

## Re-Examining a Framework for Teacher Identity as an Embedder-of-Numeracy

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Research interest in numeracy is growing as a result of increased understanding of the impact of low levels of numeracy. However, there has been little research on factors that influence how teachers implement learning from professional development interventions to support teachers to promote numeracy learning. This paper reports on how a theoretically developed framework for identity as an embedder-of-numeracy was re-examined through empirical research. Additional factors were added to the framework and each factor included in the framework was explicitly defined. The framework seems to capture the complexity of a teacher's identity in this context and is amenable to empirical research.

There is increasing interest in research on numeracy (or mathematical literacy), both in Australia and internationally (Geiger, Goos, & Forgasz, 2015). One of the reasons for this interest is the growing understanding of the impact of low levels of numeracy on productivity, as a result of globalisation and technological changes, and on the economic and social well-being of individuals (Organisation for Economic Co-operation and Development, 2013). While numeracy capabilities continue to develop beyond school, there is an important role for schools in equipping students with the capacity to cope with the mathematical demands of life in the 21st century.

An across the curriculum approach has been taken in Australian schools, with numeracy identified in the Australian Curriculum (Australian Curriculum, Assessment and Reporting Authority, n.d.) as a general capability to be developed in all school subjects. This approach utilises subjects other than mathematics to provide meaningful contexts for students' numeracy development (Steen, 2001). However, it is necessary for teachers to attend explicitly to numeracy learning demands and opportunities in the subjects they teach for this approach to be successful. Previous research has investigated professional development interventions to support teachers to promote numeracy learning (e.g., Goos, Geiger, & Dole, 2014). However, these studies have tended to focus on the effectiveness of the interventions without considering how teachers' knowledge and affective attributes, social interactions, and environmental factors shape the way in which they respond to ideas promoted through these interventions. This issue was addressed in a study that used teacher identity as the analytic lens to identify ways to support teachers to promote numeracy learning across the curriculum.

One of the outcomes of the study was a framework for *identity as an embedder-of-numeracy* that was developed theoretically and then re-examined and revised through empirical research. The development of the initial framework has been reported on previously (Bennison, 2015a). This paper extends this research by presenting the revised framework in order to more fully address the following research question: What factors that contribute to a teacher's identity influence his/her capacity to promote numeracy learning across the curriculum?

### Background to the Study

The study aimed to identify how to support teachers to promote numeracy learning in

subjects across the curriculum. It was conducted in two interrelated phases: a theoretical phase and an empirical phase. The theoretical phase informed the design of the empirical phase, which in turn contributed to re-examining the outcomes of the theoretical phase.

### *The Theoretical Phase of the Study*

The theoretical phase employed an extensive review of literature to propose a sociocultural approach to addressing the study's aims. This approach included using teacher identity as an analytic lens and identifying factors that might contribute to shaping the identity of a teacher in the context of promoting numeracy learning through the subjects they teach. One of the outcomes of this phase of the study was to propose a framework for identity as an embedder-of-numeracy (Bennison, 2015a).

The framework for identity as an embedder-of-numeracy is underpinned by the understanding that:

1. being numerate involves having the *dispositions* that support the *critical use* of *mathematical knowledge* and appropriate *tools* (representational, digital, and physical) in a range of *contexts*: five dimensions of numeracy seen in the numeracy model developed by Goos et al. (2014); and
2. an effective way for teachers to promote numeracy learning is to enhance discipline learning by embedding numeracy into subjects across the curriculum (For an example of how attention to numeracy can enhance learning in history, see Bennison, 2016).

Five Domains of Influence were used to organise the framework: Life History, Knowledge, Affective, Social, and Context. Factors that have previously been shown to influence a teacher's identity were included where it could be argued that these factors were likely to influence how teachers promote numeracy learning through the subjects they teach. For example, the factor, attitudes towards mathematics, was included in the Affective Domain because of the phenomenon of maths anxiety experienced by many pre-service teachers (e.g., Hembree, 1990). The resulting framework is summarised in Table 1.

Table 1  
*Conceptual Framework for Identity as an Embedder-of-Numeracy (Bennison, 2015a, p.15)*

Domains of influence	Characteristics
Knowledge	Mathematics content knowledge (MCK) Pedagogical content knowledge (PCK) Curriculum knowledge (CK)
Affective	Personal conception of numeracy Attitudes towards mathematics Perceived preparation to embed numeracy
Social	School communities Professional communities
Life History	Past experiences of mathematics Pre-service program Initial teaching experiences
Context	School policies Resources

One of the limitations of the framework for identity as an embedder-of-numeracy is that it is static and cannot provide insights into identity formation and possible trajectories of this identity. For this reason, Valsiner’s (1997) zone theory was employed in the study to understand how the factors that influence this identity interact to produce particular identities and how these might change over time. This aspect of the study has been reported elsewhere (Bennison, 2015b).

### *The Empirical Phase of the Study*

The empirical phase of the study was conducted over a two year period (2014-2015) and employed case study methodology (Stake, 2003). Participants were eight teachers from two Australian secondary schools who were recruited because they were participating in a larger project (Numeracy Project). The experience of the teachers ranged from early career to very experienced and the subjects taught were English, history, science, and mathematics. The teachers’ participation in the Numeracy Project meant that they had access to a range of activities to support them to promote numeracy learning in the subjects they taught. Data collected during school visits included interviews and lesson observations. Interview transcripts were analysed using content analysis that employed Valsiner’s (1997) zone theory as the theoretical framework. Teacher’s personal conception of numeracy and the tasks that were used in observed lessons were analysed in terms of the dimensions of Goos et al.’s (2014) numeracy model (For further details of the research design and methods, see Bennison, 2015b).

### Revising the Framework for Identity as an Embedder-of-Numeracy

Several modifications were made to the initial framework for identity as an embedder-of-numeracy (Bennison, 2015a) in light of the findings from the empirical phase of the study: Additional factors were added to the Knowledge and Affective Domains, some of the factors were re-named to better reflect what was meant, and the Life History Domain was placed first because factors that contribute to other domains are shaped by factors from this domain. Furthermore, each factor that was included in the framework was explicitly defined. The revised framework is presented in Figure 1. It is not possible within the space limitations of this paper to fully describe how the inclusion of each factor was supported by the literature and empirical phase of the study. Consequently, attention will be given to the changes made to the framework and the definitions of each factor.

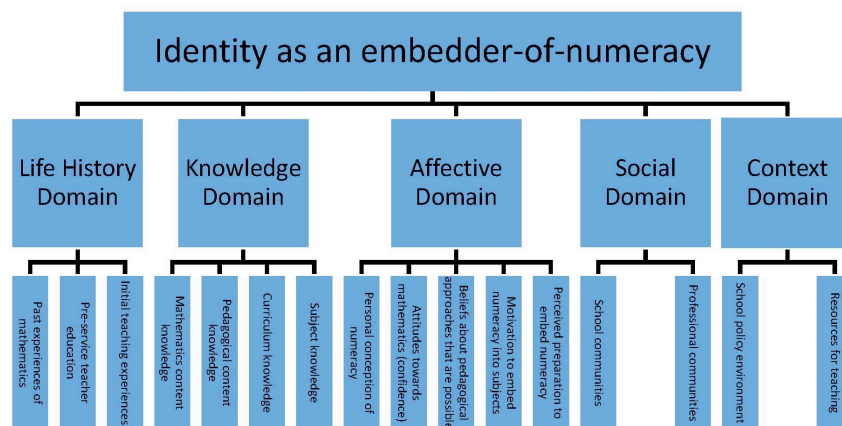


Figure 1. A framework for identity as an embedder-of-numeracy.

### *Life History Domain*

Past experiences contribute to identity (e.g., Phillip, 2007). Consequently, many factors that influence how teachers promote numeracy learning are likely to have been shaped by their past experiences. The Life History Domain in the initial framework included three factors: *past experiences of mathematics*, *pre-service teacher education* (named as pre-service program), and *initial teaching experiences*. No changes were made to this domain as a result of the empirical phase of the study and the included factors were defined in the following manner:

- Past experiences of mathematics: nature (positive/negative) with mathematics and opportunities (both formal and informal) to develop competency with the inherent mathematics in the subjects taught.
- Pre-service teacher education: opportunities during pre-service teacher education to learn about how numeracy can support subject learning and develop pedagogical content knowledge for numeracy.
- Initial teaching experiences: opportunities to engage with an across the curriculum approach to numeracy early in career.

One of the findings of the empirical phase of the study was the limited opportunities for participating teachers, even the most recent graduates, to develop the knowledge for addressing numeracy across the curriculum during their pre-service teacher education. Although not widespread, there have been courses in some pre-service teacher education programs that address numeracy for some time (e.g., Groves, 2001). However, this area of pre-service teacher education will be addressed in the near future in light of the recommendations of the Teacher Education Ministerial Advisory Group (TEMAG, 2014).

### *Knowledge Domain*

A teacher's knowledge is an important part of his or her identity (e.g., Van Zoest & Bohl, 2005). Several types of knowledge are needed for teaching (Shulman, 1987), but only three types were initially included in the Knowledge Domain: *mathematical content knowledge* (MCK), *pedagogical content knowledge* (PCK) and *curriculum knowledge* (CK). Following the empirical phase of the study, *subject knowledge* was added and these types of knowledge were defined as follows:

- MCK: Level of expertise in the mathematics inherent in the subjects taught.
- PCK: Capacity to design effective numeracy tasks.
- CK: Capacity to identify numeracy learning opportunities and make connections between numeracy and subject learning.

Subject knowledge was seen to encompass content, pedagogical and curriculum knowledge of the subject taught. This was added as a single factor to the Knowledge Domain because the interest in the study was on promoting numeracy learning, not on teaching the subject per se. Two of the teachers in the study were teaching science out of field. While one had completed some tertiary science courses, the other had no formal post-secondary science education. This second teacher, a qualified mathematics teacher, conceded that she needed to learn the science content she was teaching and was not seeing the relationship between numeracy and learning in science:

I'm not science trained, so, I mean I'm comfortable with the maths more than the science, so maybe I'm not seeing the links as much as somebody trained in science would because I don't know the content beyond that curriculum that I'm studying to deliver.

Conversely, another teacher, who was a qualified history teacher, recognised the importance of providing students with opportunities to develop numeracy-related historical skills such as using timelines, maps and graphs, even if this was at the expense of covering historical content:

I've really pushed, and a lot of teachers have, to reduce the amount of content we teach and focus on skills because at the end of the day a student can Google when Balboa found the Pacific Ocean but if they can't read a timeline or read a map or construct a graph then, you know, they've lost significant skills.

Not being able to see the links between numeracy and learning in a subject may be the result of a lack of subject knowledge (content, pedagogical, and curriculum). Thus it could be argued that this type of knowledge influences how teachers promote numeracy learning, and so contributes to their identity as an embedder-of-numeracy. However, it should be noted that there is some overlap in the four types of knowledge included in the framework.

### *Affective Domain*

The Affective Domain proved to be the most challenging to conceptualise, possibly because affective attributes cover a broad spectrum (e.g., Phillip, 2007) and the identified factors could also be considered as part of other domains. Three factors were initially included in the Affective Domain: *personal conception of numeracy*, *attitudes towards mathematics*, and *perceived preparation to embed numeracy into subjects*. Following the empirical phase of the study two additional factors were added: *motivation to embed numeracy* and *beliefs about pedagogical approaches that are possible*. The first two of these factors were defined in the following manner:

- Personal conception of numeracy: Belief about what numeracy encompasses.
- Attitudes towards mathematics: Level of confidence with the inherent mathematics in a subject.

The limited opportunities for the teachers to participate in courses during their pre-service teacher education or professional development post-graduation that explicitly addressed promoting numeracy learning across the curriculum meant that the factor, perceived preparation to embed numeracy, was not explored during the empirical phase of the study. For this reason, no definition is provided but it could be seen as related to confidence in dealing with numeracy in the subjects taught.

Teachers who could be described as embedders (Thornton & Hogan, 2004) see numeracy as enriching understanding in the subjects they teach, and so have incentive to promote numeracy learning. In contrast, teachers who find it difficult to make connection between numeracy and subject learning may see numeracy as something extra to be added (e.g., Carter, Klenowski, & Chalmers, 2015). For these latter teachers, it could be argued that making changes to their practices is only likely if they come to see a benefit to student learning in the subjects they teach, thereby making the changes worthwhile (Gresalfi & Cobb, 2011). For example, an early career history teacher placed much greater emphasis on the numeracy learning opportunity provided by timelines in the second year of the study than she had done in the previous year and was able to make explicit links between numeracy and learning in history:

I think numeracy is used more to help students understand concepts. So next lesson we have lots of data, population statistics, we look at [pause] pie charts and stuff about how many of the Indigenous population were left after the Spanish arrived and that kind of stuff and it helps them to understand how devastating the arrival of the Spanish was. And so I think the numeracy has been used to push, to help students understand concepts.

While there are many possible explanations for this teacher's change in practice (e.g., her increasing experience as a history teacher), it is not unreasonable to suggest that motivation for this change stemmed from recognising that explicit attention to numeracy enhanced learning in history. Thus, motivation to embed numeracy into a subject could be seen as contributing to a teacher's identity as an embedder-of-numeracy.

The interactions teachers have with students can influence whether or not they are prepared to expend the emotional energy to employ pedagogical practices that promote numeracy learning. These interactions lead to beliefs about pedagogical approaches that are possible with particular groups of students and are related to teachers' self-efficacy and agency (Bandura, 1977). Two of the teachers in the study mentioned how their perceptions of students influenced the pedagogical approaches they felt able to utilise in lessons. For example, one teacher reported sensing that the students in her science class needed structured activities and as a result did not allow students to work in groups on a more open task:

[My students] struggle with any activity that is out of the ordinary, or out of their routine or involves them in having less guidance. They tend either go, "Oh, that's too hard" and switch off ... anything outside of their routine just kind of scares them and rather than failing they'd rather not try.

Consequently, beliefs about pedagogical approaches that are possible were seen to contribute to a teachers' identity as an embedder-of numeracy.

### *Social Domain*

Identity development involves participation in communities (Wenger, 1988), so it could be argued that teachers' participation in school and professional communities contribute to how they promote numeracy learning. For the purposes of the study, *school communities* were restricted to the interactions that teachers have with students, colleagues and administrators. Following the empirical phase of the study, interactions teachers have with students were seen as likely to influence teacher beliefs about the pedagogical approaches they could employ and were included in the Affective Domain. *Professional communities* can offer opportunities for teachers to engage in learning, and therefore contribute to how they promote numeracy learning. The two factors included in the Social Domain were defined as follows after the empirical phase of the study:

- School communities: Interactions with colleagues and school administrators related to the meaning of numeracy and who is responsible for numeracy learning.
- Professional communities: Interactions with others in professional associations and professional development activities (including research and development projects) related to promoting numeracy learning.

### *Context Domain*

Practice and identity are related (Wenger, 1998), so affordances and constraints on practice within teachers' professional contexts can influence the ways in which they promote numeracy learning. The *school policy environment* and *access to appropriate resources* for teaching seemed pertinent (named as school policies and resources in the

initial framework, see Table 1), and so these were included in the Context Domain. Following the empirical phase of the study, these factors were defined as:

- School policy environment: Curriculum initiatives and accountability measures related to numeracy.
- Resources for teaching: Access to representational, physical, and digital tools needed to support numeracy learning.

### Concluding Remarks

The situated nature of identity (Wenger, 1988) makes it possible to theoretically develop a framework that encompasses factors likely to contribute to a teacher's identity in a given situation. This approach was used to develop a framework for identity as an embedder-of-numeracy (Bennison, 2015a) in a study that sought to identify ways to support teachers to promote numeracy learning across the curriculum. An empirical phase in the study allowed the framework to be evaluated and led to several revisions that are reported in this paper. Furthermore, evidence from this phase of the study indicates that the framework allows the complexity of a teacher's identity in this context to be captured, and yet overcomes some of the difficulties of using a more complex framework such as Van Zoest and Bohl's (2005) framework for mathematics teacher identity in empirical research. The empirical phase of the study was limited to eight teachers in two schools who taught a small number of subjects. Further evaluation of the framework could be undertaken by extending the research to more teachers, schools, and subjects.

The focus of the study reported in this paper was identifying ways to support *practising* teachers to promote numeracy learning through the subjects they teach. The teachers who participated in the empirical phase of the study reported that their pre-service teacher education programs had provided limited opportunities to develop the capacity to promote numeracy learning. In light of this finding and the imminent changes to pre-service teacher education programs as a result of the Teacher Education Ministerial Advisory Group (2014) recommendations, there is a need to investigate how best to prepare pre-service teachers so that they are able to attend to numeracy demands and opportunities in ways that enhance subject learning.

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