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EXPLORING NUMERACY TEACHER IDENTITY: AN ADAPTATION OF VALSINER'S ZONE THEORY

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Abstract

Numeracy is identified in the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2012) as one of seven general capabilities that are to be developed across all curriculum areas, making the development of students' numeracy capabilities the responsibility of all teachers. As mathematics is the discipline that underpins numeracy, teachers must be able to identify the mathematics inherent in their own learning area and design appropriate learning activities in the context of this learning area. If they are to do this they must see themselves not only as teachers of their learning area but also as teachers of numeracy, in other words, develop an identity as a teacher of numeracy. An understanding of how teachers form and develop a numeracy teacher identity will assist in supporting them to develop effective strategies for numeracy learning in their learning area. This paper extends a framework for numeracy teacher identity (Bennison & Goos, 2013) developed through a literature review of teacher identity and explores how the development of numeracy teacher identity could be investigated empirically. The paper argues that an understanding of how the characteristics identified in the numeracy teacher identity framework interact and contribute to the development of numeracy teacher identity can be gained through a sociocultural approach that uses an adaptation of Valsiner's (1997) zone theory as the theoretical framework. The characteristics of the knowledge, affective, social and life history domains of the numeracy teacher identity framework are mapped onto the Zone of Proximal Development (ZPD), Zone of Free Movement (ZFM) and Zone of Promoted Action (ZPA). To illustrate how empirical data can be analysed through this theoretical framework two hypothetical case studies are described and the hypothetical data are mapped onto the ZPD, ZFM and ZPA to gain an understanding of each hypothetical teacher's numeracy teacher identity.

Introduction

Being numerate "empowers people by giving them the tools to think for themselves, to ask questions of experts and to confront authority" (Steen, 2001, p. 2). On the other hand low levels of numeracy have been linked to reduced rates of school completion (Palidarno, Hanel, & Buddelmeyer, 2012) and reduced workforce participation (Shomos, 2010). Evidence from international testing indicates that 16% of Australian 15 year olds do not meet internationally accepted minimum numeracy standards and that the problem is much worse for certain groups, such as those from low socioeconomic backgrounds, indigenous students, and students in remote areas (Thomson, de Bortoli, Nicholas, Hillman, & Buckley, 2011). Despite the importance placed on numeracy by the Australian Government, as demonstrated in policies and funding for more than ten years (Department of Education, Training, and Youth Affairs, 2000; Department of Employment, Education, Training, and Youth Affairs, 1997; Ministerial Council for Education, Early Childhood Development, and Youth Affairs, 2009a, 2009b; Ministerial Council on Education, Employment, Training, and Youth Affairs, 2008), results from international testing show that since 2003 there has been no significant improvement in the number of students reaching the minimum international standard and a significant decline in mean score achieved by Australian students (Thomson et al., 2011).

The *Melbourne Declaration on Educational Goals for Young Australians* (Ministerial Council on Education, Employment, Training, and Youth Affairs, 2008) sets out commitments by Federal and State Governments for schooling in the twenty-first century that include developing a world-class curriculum with a strong emphasis on literacy and numeracy. The Australian Curriculum that has been developed in response to the Melbourne Declaration identifies numeracy as one of seven general capabilities that should be developed across all curriculum areas (Australian Curriculum, Assessment,

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and Reporting Authority, 2012). This means that *all* teachers have a role in developing the numeracy capabilities of students. While this has been recognised for a long time in Australia (Council of Australian Governments, 2008; Department of Employment, Education, Training, and Youth Affairs, 1997; Thornton & Hogan, 2004), it remains problematic with a recent survey finding that 55% of beginning teachers from all disciplines felt that they were adequately prepared to teach numeracy (Milton, Rohl, & House, 2007). Although a similar study on practicing teachers does not appear to have been conducted there is no evidence to suggest that that the situation is different for this group. As mathematics is the discipline that underpins numeracy, this means that teachers must be able to recognise the mathematics inherent in a learning area and to use this mathematics confidently (Thornton & Hogan, 2004). In order to do this they need to see themselves not only as teachers of their own discipline but also as teachers of numeracy, in other words, develop an identity as a teacher of numeracy. Although interest in research into teacher identity has grown over the last decade there has not been any research that has focused on teacher identity in the context of teaching numeracy. This paper aims to extend a recently developed framework for numeracy teacher identity (Bennison & Goos, 2013) and propose a theoretical framework that can be used in empirical studies to analyse and compare case studies of individual teachers.

Defining numeracy teacher identity

Effective teachers need well-developed identities (Grootenboer & Zevenbergen, 2008), but investigating teacher identity is difficulty because of its complexity. Van Zoest and Bohl (2005) developed a comprehensive framework for mathematics teacher identity, but this is difficult to use in empirical studies that must focus on limited number of characteristics because of resourcing constraints. We recently developed a framework for numeracy teacher identity (Bennison and Goos, 2013) by drawing on Van Zoest and Bohl's framework and selecting characteristics from cognitive and social domains thought to be most relevant in the context of teachers developing the numeracy capabilities of students. This framework is arranged around four interconnected domains; a knowledge domain, an affective domain, a social domain, and a life history domain.

The knowledge domain includes mathematical content knowledge and pedagogical content knowledge. We argued that for numeracy teacher identity these are the two most relevant of the seven types of knowledge Shulman (1987) suggested were needed for teaching. However, if a teacher is to develop a numeracy teacher identity a third type of knowledge, knowledge of curriculum is also important. For each learning area in the Australian Curriculum the numeracy demands inherent in that learning area are identified with icons and online filters (e.g., Australian Curriculum, Assessment, and Reporting Authority, 2011); however an audit of the *Australian Curriculum: History* (Goos, Dole, & Geiger, 2012) identified numerous learning opportunities that were dependent on the teacher identifying them and choosing appropriate learning activities. Therefore teachers must be able to identify the mathematics inherent in the learning area (knowledge of curriculum), be able to use it confidently (mathematical content knowledge), and choose appropriate learning activities (pedagogical content knowledge) if they are to develop a strong numeracy teacher identity.

We did not explicitly deal with the life history domain but described it as influencing each of the other domains. The parts of a teacher's life history that are relevant to their numeracy teacher identity will include their experiences of school mathematics, their experiences during their university studies, and their teaching experience. For many school students their experiences of school mathematics resulted in them lacking confidence in mathematics, and failing to see any personal relevance in it (Council of Australian Governments, 2008). As a result they choose not to study mathematics beyond the middle years of school when it is compulsory and can even have developed a "general fear of contact with mathematics" (Hembree, 1990, p.45) – often called maths anxiety. Some of these students will enter pre-service teacher education to become primary teachers or teachers of disciplines other than mathematics. Whether future teachers have positive or negative experiences of school mathematics, characteristics of both the knowledge domain (mathematical content knowledge) and affective domain (confidence, beliefs) will be influenced by these experiences.

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Pre-service teacher education provides opportunities for teachers to develop pedagogical content knowledge and knowledge of curriculum in their chosen learning area, be that the primary school curriculum, mathematics or a discipline other than mathematics. Opportunities to develop mathematical content knowledge will only be available to specialist mathematics teachers and primary teachers. For primary teachers, developing mathematical content knowledge can be challenging as high levels of maths anxiety have been found among students preparing to teach at this level (Gresham, 2008; Hembree, 1990). In secondary schools in Australia one fifth of those teaching secondary mathematics have not studied mathematics beyond first year and one in six have not undertaken mathematics methods courses (Harris & Jensz, 2006). Although different differences exist for primary school teachers, mathematics teachers (those who are specialists and those who are teaching 'out of field') and teachers of disciplines other than mathematics, their life histories will influence the knowledge domain and the affective domain (confidence, beliefs).

Initial teaching experience will also shape a teacher's emerging identity as expectations of colleagues and workplace constraints can influence developing teacher identities (e.g., Beisiegel & Simmt, 2012). In secondary schools in Australia, where teachers tend to be grouped in departments structured around learning areas, this can lead to a view that the responsibility for numeracy lies with the mathematics department (Thornton & Hogan, 2004). The characteristics of numeracy teacher identity are summarised in Table 1.

Table 1 *Characteristics of Numeracy Teacher Identity*

Domains	Characteristics of numeracy teacher identity
Knowledge	Mathematics content knowledge
	Pedagogical content knowledge
	Knowledge of the Australian Curriculum
Affective	Confidence
	Beliefs
Social	School communities
	Professional communities
Life History	Past experiences of mathematics and teaching

The life history domain looks to what a teacher has experienced in the past. While this contributes to the teacher's current identity, identity is not static (Beijaard, Meijer, & Verloop, 2004). It is a negotiated experience as the teacher negotiates meaning through participation in various communities of practice (Lave & Wenger, 1991; Wenger, 1998). This process of negotiation involves learning that can take place though informal interactions with colleagues, participation in professional development activities and participation on research projects. However this learning will take place within constraints determined by the context in which the teacher works. Support or otherwise from school administrators and colleagues, curriculum requirements, and the nature of students will all influence whether and to what extent a teacher's practice is influenced by their learning.

A sociocultural perspective on learning

A theoretical framework through which to analyse numeracy teacher identity needs to incorporate both cognitive and social aspects. Although a range of perspectives have been used in research in mathematics teacher education, Lerman (2001) has argued that sociocultural perspectives provide an effective means of investigating the complexity associated with the developing identities of teachers. Although many researchers do not make their theoretical framework explicit, sociocultural approaches have been used previously in studies on pre-service teacher identity (see Ponte & Chapman, 2008 for a review of these studies).

One sociocultural approach that can be used for research on teacher identity is the theoretical framework developed by Valsiner (1997) to understand human development. Drawing on the work of

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Vygotsky and other psychologists, Valsiner viewed the process of development (or learning) as involving interpsychological processes that are followed by intrapsychological processes. The former occur as new ways of behaving appear as a result of interactions between an individual and their social context (microgenesis). The latter occur as these new ways of behaving become internalised (ontogenesis). To represent these interactions, Valsiner redefined Vygotsky's (1978) *Zone of Proximal Development* (ZPD) and defined two additional zones, the *Zone of Free Movement* (ZFM) and the *Zone of Promoted Action* (ZPA). For Valsiner, the ZPD is the *set of possibilities* that result from interactions between individuals, and their environment and the people in it. This zone depends on the knowledge and previous experience of the individual and includes consideration of developmental possibilities that may or may not occur. The ZFM is related to the individual's environment and includes the set of actions that the individual is *allowed* to perform, while the ZPA is the set of actions that are *promoted* by other individuals. As these two zones work together, Valsiner suggested that they be considered as a ZFM/ZPA complex. He described the three overlapping zones as "abstract organizational devices of a transient nature" (p. 188). As well as being dynamic, the content of each of the zones is not fully known at any particular moment and individuals are able to act as agents in their own development (e.g., by accepting or rejecting actions that are promoted). Therefore development can be directed (by structuring successive ZFM/ZPA complexes for the learner) but the outcome of the process cannot be determined, a process Valsiner describes as canalisation.

One way to represent the interactions between the ZPD, ZFM and ZPA is as three overlapping circles (e.g., Goos, 2008, 2009) as shown in Figure 1. According to Valsiner's theoretical framework learning can only occur if the actions that are being *promoted* (ZPA) are within the individual's *possibilities* for learning (ZPD), that is, their current knowledge and past experiences provide them with the capacity to develop in this way (depicted by the intersection of the circles representing the ZPA and ZPD). A further constraint is that these actions must be allowed within the individual's environment (depicted by the intersection of the circles for ZPA, ZPD and ZFM).

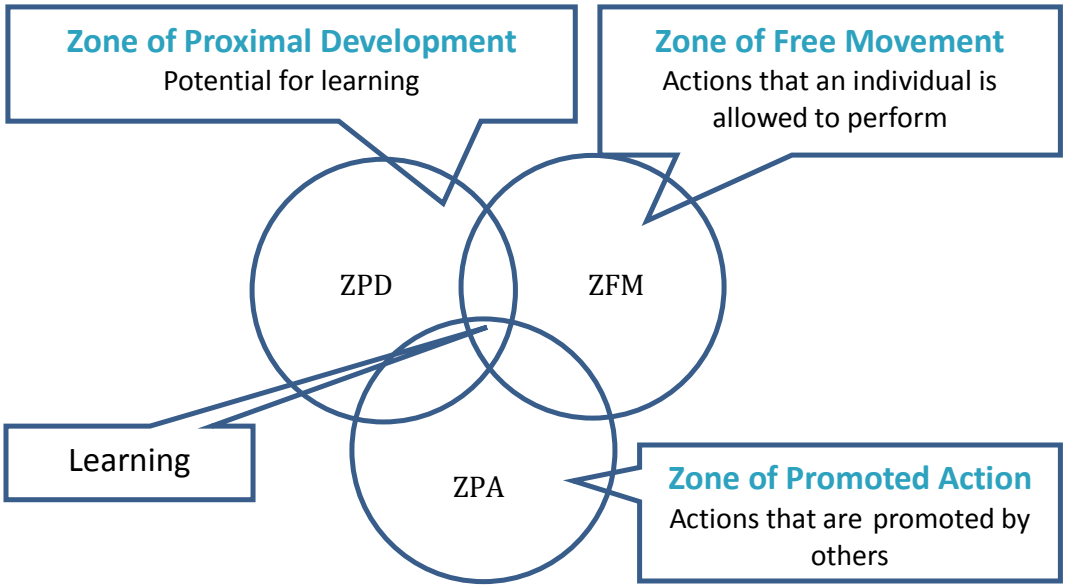

Figure 1

Valsiner's zones

Valsiner's zone theory and a focus on teacher learning

Several researchers have used adaptations of Valsiner's zone theory as a theoretical framework in mathematics education research. The way that they have interpreted this theory has depended on the

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focus of their research. Blanton, Westbrook, and Carter (2005) argued that the ZFM/ZPA complex *created by a teacher for students* provides insights into the teacher's ZPD as it exists between the teacher and the environment, whereas the ZPD is within the teacher and therefore difficult to access. Student learning can only occur if what is promoted by the teacher (ZPA) is also allowed by the teacher (ZFM) and therefore the ZPA needs to be within the ZFM. In case studies of three teachers in mathematics and science, Blanton et al. (2005) defined an additional zone, the *illusionary zone of promoted action*, to account for some actions that the teachers professed to promote, even though they structured a ZFM in the classroom that did not allow these actions. They argued that teachers could be assisted to develop these actions (i.e., they were part of the teacher's ZPD) so that the ZFM they structured for students could be expanded to allow these actions.

Bansilal (2011) also focused on the ZFM/ZPA complexes created by the teacher for students. She analysed the instructional decisions made by a teacher in the context of assessment reform in South Africa as a series of ZFM/ZPA complexes that were ultimately unsuccessful in promoting student learning. The successive ZPAs created by the teacher were intended to expand the students' ZFM, but student learning did not occur because the ZFM/ZPA complexes were outside the students' ZPD. The adaptations of Valsiner's zone theory used by Blanton et al. (2005) and Bansilal (2011) were similar in that they both used the ZFM/ZPA complexes created by the teacher but differed in that the former related the analysis to the teacher's ZPD while the latter to that of students. Focusing on the ZFM/ZPA complexes created by the teacher for students, while appropriate for these studies, does not help in understanding numeracy teacher identity as this is influenced by what the teacher experiences.

An alternative approach was taken by taken by Goos (2005) who mapped factors known to influence teachers' use of technology onto the ZPD, ZFM and ZPA to understand how the teachers developed identities as users of technology as they moved from pre-service to beginning teachers. In this study the focus was on the ZFM/ZPA complex *experienced by the teacher* and therefore provided insights into teacher learning. In this adaptation of Valsiner's zone theory the ZFM is related to teaching actions that are *possible* and the ZPA is related to teaching skills or approaches that are *promoted* by others, for example a teacher educator, supervising teacher or more experienced colleague. The ZPD was not explicitly defined but was related to the knowledge, skills and experience of the teacher.

Goos has used and further developed this theoretical framework with colleagues to investigate teacher learning in a professional development intervention that aimed to assist secondary mathematics teachers to design and implement mathematical investigations consistent with new curriculum requirements (Goos, Dole, & Makar, 2007); in a study that investigated how and why secondary mathematics teachers integrate technology into their practice (Goos & Bennison, 2007); to analyse a survey on teachers' use of and professional development needs related to the use of technology in secondary mathematics classrooms (Bennison & Goos, 2010; Goos & Bennison, 2008); and to suggest its potential use in research on the learning of teacher educators (Goos, 2008, 2009). Recently Goos (2013) has argued that a zone theory approach provides a way to understand how teachers learn from their experiences and change over time. She defined the ZPD as "a set of possibilities for development of new knowledge, beliefs, goals and practices created by the teacher's interaction with the environment, the people in it, and the resources it offers" (p. 523), the ZFM as the constraints and affordances provided by the teacher's professional context, and the ZPA as activities that the teacher can be involved in that promote certain teaching approaches. Goos argues that this approach allows the complexity of teacher learning and development to be analysed while still allowing for the influence of the teacher to direct their own learning by seeking out professional development or modifying their environment (i.e., reorganising elements of their ZPA and ZFM respectively). This is an approach consistent with Valsiner's (1997) idea that individuals are active agents in their own development.

In a recent study, Hussain, Monaghan, and Threlfall (2013) also used an adaptation of Valsiner's zone theory. They investigated how the ZFM/ZPA complexes created by a teacher for students and that experienced by the teacher interacted and changed over time as the teacher and students functioned in a "mutually constituted ZPD" (p. 301). While this approach recognises the dual roles of the teacher (i.e., teacher-as-teacher and teacher-as-learner; see Goos, 2009) it does not provide insights into

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teacher learning as the teacher's ZPD is not considered. The adaptation of Valsiner's zone theory developed by Goos (2005, 2013), on the other hand, has teacher learning as a central focus and enables sense to be made of the interactions between cognitive, affective, and social aspects associated with teacher learning, thus making it an appropriate theoretical framework for developing an understanding of numeracy teacher identity.

A zone theory approach to understanding numeracy teacher identity

The framework for numeracy teacher identity we developed (Bennison and Goos, 2013) included four interconnected domains: a knowledge domain, an affective domain, a social domain, and a life history domain. The elements of these domains, which are directly related to numeracy in the context of a teacher's curriculum area, can be mapped onto the teacher's ZPD, ZFM and ZPA. As the ZPD represents the set of possibilities for development, it will depend on the teacher's knowledge of where numeracy fits into the learning area (curriculum knowledge), knowledge of the mathematics (mathematical content knowledge), and how to teach it (pedagogical content knowledge), beliefs about numeracy, and confidence with numeracy. As described previously, these will all be influenced by their life history. The ZFM represents affordances and constraints within the school environment that either allow or limit a teacher's attempts to embed numeracy into learning experiences they provide for students in the context of the learning area they teach. Therefore this zone includes characteristics of students such as their perceived abilities and attitudes towards mathematics and numeracy, support (or lack thereof) from colleagues and administrators, and the requirements of the Australian Curriculum. The ZPA represents opportunities to learn about teaching numeracy that may occur through professional development, participation in research projects or through informal interactions with colleagues. The way that elements of the framework for numeracy teacher identity relate to the elements of Valsiner's zones as defined by Goos (2013) is summarised in Table 2. There is not an exact correlation between the characteristics shown in Table 1 and Table 2 because many of the characteristics of the framework for numeracy teacher identity do not fit neatly into the zones. For example, from the social domain; school communities can influence a teacher's beliefs about numeracy (ZPD), can provide support or otherwise (ZFM), and can provide opportunities for learning (ZPA). In terms of this theoretical framework, development of numeracy teacher identity will be influenced by how the teacher's ZPD, ZFM and ZPA interact and takes place when the teacher has the appropriate knowledge and experience (ZPD) to underpin the activities promoted by others (ZPA) provided these activities are allowed in the professional context in which the teacher works (ZFM).

Table 2 *Valsiner's Zones and Numeracy Teacher Identity*

Valsiner's zones	Characteristics of numeracy teacher identity
Zone of Proximal Development (ZPD)	Mathematics content knowledge
	Pedagogical content knowledge
	Curriculum knowledge
	Beliefs about numeracy
	Confidence with numeracy
Zone of Free Movement (ZFM)	Support from colleagues and administrators
	Requirements of the Australian Curriculum
	Characteristics of students
Zone of Promoted Action (ZPA)	Professional development
	Participation in research projects
	Informal interactions with colleagues

The use of this theoretical framework in empirical studies can be illustrated by considering the hypothetical examples of Peter and Stephanie in the context of their participation in a two-year research project that promotes numeracy across the curriculum by providing a series of professional development activities that support teachers in planning for numeracy learning.

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Peter's story

Peter is a teacher of mathematics with over 20 years of experience. He completed a Bachelor of Science, majoring in mathematics and chemistry, followed by a Graduate Diploma in Education. He believes that mathematics is best taught by demonstrating solutions to problems and providing students with lots of examples to practice procedures. His colleagues within the mathematics department agree with this approach. A new principal started at Peter's school at the beginning of the year and is starting to develop a whole of school numeracy plan that requires the mathematics department to provide leadership by teaching mathematics in context and supporting teachers of other learning areas to identify the numeracy demands inherent in their learning areas. As part of this approach the new principal has agreed to participate in a two-year research project that promotes numeracy learning across the curriculum. Peter and a teacher of History are invited to participate in the project. Peter agrees to participate.

Peter's ZPD is influenced by strong mathematics content knowledge but is limited by pedagogical content knowledge that supports a transmission mode of teaching. He is confident he can provide numeracy learning opportunities for students but this is restricted by his beliefs about mathematics teaching and what numeracy is. The conservative mathematics department of which he is a member has a particular view of what mathematics is and how it should be taught, structuring a narrow ZFM. Peter's participation in the research project (ZPA) will provide opportunities to develop his pedagogical content knowledge and challenge his existing beliefs while his ZFM will be extended by the goals and direction of the new principal wants for numeracy in the school.

Stephanie's story

Stephanie is a beginning teacher in her second year of teaching. She completed a Bachelor of Arts/Bachelor of Education with English and History as her teaching areas. She believes that literacy and numeracy should be included in all learning areas but lacks confidence and finds it difficult to incorporate numeracy ideas into her English and History classes. She feels that she has the necessary mathematics content knowledge but she is unsure how to identify numeracy learning opportunities and design lessons that make the most of these (i.e., she lacks the necessary pedagogical content knowledge). Stephanie has an opportunity to participate in a two-year research project that promotes numeracy across the curriculum. She volunteers to participate in the project, as she is keen to develop ways of promoting numeracy through English and History. Her goal in doing this meets with some resistance from her colleagues in the English and History departments in her school as most of her colleagues believe that she should focus on literacy and leave numeracy to the mathematics teachers.

Stephanie's ZPD includes mathematics content knowledge appropriate for the mathematics that students will encounter through their studies in English and History but lacks the relevant pedagogical content knowledge. Her beliefs about what numeracy is support her potential development but this is restricted by her lack of confidence. The attitudes of her colleagues influence her ZFM but her participation in the research project (ZPA) provides her with opportunities to develop her pedagogical content knowledge and *permission* to include numeracy learning activities into her lessons.

At the beginning of the research project Peter and Stephanie will each have a particular numeracy teacher identity determined by aspects of the knowledge, affective, social and life history domains that can be seen in terms of their ZPD, ZFM and ZPA. Although changes to their numeracy teacher identity are probable over the period of the research project they are not guaranteed as these teachers will be influenced by a number of factors and are free to accept or reject what is being promoted through the professional development activities of the research project.

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Conclusion

Many Australian 15 year olds do not meet internationally accepted minimum numeracy standards (Thomson et al., 2011) and this can affect their future career opportunities (Palidarno et al., 2012; Shomos, 2010). The introduction of the Australian Curriculum (Australian Curriculum, Assessment, and Reporting Authority, 2012) with a focus on numeracy in all learning areas means that numeracy is the responsibility of all teachers. If teachers are to be supported in developing effective strategies for developing the numeracy capabilities of their students then it is important to understand how they develop a numeracy teacher identity. This paper has extended a framework for numeracy teacher identity we recently developed (Bennison & Goos, 2013) and proposed a theoretical framework that can be used to analyse and compare case studies of individual teachers in order to gain an understanding of how teachers develop a numeracy teacher identity. Such an understanding will assist in identifying mechanisms to support the development of numeracy teacher identity.

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