being, living and projecting into the teaching profession. These self-understandings are socially and culturally constructed with other participants in the world of teaching. This notion draws on Holland et al.’s (1998) definition of identities as one’s objectifications of their self-understandings. The self-understandings involve people telling narratives to themselves and others regarding who they are, and trying to act as though they are who they say they are. This research then draws on the work of Sfard and Prusak (2005) to describe these narratives – the objectifications of self-understandings – as 1<sup>st</sup> person identities. These narratives are described as 1<sup>st</sup> person, given that they are told by the identifying person (Mary), about the identifying person (Mary), to a third party (the researcher). The distinction of 1<sup>st</sup> person, then, demarcates who is doing the identifying, reflecting the multiplicity and fluidity of the dynamic construct of identity, while building on the work of Wenger (1998), Holland et al. (1998), Gee (2000), Sfard and Prusak (2005) and Bosse and Törner (2015). In the context of mathematics teaching, these narratives and self-understandings in relation to mathematics teaching are one’s 1<sup>st</sup> PM-R teacher identity. Following Sfard and Prusak (2005), there exists current 1<sup>st</sup> PM-R teacher identities and designated 1<sup>st</sup> PM-R teacher identities, and when the gap between current and designated 1<sup>st</sup> PM-R teacher identities is reduced, learning has taken place. This learning transforms who one is and what one does – it is a matter of identity and reflects the process of becoming a certain person (Wenger, 1998). It follows that 1<sup>st</sup> PM-R teacher identity is understood to be *multiple*, *transactional* and *relational*; it is both *narrative* and *participatory*, involving the enactment and recognition of situated identities. Primarily, it is constructed, maintained and negotiated through discourse. Hence, data collected to explore and investigate Mary’s 1<sup>st</sup> PM-R teacher identity, documenting her learning whilst undertaking the PDMT to obtain mathematics teacher certification, was qualitative in nature.

### Methodology

This paper draws on data from a larger two-year, qualitative doctoral study that explored the mathematics-related teacher identities of five OOF mathematics teachers undertaking the

PDMT. The case of Mary, one of the five participants in the doctoral study, is the focus of this paper, and in particular, the analysis of interview data, as part of a larger corpus of data, gathered over her involvement in the PDMT. The paper contains the analysis of qualitative data emanating from three interviews, the first of which took place in November 2016 (shortly after Mary had commenced the PDMT), the second in April 2017 (following the observation and video recording of a mathematics lesson taught by Mary) and the final interview in April 2018 (shortly before Mary had completed the programme). The research used standardized open-ended interviews for all five participants, which focussed on extracting narratives in relation to their 1<sup>st</sup> PM-R teacher identity. Additionally, for interviews 2 and 3, the participants were asked participant-specific questions on the basis of what they had said in the previous interview(s). These questions enabled the participants to further elaborate on some issues that were not formally addressed in the standardized interview protocol, while also affording the opportunity for member checking to assist with researcher reflexivity. A combination of thematic analysis (Braun & Clarke, 2006) and sociolinguistic tools (Gee, 2011a; Sfard & Prusak, 2005) were used to analyse the data. The thematic analysis was supported with the use of the Figured Worlds Tool (Gee, 2011b), which requires an analysis of the typical stories being told, the Big 'D' Discourse Tool (Gee, 2011b), involving an analysis of what kind of identity the person is seeking to enact, and the Telling Identities tool (Sfard & Prusak, 2005), equating identities with stories which are reifying, endorsable and significant. Sfard and Prusak (2005) delineate between current identities, which are stories told about the current state of affairs, and designated identities, reflecting narratives expected to be the case in the future. In relation to this analysis, it should be noted that case studies follow the interpretivist view of multiple social realities with the researcher's view and interpretation being one of many (Cohen et al., 2018); thus, researcher reflexivity was central to the data analysis. It is therefore acknowledged that the research knowledge disseminated in this paper is affected by and refracted through the lens of the researcher.

## Findings

For Mary, a number of factors contributed to her ongoing 1<sup>st</sup> PM-R teacher identity (re)construction: *her experience learning mathematics; her motivation to obtain teacher certification, and her mathematics teaching practices*. Mary completed a Bachelor of Business degree for her undergraduate studies and worked as a teaching assistant at a third level institution, before completing her postgraduate diploma in business education, which certified her to teach business studies and accounting at post-primary level. To be a business studies and accounting teacher, however, was not always Mary's plan; instead, from the age of twelve, she wanted to become a mathematics teacher, a goal she maintained until she endured a negative experience as a student studying mathematics for the Leaving Certificate.

### Learning Mathematics

In the initial interview, Mary remarked that mathematics was her favourite subject in school; she had thoroughly enjoyed the subject up until 3<sup>rd</sup> year, the final year of the Junior Cycle. Mary completed the higher level mathematics course for the Leaving Certificate; however, this was not a positive experience for her, primarily due to the mathematics teacher that she had.

I didn't have a good experience in the maths classroom. I didn't appreciate being told I should know things already when I ask for explanations, and I never got explanations and it kind of just spiralled a bit, so then I went into business in college.  
(Mary, Interview 1)

This experience of learning mathematics influenced Mary's mathematics teaching practices, which she described as being "slightly old fashioned" (Mary, Interview 1). She explains:

My most common phrase is probably, you could always ask me a question ... I probably over emphasise that a lot.

(Mary, Interview 1)

Mary acknowledged that she almost enjoyed teaching mathematics more than business studies or accounting, given that she had now returned to a career she had once imagined and a subject that she was very passionate about.

### ***Mathematics Teacher Certification***

Mary noted that given her positive disposition towards mathematics, she was very happy to add the subject to her teacher certification; however, this was not her primary motivating factor for undertaking the PDMT. Instead, Mary remarked that she was concerned at the prospect of her students' parents opposing her teaching and discovering that she was not fully qualified to teach the subject. Mary described her feelings when teaching mathematics OOF in comparison to teaching her in-field subjects:

I was more worried ... they're going I already have the qualification, I am one hundred per cent, I am certified to teach this subject compared to going into something where you're not and there's a worry if something goes wrong along the way that there's going to be parents complaining about you and that the first thing that is going to be said is, "what are her qualifications?"

(Mary, Interview 1)

From the outset of the PDMT, Mary did not feel that being certified to teach mathematics would change her teaching practices, and following her studies on the PDMT, despite acknowledging the positive effect that the programme had on her confidence in her mathematical content knowledge, she believed that her teaching practices remained unaltered.

### ***Mathematics Teaching Practices***

For Mary, the PDMT did not impact on her mathematics teaching practices; instead, she highlighted that other factors, such as the pedagogical approaches she adopted from her business teaching, learning from her experience teaching mathematics and by observing other teachers teaching mathematics, influence her practice. She remarked:

I don't think having the 'piece of paper' changes your teaching necessarily; it's other things that impact on that all the time.

(Mary, Interview 3)

Mary believed that the PDMT did not alter her teaching practices due to the significant focus on the developing mathematical content knowledge (MCK), as opposed to mathematical pedagogical content knowledge (MPCK). She explained:

There's very, very, very little emphasis on how to actually teach [mathematics], and the how to teach it would be far more beneficial. It's all focused on the maths.

(Mary, Interview 3)

Mary's belief regarding the emphasis of the PDMT on developing MCK reflects the guidelines in the Request for Tender of the DES, which outlined that the programme must enable participants to meet the Teaching Council's criteria of 60 European Credit Transfer System (ECTS) credits of study in mathematics-related modules and 5 ECTS credits in the study of the teaching of mathematics. Mary was aware of this criteria and its determining effect on the structure of the PDMT, as she noted:

We have to have certain credits, certain subjects, certain topics to meet what the Teaching Council requires in order for us to be ... qualified maths teachers. So in terms of what they can put in the course, they were strict in that – I think that's had an effect.

(Mary, Interview 3)

Through the PDMT, Mary obtained 60 ECTS credits in mathematics-related modules and 15 ECTS credits in the teaching of mathematics modules, and she was subsequently qualified to teach mathematics across all years and levels at post-primary school. Mary acknowledged that she felt more confident in her MCK, and that she felt in-field with regards to teaching mathematics up to the Senior Cycle ordinary level course of study. She maintained, however, that despite her studies of intensive mathematics modules, she was not ready to teach the Senior Cycle higher level curriculum.

[I'm] probably closer to in-field now than out-of-field, but maybe not kind of fully there. Like I mostly have the expertise for what I'm doing ... I suppose I'm nearly qualified now, but ... if I had to go into higher level [Senior Cycle] maths now, I wouldn't feel that I'd have the expertise for that.

(Mary, Interview 3)

Mary surmised that after finishing the PDMT, she would then have the time available to specifically study the content on the Senior Cycle higher level curriculum, which would enable her to feel more comfortable to teach that course of study.

In effect, Mary believed that the PDMT altered her participation in the mathematics teacher community because she felt she was now worthy of giving her opinion at department meetings, owing to her qualification, and it gave her a sense of security, if her teaching was questioned by others. Thus, the PDMT impacted on Mary's 1<sup>st</sup> PM-R teacher identity in terms of her *teacher quality*, given that she had accumulated the requisite certification deemed to predict success in the classroom. By contrast, Mary's 1<sup>st</sup> PM-R teacher identity tells the story that her mathematics teaching practice did not change from her participation in the PDMT. For Mary then her *teaching quality* was unaffected by completing a programme to obtain mathematics teacher certification. These findings, perhaps, raise some questions for mathematics teacher certification requirements and consequently, mathematics teacher education programme development.

## Conclusion

Mary's journey to mathematics teacher certification presented her with the opportunity to cement or reify her status as mathematics teacher; it provided her with an opportunity to pursue the career path that she had once intended on following, to develop her confidence in her mathematical knowledge and to offer validation to her opinions when expressed in mathematics department meetings. However, the journey to mathematics teacher certification did not, according to her, impact on her enacted mathematics-related teacher identity in the classroom. It should be noted that from the outset, it was not part of Mary's designated 1<sup>st</sup> PM-R teacher identity that the PDMT would alter her practice, and so, if the aspirations to tell different stories for the future were not in existence prior to undertaking the PDMT, then it was going to be difficult for the programme to impact on her practice. With that being said, it is well understood that prospective teachers' existing images and beliefs serve as a filter for making sense of the knowledge and experience they encounter during preservice preparation (Feiman-Nemser, 2001); thus, these taken-for-granted beliefs need to be addressed in preservice teacher education. It may well be the case then that these pre-existing images and beliefs may be heightened in the context of OOF teachers, given their teaching experience. Consequently, there may be greater demands placed on OOF mathematics teacher education programmes to address these taken-for-granted beliefs to ensure they can effect change in

teachers' 1<sup>st</sup> PM-R teacher identity in relation to their teaching practice. It may also be the case, as Hodgen and Askew (2007) suggest, that significant changes in one's 1<sup>st</sup> PM-R teacher identity may not become apparent, even to the person themselves, until an extended period has elapsed after the professional development programme. As such, this is a limitation of this study, given that the final interview took place shortly before Mary had completed her studies on the PDMT. In any case, the findings here do raise questions regarding how mathematics teacher education programmes can meaningfully impact on teachers' narratives of their practice as part of their 1<sup>st</sup> PM-R teacher identity – in essence, their *teaching quality*. Mary's opinion reported on here in this paper in relation to the PDMT failing to impact on her practice and her sense of being unprepared to teach the Senior Cycle higher level curriculum was echoed by the other participants in the larger doctoral study. Therefore, given that the requirement for obtaining ECTS credits in the teaching of mathematics has been removed from the Teaching Council's criteria for mathematics teacher certification (Teaching Council, 2020), it remains to be seen the impact that possible routes to mathematics teacher certification, which exclude the study of the teaching of mathematics, have on *teaching quality*.

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