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# Investigating mathematics teacher identity development: A theoretical consideration

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*The paper discusses a theoretical framework for investigating the process of becoming a mathematics teacher, based on the need to better understand how mathematics and teaching combine in developing mathematics teacher identities. Identity is understood as a function of participation in and at the boundaries of various communities of practice, during university teacher education and at school. In order to reveal possible relationships between developing teacher identities and the discipline of mathematics, teachers' changing concept images of mathematics are embedded within the definition of identity.*

**Key words:** Identity, identity development, transition, situated concept images.

## INTRODUCTION

Becoming a secondary school mathematics teacher can be described as a role change, as one goes from being a university student who is learning and knowing mathematics for oneself, to becoming a mathematics teacher in school and being able to enable others to know it (Rowland, Huckstep, & Thwaites, 2005). It is about carving out a space for one's identity as a mathematics teacher (Alsop, 2006), as one is negotiating shifting conceptions of what mathematics teaching is or should be (Beauchamp & Thomas, 2009). In parallel with undergoing the transition from university teacher education to a professional debut in school, the character of the mathematics content is changing. It goes from being a scientific discipline represented by the discourse taking place between mathematicians and mathematics students at the university, to becoming a school subject as part of general education, preparation for everyday life and as a basis for higher education. Hence, the process of becoming a mathematics teacher is concerned with both; changes in practices and changes in the mathematics content.

The purpose of this paper is to understand better how mathematics and teaching combine in teachers' development of identities (Adler, Ball, Krainer, Lin, & Novotná, 2005). From research on mathematics teacher education, there is known a great deal about some of the specialty of mathematics teachers' knowledge (e.g., Ball, Lubienski, & Mewborn, 2001) and their beliefs (Phillip, 2007). However, there is a need to understand better the dynamics of mathematics teachers' learning, as they move across different practices in university and school and unite their experiences into a role as a professional teacher. According to Lerman (2000), this requires an extension of the unit of analysis from concerning the individual mathematics teacher, her mathematical knowledge and beliefs, to also including the social practices in which the teacher participates. In order to study how learning takes place within and across practices and institutions, I present a theoretical framework for investigating how prospective mathematics teachers make sense of undergoing the transition between university teacher education and school. Learning is here understood as identity development, when a person participates within and at the boundaries of communities of practice (Wenger, 1998). Further, I assume that the discipline of mathematics is a distinguishing characteristic of the learning context, meaning that the nature of practices of mathematics is fundamentally different from other disciplines. Consequently, developing an identity as a mathematics teacher is different from developing a teacher identity in other subjects.

In order to study identity development through the profession of a secondary school mathematics teacher, I offer for critique a situated understanding of teachers' concept images in mathematics as being part of their professional identity and development. The framework is used in a longitudinal interview study of a group of prospective secondary school mathematics teachers' accounts of their ongoing transition

into the mathematics teacher profession. It is based on the assumption that the teachers' accounts provide a window into the sort of learning they can experience as they move from one setting into another (Jansen, Herbel-Eisenmann, & Smith III, 2012). Embedded in the learning process are the teachers' situated concept images in mathematics. Hence, the focus of the study is the teachers' meaning making when participating in different communities of practice, rather than identifying possible impact from communities on their concept images.

### **OUTLINING A FRAMEWORK FOR INVESTIGATING MATHEMATICS TEACHER IDENTITY**

Identity in teaching has been explored from a range of theoretical approaches (Beauchamp & Thomas, 2009). It spans from categorising aspects of teacher identity in order to better understand and describe it and possible influences on teachers and their practice, to viewing identity as a function of participation in different communities (Wenger, 1998). The latter is in line with what Lerman (2000) has denoted as the *social turn* in mathematics education research, identified by the rise of theories viewing learning as participation in practices rather than as acquisition of new knowledge structures or beliefs. Following Wenger (1998), identity develops through "negotiated experiences of self" (p. 150), as a person interacts with others and regulate her participation according to the reactions of others to her. In other words, mathematics teacher identities exist both in teachers and in their relations with others (Ponte & Chapman, 2008). Consequently, mathematics teaching can be considered a complex personal and social set of embedded processes and practices that concern the whole person (Olsen, 2008).

Wenger's (1998) theorisation of identity in communities of practice enables me to study individual mathematics teachers through their social settings. Hence, the primary unit of analysis is neither the individual mathematics teacher, nor the learning communities in the transition from university teacher education to school, but instead the teacher-in-the-learning-community-in-the-teacher (Graven & Lerman, 2003; Lerman, 2000). The first part, teacher-in-the-learning-community, acknowledges that the object of study is more than individual cognition and affect, because learning is the development of modes of participating with others in society. The second part, learning-com-

munity-in-the-teacher, implies that participation develops identity in such a way that the practice becomes part of the individual. In other words, the focus is neither directed towards categories of mathematics teacher knowledge, nor is it directed towards measures of teachers' mathematical knowledge for teaching. Instead, I study mathematics teachers' developing sense-making of mathematics and mathematics teaching in light of their experience of participating within and at the boundaries of communities of practice in university and school.

In the following, I will present a framework that allows me to change the focus on the object of study, by placing respectively the collective and the individual in the foreground (Palmér, 2013b). With the collective in the foreground, I am interested in the mathematics teachers' community memberships in terms of modes of belonging: engagement, imagination and alignment (Wenger, 1998). Further, becoming a mathematics teacher is about reconciling various memberships across communities, and consequently, trying to establish continuity across community boundaries. By placing the individual in the foreground, I assume that when a teacher is stepping into a practice, the teacher is somehow changed. By orienting towards the practice, taking up new practices or marking a distance towards it, the teacher consequently develops new understandings of herself as a learner and doer of mathematics and mathematics teaching.

Wenger (1998) provides a general theorisation of learning and a superior framework for this paper, and I will in the following section elaborate on an understanding of mathematics teacher learning within and between communities of practice. In order to adapt the framework to *mathematics* teacher identities, I will argue for the necessity of combining Wenger's notion of identity with a situated understanding of Tall and Vinner's (1981) definition of concept image. This is built upon a sociocultural understanding of concept images (Bingolbali & Monaghan, 2008), and its compatibility with Wenger's concept of reification.

### **MATHEMATICS TEACHER LEARNING WITHIN AND BETWEEN COMMUNITIES OF PRACTICE**

Based on the assumption that learning is located in the relationship between a person and the world in which the person participates, Wenger (1998, 2010) considers meaning making as a dual process. On the

one hand, a person engages in different forms of *participation*, referring to the social experience of living in the world in terms of membership in social communities and active involvement in social enterprises. On the other hand, *reification* accounts for the way in which a person of a community builds her own meaning for her participation. For Wenger (1998), reification and participation are viewed as complementary concepts naming the process whereby individual and community experiences are shared and lead to the production of shared ideas and concepts. A mathematics teacher's identity can therefore be understood as the intersection of individual and social aspects of learning. Individual aspects represent who one is as a mathematics teacher due to one's knowledge and views about mathematics and mathematics teaching and learning. However, these individual aspects are continuously negotiated through the teacher's participation in different communities of practice.

For prospective mathematics teachers, learning can take place when they enter communities of practice during teacher training as peripheral participants and gradually develop as central participants (Lave & Wenger, 1991). A gradual change in participation, from the periphery towards the centre, can be described in terms of engagement, imagination and alignment (Wenger, 1998). Within the community, the prospective mathematics teacher *engages* with ideas about mathematics and mathematics teaching through engagement in communicative practice and develops the ideas through exercising *imagination*. Further, the prospective teacher *aligns* with conditions or characterisations of the practice. The term alignment has later been challenged by Jaworski (2006) in terms of *critical alignment*, a means of not just aligning with practice as established in the community, but of looking critically at that practice while aligning with it. The *boundary* of the community is constitutive of what counts as central participation and what does not. Other learning opportunities will therefore occur *at* the boundaries, as the mathematics teachers are exposed to foreign competences when they enter other communities in school and may try to create bridges across them and former communities (Wenger, 1998). I explore the transition between mathematics teacher education and the professional debut in school in terms of *boundary crossing*, as prospective mathematics teachers become participants in communities of practice in school and do the work of reconciliation of different forms of memberships in various

communities. Hence, different forms of knowledge and understanding of mathematics and mathematics teaching may coexist. Developing a mathematics teacher identity during boundary crossing is then about continuously synthesizing what counts as legitimate knowledge within various communities. Simultaneously, the teacher is striving towards continuity across boundaries by maintaining a sense of self through time (Abreu, Bishop, & Presmeg, 2002).

Wenger (1998) discusses how participation and reification have the potential to create continuities across boundaries in terms of brokering and boundary objects. *Brokering*, as participation across communities, is provided by people who can introduce elements of one practice into another. A prospective mathematics teacher may act as a broker when moving between communities in university and school, and bringing ideas of mathematics and mathematics teaching stated in teacher education into communities of mathematics teachers in school. However, acting as a broker is challenging and uncomfortable, since it requires enough legitimacy to influence the development of practice within a community, and enough courage to address conflicting interests. Hence, entering school as a novice mathematics teacher can be described as an experience of confrontations between own expectations about teaching and expectations stated by teacher education, students in the classroom and colleagues. Another dimension of continuities across boundaries is constituted by *boundary objects*, being reified connections between communities (Wenger, 1998). An example is the guidance paper that student teachers are supposed to write and submit to a teacher educator at the university and their tutor in school prior to their lessons during teacher training. The paper may act as a boundary object when it bridges views and knowledge of mathematics teaching in university with experiences of classroom practice in school.

In Akkerman and Bakker's (2011) review of research on literature on boundary crossing, boundaries are defined as "sociocultural differences leading to discontinuities in action and interaction" (p. 133). The definition highlights that boundaries are not about sociocultural differences per se. Instead, boundaries are "real in their consequences" (p. 152). Thus, unlike describing sociocultural differences in university and school, I am interested in how the differences play out in and are being shaped by the process of developing



mathematics teacher identities. By overcoming discontinuities, boundary crossing carries a potential to learn about practices and about one's own identity. Akkerman and Bakker (2011) present potential learning mechanisms that may occur when crossing boundaries, two of them concerning processes of making sense of practices in multiple contexts. *Identification* entails a renewed sense making of different practices and related identities, by encountering and reconstructing boundaries but not being able to overcome discontinuities. Learning in terms of *reflection* will result in an expanded set of perspectives and a new construction of identity, which in turn will have an impact on future practice. Here, reflection is the desirable learning outcome, when one is establishing continuity across boundaries by reconciling memberships across communities. For prospective mathematics teachers, crossing boundaries is both a valuable and a risky process. On the one hand, they are in a position to introduce elements of one practice into the other. On the other hand they face the risk of never fully belonging to or being acknowledged as a participant in any one practice.

### **MATHEMATICS TEACHER IDENTITY AND SITUATED CONCEPT IMAGES**

As have been emphasised by other researchers (e.g., Palmér, 2013a), Wenger (1998) does not focus specifically on mathematics education and mathematics teaching, but on learning in its broadest sense. Yet others have discussed the possibility of Wenger's framework to take into account the full spectrum of locations of cognitive development, from in-the-brain to socially dependent (Van Zoest & Bohl, 2008). In order to comply with this request, Van Zoest and Bohl (2008) combine Wenger's (1998) theory of communities of practice with Shulman's (1987) heuristic of teacher knowledge, and an understanding of knowledge and beliefs as cognitive in nature. However, unlike viewing identity as dynamic and in continuous development, they describe it as something the teachers "carry with themselves as they move from context to context" (Van Zoest & Bohl, 2008, p. 338). Consequently, their framework is not consistent with my investigation of how teachers make sense of their ongoing transition, due to their present situation of participating in communities of practice.

Taking a different theoretical approach, Palmér (2013a, 2013b) connects Wenger's notion of identity

with Skott's (2010) and Skott, Larsen and Østergaard's (2010; 2011) theory of patterns of participation. This is done in order to describe primary school mathematics teachers' professional identity development, "by including both the individual and the social parts of identity development" (Palmér, 2013a, p. 2851). Further, the theories are argued to be consistent within a situated learning perspective. However, in Palmér's (2013b) study of primary school mathematics teachers' way into their profession, the discipline of mathematics do not appear as a prominent part of the teachers' developing identities. Even so, I claim that prospective secondary school mathematics teachers need to some extent relate to and cope with mathematics both during university studies and in their profession. Hence, there is a need for developing an analytic tool which makes the mathematics within the teacher identity more visible. Inspired by Bingolbali and Monaghan (2008), I consider the notion of concept image (Tall & Vinner, 1981) as being a helpful construct when placing the individual mathematics teacher in the foreground (Palmér, 2013b). Tall and Vinner (1981) describe *concept image* as the total cognitive structure associated with a concept in an individual's mind, which includes mental pictures, associated properties and processes, strings of words and symbols. Unlike a *concept's definition*, the concept image is dynamic and develops differently among persons and through a multitude of experiences. Although concept image and concept definition are terms originating from cognitive theories of learning and a focus on individual student mathematical constructions, Bingolbali and Monaghan (2008) argue that the dynamic nature of concept image is consistent with a sociocultural perspective on learning:

Indeed, the construct can be viewed in terms of Vygotsky's (1934/1986) *complexes*, a 'phase on the way to concept formation' (ibid, p. 112) and the original view of concept images as developing differentially over students through a multitude of experiences is essentially a contextual viewpoint. (p. 21)

Bingolbali and Monaghan (2008) base their argument on a study of undergraduate students' learning of the derivative, in which the context of learning is regarded as paramount. They found that students' developing concept images are closely related to teaching practices and departmental perspectives, respectively within mechanical engineering and mathematical

sciences. I will take a step further by claiming that the dynamic nature of concept image is compatible with a situated perspective on learning. According to Wenger (1998), different types of memberships in various communities entail opportunities and limitations for developing practice, which consequently affects a mathematics teacher's knowing. Hence, I assume that situated concept images in mathematics are embedded in a mathematics teacher identity. It is about knowing mathematics for oneself and for teaching, which is related to one's views and emotions about mathematics and mathematics teaching. Further, concept images are dynamic in the sense that they are negotiated through interaction with other participants within various communities of practice.

A further argument for the compatibility of Wenger's notion of identity and a situated understanding of concept images can be found by the term reification. As part of the negotiation of meaning, reification is a way of giving form to our experience "by producing objects that congeal this experience into 'thingness'" (Wenger, 1998, p. 58). Simultaneously, reification shapes our experience, since forming a certain understanding about a topic brings a new focus for negotiating meaning within a community, leading to new ways of reasoning or acting. Reification of practice can appear as abstractions, symbols, concepts and tools, and becoming a participant in a community is then about growing into the practice in which one engages, including its reifications. Regarding the prospective mathematics teacher, she takes up new practices in mathematics and mathematics teaching by participating in different communities of mathematics students at university, mathematics student teachers during teacher training and teacher colleagues at school. These practices include knowledge of mathematics concepts, skills, and beliefs about mathematics and mathematics teaching, which I further assume provide a basis for developing situated concept images in mathematics.

Nevertheless, reification in terms of situated concept images does not mean that they are simply objects of knowledge and beliefs in mathematics that teachers have or gain, but instead they are both "a process and its product" (Wenger, 1998, p. 60). In other words, a situated understanding of concept image highlights its location in social practices, being continuously negotiated through participation. Further, situated concept images are only "the tip of an iceberg" (Wenger,

1998, p. 61), being indications of larger contexts of meaning realised in human practices. This is in line with Tall and Vinner's (1981) notion of evoked concept images, which is the part of a person's memory evoked in a given context, and which is not necessarily all that a person knows about a certain topic or area. Hence, there is a problem of gaining insight into mathematics teachers' concept images. However, based on a longitudinal interview study, including interview tasks in mathematics, I gain insight into an ongoing process of identity development on given times and over a prolonged period of time. I am therefore able to describe the dynamic nature of mathematics teacher identities and associated concept images, not as objects within teachers, but as objectifications of ongoing processes (Palmér, 2013b).

Taking a situated perspective on concept images, they do not count for comparing a teacher's knowledge and/or beliefs before and after undergoing the transition between university and school. Instead, the underlying question is under which conditions successful participation in university communities facilitates successful participation in school communities (Greeno, 1997). This re-establishment of participation across settings may lead to experiences of discontinuities, e.g., experiences of shifts in practices of mathematics teaching and in the mathematics content. By overcoming them, boundary crossing carries a learning potential of developing one's identity as a mathematics teacher and consequently one's concept images in mathematics.

## FINAL REFLECTIONS

I have presented a framework for investigating teacher learning in the transition between university teacher education and the professional debut in school, using Wenger's (1998) theory of community of practice as a starting point. In addition to recognise the learning potential that resides within a community, the framework takes into account learning during boundary crossing, where reflection is the desirable learning outcome (Akkerman & Bakker, 2011). Developing an identity as a mathematics teacher is then about negotiating what counts as legitimate knowledge within various communities in university and school, comprising shifting conceptions of what mathematics teaching is or should be. Based on the assumption that the discipline of mathematics is a distinguishing characteristic of the learning context, I

have argued for the necessity of combining Wenger's notion of identity with a situated understanding of mathematics concept images. They are related to the teachers' knowledge and views about mathematics and mathematics teaching, and continuously negotiated through their participation in various communities of practice.

I take the mathematics teacher's perspective and investigate identity development based on how prospective mathematics teachers make sense of their ongoing transition between university and school. This meaning making is situated within a context, based on the teachers' participation in various communities of practice. Hence, the way the teacher looks back and reflects on being a student teacher in mathematics and a novice mathematics teacher in school, and how she discusses mathematics and mathematics problems, may change and develop due to her present situation. In addition, the teachers' accounts provide a means for them to create continuity across time, in terms of maintaining a sense of self. I thus assume that possible changes or development in the mathematics teachers' accounts constitutes evidence for their identity development, in which the teachers' situated concept images of mathematics are embedded.

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