Non-Specialist Primary School Mathematics Teachers' Professional Identity

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Abstract

This study explored the mathematics teacher identity (MTI) of three purposefully selected grade 6 non-specialist primary school mathematics teachers. The participants' subject matter knowledge and didactical skills were explored by means of semi-structured interviews, lesson observations, and document analysis of lesson plans. The data were analysed using thematic analysis; themes were predetermined from the conceptual framework, and codes and categories emerged from the semi-structured interview transcriptions. The conceptual framework describes teacher identity in terms of subject knowledge, teaching and learning knowledge, and the skills and ability to care for the learners as people. The analysis of the data indicated that non-specialist primary school mathematics teachers not only lack subject matter knowledge, but also do not have the teaching skills to recognise and address the learners' lack of understanding of concepts. In turn, this influences the teaching and learning of mathematics in their classroom and results are generally poor. In particular, the three participants demonstrated difficulties in explaining new concepts and in employing a learner-centred approach. It is recommended that in-service training workshops be tailored to teach both content and didactics as well as the skills required to become reflective practitioners to better equip non-specialist mathematics teachers for the mathematics classroom.

Keywords: didactical knowledge expertise; mathematics teacher identity; non-specialist teacher; reflection; subject knowledge expertise

Introduction and Context

"Teachers cannot teach what they do not know" (Spaull 2013, 5). This definitive claim seems to be a statement of the obvious. However, it raises concerns in view of the practice in many education departments worldwide to appoint non-specialist teachers to teach specialised subjects such as mathematics. Non-specialist teaching occurs internationally in both primary schools (Bosse and Törner 2015; Du Plessis 2020), and secondary schools (Bosse and Törner 2015; Crisan and Rodd 2017; Du Plessis 2020; Ingersoll 2001a; Ríordáin, Paolucci, and O'Dwyer 2017; Weldon 2016). However, as Luft et al. (2020, 710) point out, one of the reasons for "the global persistence of out-of-field teaching pertains to the absence of discussion of this area." They also point out that the political structure of the area in question plays a role in the prevalence of this phenomenon.

In South Africa, this is certainly the case and researchers have found that often teachers in rural mathematics classrooms are non-specialists and the results are not good (Onwu and Sehoole 2015; Spaull 2013; Seroto 2009; Venter and Viljoen 2020; Long and Wendt 2019). Du Plessis (2013) narrows the focus to schools in low socio-economic environments where she found an increased prevalence of non-specialist teaching. The majority of private schools, because of their high socio-economic status, are financially more able than public schools to employ highly qualified teachers to meet their school's needs. In fact, Carnoy and Chisholm (2008) discovered that the current appointment process in South Africa enables richer schools to choose their teachers on the basis of advertisement and interviews, while poorer schools are obliged to select from a list of teachers often considered redundant by other school principals. This appointment process results in an uneven distribution of competent mathematics teachers because competent mathematics teachers are generally snapped up by schools in wealthy socio-economic areas, whereas non-specialist mathematics teachers become part of the improvisation plans of schools in poor socio-economic areas who need to fill the gaps in their staff contingent (Long and Wendt 2019; Motala and Carel 2019). This appointment process is bolstered by the fact that schools in poor socio-economic areas lack resources while mathematics specialist teachers prefer to teach in well-resourced institutions such as private schools (Du Plessis and Mestry 2019). It follows that schools in poor socio-economic areas have difficulty in attracting and retaining mathematics specialist teachers (Du Plessis and Mestry 2019; Handal et al. 2013).

In this study, we look at the practices of three non-specialist primary school mathematics teachers in terms of the basic tenets of mathematics teacher identity (MTI). While Beauchamp and Thomas (2009) confirm that finding a useable definition for teacher identity is extremely difficult, we use the definition provided by Beijaard, Meijer, and Vermunt (2004, 108):

> Professional identity refers not only to the influence of the conceptions and expectations of other people, including broadly accepted images in society about what a teacher should know and do, but also to what teachers themselves find important in their

> professional work and lives based on both their experiences in practice and their personal backgrounds.

Of particular relevance to this study is the duality of this definition which speaks on the one hand of what society expects of teachers in terms of their knowledge and actions, and on the other hand the teachers' own perceptions in terms of their experience and practice. This study holds the one up against the other in so much as expectations of the knowledge and skills of the participants are juxtaposed with their own perceptions of their knowledge and skills.

Lutovac and Kaasila (2018, 3) speak of "the vast body of research [that] has demonstrated great differences between the identities of specialist and non-specialist mathematics teachers" and therefore they prefer to use a more general term: "mathematics-related teacher identity." While the term professional mathematics teacher identity (PMTI) has been defined as applying to people who have been specifically trained to be mathematics teachers (Lutovac and Kaasila 2018; Skott 2019; van Putten 2011), MTI involves people who teach mathematics but are not qualified mathematics teachers (van Putten 2011), and it is this identity that is the focus of this study.

Spaull's (2013) statement was borne in mind when the research question was being developed for this study: Did the teachers know what they knew in terms of what they were teaching and how they taught it? The resultant research question in this study is, therefore: Do non-specialist mathematics teachers understand their instructional and pedagogical practices? In this study, subject knowledge and didactical expertise are related to two aspects of professional teacher identity (PTI) as described in the seminal work by Beijaard, Verloop, and Vermunt (2000), who established a three-factor model for PTI: subject expertise, didactical (teaching and learning) expertise, and pedagogical expertise (nurturing or caring). Our research question thus relates to the first two aspects of Beijaard, Verloop, and Vermunt's (2000) model in terms of the practice of non-specialist mathematics teachers in a developing context such as South Africa

Currently, there is a paucity of research in the area of non-specialist primary mathematics teachers (Bosse and Törner 2015; Du Plessis 2020; Lane and Ríordáin 2020) as well as in current interventions to assist non-specialist mathematics teachers in upskilling themselves to improve their practice (Bosse and Törner 2019; Du Plessis 2018). Hobbs and Törner (2019) emphasise the need for research in specific contexts, since school systems are different and the potential responses to the dilemmas associated with the non-specialist teaching can be very different.

In this study, the narratives of three grade 6 non-specialist mathematics teachers were explored in an attempt to describe their MTI as per the research focus of PTI described by Beijaard, Meijer, and Verloop (2004).

Literature Review

Non-Specialist Teaching in Mathematics

Non-specialist mathematics teaching means that teachers teach mathematics outside their field of qualification or expertise (Hobbs and Törner 2019). In the past decade, there has been increased focus on the development of non-specialised mathematics teachers because of the increased prevalence of such teachers on a worldwide scale (Goos et al. 2020; Ntow and Adler 2019), for example, in Germany (Bosse and Törner 2015), Ireland (Ríordáin, Paolucci, and O'Dwyer 2017; Lane and Ríordáin 2020), Nigeria (Aina 2016; Kola and Sunday 2015), the United States of America (Ingersoll 2001a), Western Australia, (McConney and Price 2009), and England (Crisan and Rodd 2017). All of these studies seem to be driven by the general emphasis on improving teacher quality, with a specific focus on improving STEM education (Du Plessis 2020; Hobbs and Törner 2019; Lane and Ríordáin 2020). However, scant attention is paid to primary school teachers in these studies and a limited number of studies actually focus on the identity development of non-specialist mathematics teachers in developing contexts. In this regard, our study aimed not only to provide some insight into the teacher identity of practicing non-specialist primary mathematics teachers in a developing context, but to promote research into this field with a view to ameliorating the classroom practice of such teachers.

There is a saying that primary school teachers are didacticians and know how to teach children while secondary school teachers are content specialists and know how to teach subjects (Rollnick and Mavhunga 2016). This statement may be interpreted as signifying that any qualified teacher can teach any subject in a primary school, but high schools need subject specialist teachers. However, this is an impoverished view often held by school management when appointing non-specialist teachers (Du Plessis 2018), despite the requirements in such publications as the *South African Norms and Standards* for teachers (RSA2000) and international research (Ball, Thames, and Phelps 2008; Beijaard, Verloop, and Vermunt 2000; Hill et al. 2008; Rollnick and Mavhunga 2016; Van Zoest and Bohl 2005; Williams 2008). Nevertheless, there is little literary evidence in the available research (Crisan and Rodd 2017; Goos et al. 2020) or government documentation to indicate how non-specialist primary mathematics teachers could be supported when appointed in these positions. Non-specialist teaching occurs mostly in public schools in South Africa (Long and Wendt 2020; Steyn and Du Plessis 2007).

General findings from international studies suggest that non-specialist mathematics teachers lack the mathematical didactical expertise to plan and deliver effective and engaging lessons (Hobbs and Törner 2019; Lane and Ríordáin 2020). Other studies show that non-specialist teachers experience mathematics anxiety and lack confidence because of their own inadequate learning of mathematics and how to teach it (Lane and Ríordáin 2020; Ross et al. 1999). Non-specialist teachers tend to rely heavily on teaching rigidly from a textbook and are therefore unable to use practical examples or manipulatives while struggling to deliver interesting and relevant mathematics lessons

(Donaldson 2012). Donaldson speculates that this may be the result of non-specialist teachers' view of mathematics as a set of rules to be memorised and a combination of procedures to be followed. The implication is that teaching for conceptual understanding does not occur, and so non-specialists are unlikely to produce confident learners in mathematics. In this way, both teaching and learning are detrimentally affected, resulting in poor learner achievement (Caldis 2017; Hobbs 2013; Ingersoll 2001b; Kola and Sunday 2015; Ríordáin, Paolucci, and O'Dwyer 2017).

To support non-specialist mathematics teachers, Lane and Ríordáin (2020) suggest that professional development opportunities for these teachers need to involve not only the development and modification of their didactical skills, but also of their beliefs, motivation, and confidence, thus, in effect, their MTI. Bosse (2014) adds that non-specialist teachers should be encouraged to participate in developmental activities that focus on self-reflection to help them reflect on their own practices.

Mathematics Teacher Identity

There have been many attempts at defining PTI (Beijaard, Chong, and Low 2009; Day et al. 2006; Flores and Day 2006; Hsieh 2010; Rodgers and Scott 2008; Vloet and Van Swet 2010), but principally PTI is described as a dynamic process involving construction and reconstruction of identity through practice, beliefs, emotions, relationships, contexts, and experiences. Professional mathematics teacher identity (PMTI) is subsumed in PTI, as it refers to a narrowing of the concept of PTI to focus on the professional identity of teachers of mathematics (van Putten 2011). Pausigere (2015) specifically defines PMTI as a way of talking about how trained mathematics teachers know and name themselves relating to the subject (mathematics) and its corresponding activities. The non-specialist mathematics teachers in this study are not professionally qualified mathematics teachers, therefore we investigated their MTI.

There is an interconnectedness between mathematics teachers' identity and their practices (Beijaard, Meijer, and Vermunt 2004; Lutovic and Kaasila 2018; van Zoest and Bohl 2005). Yazan and Peercy (2016) see teacher identity as a framework for self-reflection and the revisitation of classroom practice. The concern pointed out by du Plessis (2018, 7) is that "unsuitably qualified teachers in STEM subject areas find it difficult to critically reflect on the purpose, context, and knowledge base of science and related fields and thus find it difficult to implement the essential pedagogical skills necessary to effectively teach the specific content."

We argue that self-reflection is an intrinsic part of MTI development and that without such reflection, non-specialist teachers may not perceive their classroom practice as it really is. By implication, then, the non-reflective non-specialist teacher may think that all is well in their teaching, when it is not. Our argument is corroborated by Jansen (2001), who found that PTI also includes the ways in which teachers understand their ability to teach in view of their levels of training, preparation, and formal qualifications, so in the absence of subject training it is not unlikely that non-specialist teachers may

lack these ways of understanding and thus may not recognise the shortcomings in their ability to teach. In this study, it is this understanding and their perceptions about their teaching that were investigated.

Methodology

This was an interpretive and explorative study involving three non-specialist mathematics teachers in South Africa. Grade 6 teachers were purposefully chosen as the sample for this study because this is the final grade in the Intermediate Phase (grades 4–6) and is foundational to mathematics in the Senior Phase (lower-secondary school level). Non-specialist grade 6 mathematics teachers in public township schools outside Johannesburg were approached. The teachers were generally reluctant to participate in this study because, as some explained, they did not have job security and were afraid that the findings of this study could be detrimental to their continued employment. Participants were assured of anonymity and rigorous adherence to ethical principles; finally, three willing non-specialist mathematics teachers were selected. Their schools were situated in low socio-economic areas, with limited access to teaching and learning resources. Class sizes in the selected schools ranged from 50–64 learners per class.

Data were collected using semi-structured interviews, lesson observations, and document analysis. Firstly, a semi-structured interview was conducted with each teacher, utilising open-ended questions that were structured according to the conceptual framework. The interviews were tape-recorded and transcribed for analysis purposes. Secondly, two lessons were observed per teacher. Field notes were kept during the observations. The lesson observations were conducted and videotaped during class time as per the school timetable. The three teachers each taught different mathematical concepts. In their classroom practice, we observed their MTI actualisation in terms of subject knowledge and didactical skill. We explored their abilities to explain concepts adequately and explicitly, if and how they implemented multiple teaching strategies and approaches to meet learners' diverse needs, and if and how they used questions to gauge learners' understanding. We also took note of their flexibility or rigidity in teaching. Lastly, the lesson plans of the observed lessons were analysed in order to gain a deeper understanding of the participants' pedagogical reasoning.

The data were analysed deductively and inductively, using themes from the conceptual framework as an organising structure. The themes that emerged from the interview transcriptions were triangulated through the lesson observation field notes and lesson plan analysis, thereby enhancing trustworthiness. Member checking to confirm the results was conducted with the participants in order to enhance the credibility and dependability of the interpretations. Finally, an audit trail was maintained as a measure to enhance the confirmability and dependability of the interpretations. The final emergent themes were grouped into categories under the following headings: teaching and learning expertise, subject expertise, and characteristics of non-specialist mathematics teachers.

Findings

The participants are referred to by the pseudonyms Given, Thato, and Musa. Given and Thato each have a Bachelor of Education in Further Education and Training degree (grades 10–12) in economics management and sciences. Given taught economics at secondary school level, but was forced to take up employment in a primary school when he was redeployed. Thato had never taught at a secondary school, despite the fact that he was qualified to teach accounting at secondary school level. He explained that he felt that he had a mathematics background because he had done mathematics as a learner himself up to grade 12 level. Musa is qualified to teach English and Afrikaans in the Senior Phase (grades 7–9). He described his background in mathematics as follows: "I grew up in a family where they were selling tomatoes, so my experience started there. That's why when they said they wanted a maths teacher, I jumped and said I am available, I can teach mathematics." The participants were therefore teaching a subject for which they had no qualifications in a grade for which they were not trained. They were thus fully compliant with Hobbs and Törner's (2019) definition of non-specialist teachers as teaching outside of their expertise in terms of both subject and grade level.

Teaching and Learning Expertise

In the semi-structured interviews, the participants described their teaching in terms of the different teaching strategies and approaches that they applied in their mathematics classroom. They were asked how they ensured effective learning in terms of content, accommodation of the diverse needs of the learners, and creation of learning opportunities. A common thread in all three interviews was the dominance of a teacher-centred approach. They explained that this approach was necessary because of the number of learners in the classroom, time limitations in the curriculum, and a lack of manipulatives.

When asked about his preferred teaching strategy, Given said, "Textbook teaching method [is] basically the method I am using." He expanded on this as follows: "Question and answer method, I will say I prefer that method because when you teach you start providing the background, baseline questions, we normally call that. That is where I involve them in question and answer. After introducing a lesson. After that now when I introduce my concept … that's when I will start involving my narrative method to explain. The narrative method that is when now explanation takes place. After narrative method, I will go back to question and answer." Musa used general questioning to find what the learners did not understand: "I just ask questions because since we have a limited time of teaching, I just make sure I asked them questions generally so that I can be able to know what the difficult part of what they were doing is [*sic*]."

When asked whether they sometimes used an alternative method to teach, two of the teachers maintained that teacher-centred teaching was their method of choice. Musa explained that sometimes he allowed the learners to work in groups. All three teachers indicated their awareness of different teaching approaches, but declared unequivocally

that they were unable to implement these in their classrooms because of overcrowding, the fullness of the curriculum, and a lack of facilities. They insisted, however, that they tried to interact with the learners and that they even tried to involve them in group activities. The quotes below reflect intention, if not necessarily action.

> Given: [I try] by engaging learners in group discussion and helping them or monitoring them when they are discussing something.
>
> Thato: After the narrative method, I will go back to question and answer then from there peer grouping. They start doing the questions in groups … I alternatively use different methods, question and answer, and then grouping peers … I involve them, they come on the chalkboard to write questions or maybe answers.
>
> Musa: Although it's difficult ... I am just trying sometimes. I put them in groups … I just make sure that they just sit as they are arranged … space is a problem. [There are] learners who cannot participate very well and there are a lot of desks, you know, tables and those lot of things, it will be time-consuming because of overcrowding.

The teachers were asked how they tried to meet the diverse needs of their learners and they uniformly referred to language problems because of learners in each class speaking any one of the nine official South African languages. Thato explained as follows: "I explain in English and I also put it in Zulu and then let them explain to those who do not understand, particularly the Venda and Tsonga." Musa described his strategy as follows: "Most of the time I use English because of the … different cultures ... In fact, I encourage them to interact with one another … I want them to share … you may find that I have put a Zulu learner and Pedi learner [at a] table so that they can interact." Given was the only teacher who specifically assisted learners with difficulties:

> I give fast learners extra work to do and give slow learners extra time to do their work and complete it. Within a period, I make sure I sit with the slow learners to teach them at least five minutes. I show them how to do the work step by step. Sometimes after school, we remain and redo the work we were doing during the lesson. The clever ones, normally when I give them classwork, I will give them more work to do that they can be busy with something when I am busy with the slower ones.

Thus, in terms of teaching strategies, only two came up in discussion: direct instruction and group work, both of which were claimed by all three participants to be part of their teaching practice. However, in the two lessons observed per participant, only direct instruction was used. Also, in the interviews as well as during the observations, the strategy used to meet learners' needs was mainly language-related, involving code switching, while only one participant indicated that he devoted individual time to struggling learners. In the interviews, the participants indicated that they deliberately set out to help learners apply mathematics to real-life situations, but this strategy was not seen in either the observed lessons or the lesson plans and assessments that were analysed.

All the classes' seating arrangements facilitated teacher-centredness, but did not facilitate cooperative learning. The learners sat in pairs facing the chalkboard, not in groups, answered questions individually, and wrote answers in their books. Most often the teachers posed lower-order questions. The learners passively received knowledge from the teacher as they listened and did what they were told. Learning did occur, but only by memorising rules and procedures.

Subject Expertise

The lesson plans and assessment strategies, both formal and informal, were investigated. In the interviews, the teachers indicated that their lesson plans were provided by the Department of Education and could be downloaded from the website, with the advantage that these lesson plans were more or less guaranteed to be compliant with the national curriculum (CAPS). They also explained that they adapted these lesson plans in order to meet their learners' needs and the specifics of their teaching environment:

> Given: The lessons are planned by the Department, I do some alteration. I just download them from the internet from the Department of Education website and do some changes to the lesson plan to suit the needs of my learners and my needs as well, but aligned with CAPS.
>
> Thato: We normally download lesson plans, but it depends, if you go to the internet and you find that the lesson plan has been set is of poor quality, we look at what is best from the lesson plans from the internet.
>
> Musa: We are provided with the lesson plans that are prepared by the Department of Education, but I don't use that lesson as it is, there is where I add my own things in order for the learners to be able to understand what I am teaching them.

However, in analysing their written lesson plans for the observed lessons, it was found that they did in fact not do any alterations on the lessons plans provided by the Department of Education. In class, the participants relied heavily on the supplied lesson plans and the textbook. One of Musa's observed lessons was planned by him, but he did not follow the CAPS prescriptions and did not include the necessary content as per the grade 6 curriculum.

According to the Intermediate Phase Mathematics CAPS document, the purpose of assessment is to continuously collect information about the learners' understanding in order to improve teaching and learning. When they were asked how they determined their learners' understanding of the content being taught, the participants indicated that they used both formal and informal assessment. All the observed lessons were concluded by giving learners a class or home activity, thus informal assessment. Given said that this strategy helped him to find out whether the learners had understood the work. Thato also referred to homework, but added projects and assignments which were done in class. Musa described his strategy in this regard as follows:

> I give them classwork, sometimes I write problems on the chalkboard, and divide the chalkboard and I call them in groups of eight, they work on the problem given … and that's when I am going to understand if they got it clearly.

Formal assessments were usually created using previous provincial tests, by referring to the textbook, or by consulting the CAPS document. Although Musa indicated that he tried to follow the precepts of Bloom's taxonomy in drawing up a test, the analysis of the tests showed that he and the other participants relied largely on previous papers. All three avoided problem-solving questions in their formal assessments and posed most of their questions on the lower cognitive levels in the CAPS document: straightforward knowledge and routine procedures.

The lesson observations revealed that there were concerns regarding the actual subject matter that was taught. All three teachers relied heavily on the textbook to explain concepts, but even then they did not always explain concepts correctly. For example, Given referred to quadrilaterals in general as parallelograms, and did not explain obtuse angles correctly. He also referred to a trapezium as a rhombus. He seemed unable to describe the differences between a rhombus and a parallelogram. Thato seemed unable to explain what division was, and instead gave the learners an example of how to divide. Musa could not explain the differences between 2-D shapes and 3-D objects, and muddled the definitions of faces, edges, and vertices. He also consistently confused rectangular prisms with pyramids and explained, for example, that a rectangular prism was made up of two rectangles and two triangles. Thato, however, did not make any content mistakes in the two lessons that were observed.

Despite these concerns, the participants were confident in their mastery and their teaching of the subject and spoke of their love and enjoyment of mathematics:

> Given: I enjoy teaching mathematics, [it] is one of the subjects I feel comfortable when teaching. I love it, basically.

> Thato: Mathematics, I love it. It starts from within. I love maths because it is practical, because … I … am having maths inside me.

> Musa: Maths is the subject that I like the most.

Since lesson plans were provided by the education department, the teachers completely abandoned lesson planning. Nevertheless, during the observed lessons there was no evidence of attempts to follow the instructions on the provided lesson plans, such as how to achieve the required learning outcomes, that an introduction was necessary to begin the lesson, how the relevant concepts should be explained, and which teaching strategies and approaches were suggested to be used.

The use of past test question papers and exam papers did not help them to improve their own assessments because they only felt comfortable posing questions involving the first

two cognitive levels rather than all four. There may be several reasons for this: the teachers experienced anxiety because of their own inability to solve the problem-solving questions; they had never done such questions with the learners in class or in informal assessments; and they were determined to choose only questions with which the learners were familiar and could confidently solve.

Discussion

During the inductive analysis of the interviews one theme was predominant: the characteristics of non-specialist mathematics teachers. Two categories were created for this thematic analysis: subject matter knowledge and teaching knowledge.

Subject Matter Knowledge

Musa indicated that teaching mathematics is difficult, but whenever he encounters difficulty, he seeks assistance from other mathematics teachers. This was seen during the lesson observation. Given stated that he does not experience any difficulties in teaching mathematics, although this contradicts what was observed during the lesson presentation. This study revealed that the participants lacked conceptual understanding of the mathematics concepts they were teaching and struggled with explaining them effectively to the learners in order for them to build conceptual understanding.

Teaching Knowledge

The participants indicated that they want learners to develop mathematical problem-solving skills and be able to apply this knowledge in real-life situations. However, they were unable to employ instructional strategies and representations that encourage classroom discussions, critical thinking, and problem-solving skills.

In the interviews, the participants acknowledged that their classrooms were predominantly teacher-centred because of overcrowding, time constraints within the CAPS requirements, and limited resources. In a developing context, non-specialist teachers are not only faced with the challenges of poor mathematical content knowledge and limited experience in implementing effective teaching strategies, but they are also expected to manage challenging learning environments (Venter and Viljoen 2020).

The participants emphasised the complexity of the diversity of languages in the classroom. Code switching was mentioned as the solution of choice. Other pedagogical strategies such as the effective use of manipulatives or different forms of representation were not mentioned. We speculate that these, and possibly other non-specialist teachers, might have limited exposure to manipulatives or are not aware of the functional value of manipulatives in the mathematics classroom, and instead, adhere closely to the textbook and drilling. The result is an impoverished classroom in terms of Kelly's (2006, 186) description of the effective mathematics classroom: "In other words, the mathematics would optimally gain fluency and flexibility and, at the same time,

automaticity, with less traditional drill" while using a manipulative provides for learners "the moment of enlightenment in their mathematics learning because they are actually able to see and touch 'the problem' while associating the 'model' with the numbers" (187).

No professional development opportunities focusing on pedagogical strategies to specifically improve the teaching of mathematics had been offered to these teachers. This was the case despite the fact that there are several resources available to non-specialists mathematics teachers, even in rural areas, to help them improve their subject knowledge and teaching skills, such as collaboration with other teachers and district math specialists, online resources (connectedness was a constraint), textbooks, worksheets (Ivanova and Skara-Mincāne 2016; Richter et al. 2014), and in-service professional programmes (Crisan and Rodd 2017; Faulkner 2019; Goos and Guerin 2022; Goos et al. 2021). The participants declared that they relied solely on textbooks as a teaching and learning resource, and that, while they knew of other resources, these were not promoted by their schools. Non-specialist teachers should be supported not only in terms of the subject knowledge they might lack, but also in terms of how they plan and deliver effective lessons within restricted and constrained learning environments.

The participants in this study declared their dependence on textbooks, both in the classroom and when it came to creating assessments. It was evident that they only taught content as it was represented in the textbooks, without striving for conceptual understanding of mathematical concepts and procedures. Nevertheless, they claimed that they used other strategies periodically, particularly group work, to increase interaction with and amongst the learners, but this was not observed. We speculate that their slavish adherence to textbooks may well derive from their own learning, which was entirely textbook based and self-taught in the absence of professional educators in this field. Maxwell (2001, 35) also speaks of teachers who feel threatened by the complexity of mathematics and therefore "clutch at textbooks for survival purposes."

According to the literature, non-specialist secondary mathematics teachers have been found to be rigid in their classroom practice and generally unable to adapt content to the specific needs of a particular set of learners (Lane and Ríordáin 2020; Goos et al. 2020; Ríordáin, Paolucci, and O'Dwyer 2017). In this study, the lesson observations confirmed that the preferred modus was direct instruction with teacher-centred activities. Frequent content mistakes were made and the teachers themselves were confused about some of the concepts they were teaching. They rarely attempted to develop their own lesson plans and formal assessments, and posed only lower order questions. This study confirms what several authors have said: non-specialist teachers lack in-depth subject matter knowledge and didactical skills (Du Plessis 2019; Hobbs and Törner 2019; Lane and Ríordáin 2020; Ríordáin et al. 2022). They rely on textbooks while teaching and are unable to use the various teaching strategies and approaches for the development of conceptual understanding of mathematical concept taught. They

also struggle to plan their own lessons and construct good assessments. As a result, they have a negative impact on learners' mathematics performance.

According to Reys and Fennell (2003), mathematics specialist teachers have in-depth mathematics content knowledge, know how learners learn mathematics, and can employ instructional and assessment strategies that assist learners develop conceptual understanding. In addition, they know how to plan lessons, how to teach mathematics applying different teaching strategies to accommodate the diverse needs of learners, how to use mathematics manipulatives for effective teaching and learning, and how to assess the learners' knowledge and understanding of the content being taught. They encourage learners to participate in classroom discussions in order to improve learners' conceptual understanding, critical thinking and problem-solving skills (Junqueiraa and Nolanb 2016; Swars et al. 2016).

Finally, previous findings have reported that non-specialist mathematics teachers often have lower levels of confidence and may be subject to mathematical anxiety (Donaldson 2012; Lane and Ríordáin 2020; Ross et al. 1999). However, the three participants were confident in their teaching and repeatedly confirmed their love of mathematics and their enjoyment in teaching it. In fact, there was no evidence of a lack of confidence. We ascribe this to the underdevelopment of self-reflection skills which characterises the non-specialist mathematics teacher's practice (Du Plessis 2018; Lutovic and Kaasila 2018, van Zoest and Bohl 2005; Yazan and Peercy 2016). Self-reflection is an intrinsic part of MTI development (Lane and Ríordáin 2020); without such reflection, the non-specialist teachers may not be aware of their classroom practice as it really is. By implication, then, non-specialist teachers may think that all is well in their teaching when it is not.

Although Graven (2004) sees confidence as a natural outflow of certainty in teaching and learning mathematics, it was clear that the participants did not really have an understanding of the curriculum content structure, nor did they have sufficient knowledge of teaching approaches to support student learning of a coherent conceptual narrative (Hobbs and Torner 2019).

Conclusion

During the course of this study, the incongruence between the interview information and the documents and observed lessons became clear. We posit that the discrepancy between the teachers' perceptions of their MTI in terms of subject and didactical expertise, and how those two areas of expertise are actualised in the classroom is the result of poor reflective skills. In the introduction to this article we indicated that our main research question was whether the non-specialist mathematics teachers understood their instructional and pedagogical practices. Our findings show that they did not. They struggled to effectively plan and present the lessons, assess the learners conceptual understanding on four cognitive levels, and use different teaching strategies to

accommodate the diverse needs of learners. These teachers made content mistakes, and were unable to present the content in a way that was learner-centred, stimulating, and curricularly salient, but their self-perceptions did not reveal an awareness of these issues. Nor were they aware of the value or even the existence of manipulatives, didactical strategies that promote mathematical understanding and the national imperative to teach for conceptual understanding. We conclude that metacognition in this regard was lacking according to the link described by Salam et al. (2020) as existing between the person's awareness of what they knows and their awareness of what they do. In fact, Misu et al. (2019) found that a direct link exists between metacognition and understanding a mathematical concept.

It is nevertheless important to remember that all three participants were in fact trained as teachers, albeit not as mathematics teachers. This study points to a direct link between insufficient subject knowledge and teaching skills, which may in fact be present, but do not come to the fore. Therefore, their MTI in terms of Beijaard, Verloop, and Vermunt's PTI model (2000), presents as severely lacking in the subject knowledge aspect, as might have been expected, but also as lacking in the teaching and learning (didactics) aspect, despite their training as teachers. For these three teachers, it was found that inadequate subject matter knowledge correlated with ineffective teaching. It is apparent that being a qualified teacher does not guarantee that one can teach *any* subject effectively. Thus appointing non-specialist teachers has a two-fold impact: they do not know, and they cannot teach. Unfortunately, it is not a simple matter of removing these teachers from their classrooms, because, as William (2017) notes, you need to replace the teachers you deselect with better ones.

A better solution would be to design in-service training that focuses intensively on mathematical and didactical knowledge, with a mentorship programme that provides guidance in the development of reflective skills. It may be that prior education and teaching skills will then manifest in the classroom. Further research in the South African setting should be conducted to investigate the instructional and pedagogical practices of non-specialist mathematics teachers after in-service professional development training.

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