# Identity as an Embedder-of-Numeracy: Identifying ways to support teachers to embed numeracy across the curriculum

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The context in which mathematics is used is an important aspect of numeracy. Therefore, students' numeracy capabilities need to be developed in subjects across the curriculum. The case study of a secondary school history teacher is presented to demonstrate how a framework for identity as an embedder-of-numeracy can be used to identify ways that this teacher might be supported to embed numeracy into the history curriculum. While the framework was generally effective for this purpose, a potential limitation was identified.

## Introduction

The pressure on schools to demonstrate improved outcomes on the National Assessment Plan - Literacy and Numeracy (NAPLAN) influences school organisation, curriculum, and pedagogy (Hardy, 2014). This includes the use of practice tests and teaching to the test with some resultant focus on a definition of numeracy as the mathematical skills required to successfully answer NAPLAN questions. However, numeracy encompasses much more than just mathematics. The Organisation for Economic Co-operation and Development (OECD) defines mathematical literacy (the term used in some international contexts) as:

> an individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals in recognising the role that mathematics plays in the world and to make well-founded judgments and decisions needed by constructive, concerned and reflective citizens (OECD 2013, p. 25).

This widely accepted definition of numeracy recognises that the context in which mathematics is used is as an important aspect of numeracy. In fact, Steen (2001) argued that context is what distinguishes numeracy from mathematics, and if students are to develop the capabilities needed to become numerate, they need to be provided with opportunities to use mathematics in a range of contexts; in other words, in subjects across the curriculum. While the need for this type of approach has also been recognised in Australia for some time (DEETYA, 1997), it is only recently with the introduction of the Australian Curriculum (ACARA, 2014), where numeracy was seen as a general capability to be developed in all subjects, that there has been a national approach to this. However, for this approach to be successful, teachers from all disciplines need to exploit numeracy learning opportunities that exist in the subjects they teach. Therefore, there is a need to investigate how teachers can be supported to develop this capacity. One way of doing this is to use teacher identity as the analytic lens.

This paper builds on previous research in which a framework for identity as an embedder-of-numeracy was developed (Bennison, 2015, hereafter referred to as *EoN Identity*). Specifically, the purpose of this paper is to investigate the efficacy of the *EoN Identity framework* to answer the following research question: In what ways can the EoN Identity framework be utilised to identify ways to support a teacher to develop the capacity to embed numeracy into the subjects she/he teaches?

## A Framework for EoN Identity

An individual's identity develops as they negotiate meaning through individual cognition and social interactions within their environment; it is dynamic and context dependent (Wenger, 1998). These attributes make teacher identity a useful construct for investigating how teachers can be supported to exploit numeracy learning opportunities across the curriculum. However, it is difficult to design empirical studies that capture the complexity of teacher identity but are still viable practically (Enyedy, Goldberg, & Welsh, 2005). To overcome this limitation, a framework for EoN Identity was developed that identifies characteristics that are most likely to have greatest impact on a teacher's capacity to embed numeracy into the subjects they teach (Bennison, 2015). The two understandings that underpin the EoN Identity framework are that:

1. being numerate involves having the dispositions that support the critical use of mathematical knowledge and appropriate tools in a range of contexts: these five dimensions of numeracy are encapsulated in the numeracy model developed by Goos, Geiger, and Dole (2014); and
2. the belief that the best way for teachers to support numeracy learning is to embed numeracy into the subjects they teach in order to enhance discipline learning.

In Goos et al.'s (2014) numeracy model, numeracy requires *dispositions* (i.e., confidence and willingness) to use *mathematical knowledge* (concepts and skills, problem solving, and estimation) and representational, physical, and digital *tools* (e.g., graphs, measuring instruments, and calculators, respectively) in a range of *contexts* (both within school and beyond school settings). These four dimensions are set within a *critical orientation* that enables decisions and judgments about mathematical information. (See pp.83-85 for further elaboration). This model of numeracy was used to underpin the EoN Identity framework because each dimension of numeracy was made explicit and the model provided an effective means of describing a teacher's personal conception of numeracy and classroom activities. The second of the understandings that underpinned the EoN Identity framework stemmed from recognition of the important role numeracy has for conceptual understanding in disciplines across the curriculum. For example, an understanding of chronological conventions was seen as essential to conceptual understanding of history (Blow, Lee, & Shemilt, 2012), whereas lack of well-developed numeracy skills was identified as a barrier to learning science (Quinnell, Thomson, & LeBard, 2013).

The EoN Identity framework (summarised in Table 1) was arranged around five *domains of influence*: knowledge, affective, social, life history, and context. Within each of these domains were characteristics that impact on a teacher's capacity to support numeracy learning. For example, mathematical content knowledge (MCK), pedagogical content knowledge (PCK) and curriculum knowledge (CK) were the aspects of the knowledge domain. Only these types of knowledge, instead of all of the types of knowledge that Shulman (1987) suggested were needed for teaching, were included because, in order to support numeracy learning, a teacher needs to be competent in the mathematics inherent in the discipline (MCK), be able to use curriculum documents to identify where numeracy would support discipline learning (CK), and be able to design tasks that utilise some or all of the dimensions of numeracy in Goos et al.'s (2014) numeracy model (PCK). These nuanced meanings of MCK, PCK and CK focus on the knowledge needed to support students' numeracy learning. (See Bennison, 2015 for further details of how the framework was developed).

Table 1
*Framework for identity as an embedder-of-numeracy (adapted from Bennison, 2015, p.15)*

| Domains of influence | Characteristics |
| --- | --- |
| Life History | Past experiences of mathematics |
| | Pre-service program |
| | Initial teaching experiences |
| Context | School policies |
| | Resources |
| 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 |

## Research Design and Methods

The data presented in this paper were drawn from a two-year study (2013-2014) that was conducted in two schools in Queensland: one metropolitan and one regional. The study employed case study methodology (Stake, 2003) with Kylie (pseudonym), the teacher who is the focus of this paper, being one of eight teachers who were recruited for the study. These teachers had different disciplinary backgrounds and levels of experience and were recruited because they had previously agreed to participate in a larger study (hereafter referred to as the *Numeracy Project*). Thus, they had indicated an interest in developing their capacity to support numeracy learning across a range of disciplines (English, mathematics, science, and history) and provided an opportunity to learn about how teachers develop an EoN Identity.

The main sources of data for the study were semi-structured interviews with the teachers and lesson observations. Kylie was visited six times during the study. On each occasion, at least one lesson was observed and she was interviewed after the lesson(s) about the tasks she had used as well as student and teacher learning. She participated in two additional interviews: a scoping interview that was conducted near the beginning of the study (but after Kylie had participated in two workshops for the Numeracy Project) and a final interview that was conducted during the last school visit. The first of these interviews was about her background, beliefs about numeracy, and school context, whereas the final interview asked Kylie about her experiences during this study and provided an opportunity to get clarification of comments she had made during earlier interviews. Lesson observations and post lesson interviews provided data for this study and the Numeracy Project, whereas the scoping interview and final interview, the sources of data for this paper, were conducted solely for this study.

Data analysis involved coding the transcripts of Kylie's scoping and final interviews to identify comments that were related to aspects within each of the domains of influence. For example, comments she made about her studies of mathematics at school were included in

both her knowledge and affective domains because they gave some indication of her MCK and her attitudes towards mathematics, respectively. Judgments were made about her level of MCK, PCK, and CK based on her comments during interviews.

# Kylie's EoN Identity

## *Life History Domain*

While at school, Kylie focussed on humanities subjects and reported that:

[M]aths was something I kind of endured … Like, I did Maths A [a subject taken in the final two years of school by students who do not require a knowledge of calculus], and I did quite well in Maths A, but I took it because it was the easy one (Final interview).

At university, Kylie completed a Bachelor of Arts degree, majoring in Ancient History and English Literature. Although her studies at university did not require any further formal mathematics subjects, she reported that she used mathematical knowledge, especially statistics, in some of her history courses. After travelling and working overseas, Kylie returned to Australia and completed a Graduate Diploma in Education with teaching areas in English and History. Although she could not remember much emphasis being placed on literacy and numeracy during her pre-service teacher education program, she did remember having to comment on both in an assessment task for a course she completed during her final semester. However, Kylie reported that numeracy was not a focus for her in this task.

When this study commenced, Kylie was at the beginning of her teaching career in a secondary school in a regional city. During the study, she taught mainly junior classes (Years 8 and 9), which she took for English and history. However, the focus in this paper is on her EoN Identity in the discipline of history.

## *Context Domain*

There were three aspects to Kylie's context domain: the Australian Curriculum, the school where she teaches, and the Numeracy Project.

*Australian Curriculum*. The Australian Curriculum: History (ACARA, 2014) was implemented in Kylie's school in the first year of the study. Although the numeracy demands in history were identified with icons and online filters in curriculum documents, Kylie felt that "the numeracy that's outlined isn't particularly in depth or challenging" (Final interview). Despite this lack of guidance from curriculum documents, over the course of the study Kylie identified a number of learning opportunities that existed within the history curriculum.

The implementation of the new curriculum presented Kylie with some challenges. She felt pressure to cover the content: "We don't have time at the moment and that's what I am particularly concerned about" (Scoping interview), and would like to see reduced content to allow greater focus on historical skills such as reading maps and constructing graphs. Access to appropriate resources was also an issue for Kylie, who described some of the difficulties she experienced with a research project on the medieval period.

[W]e just didn't quite have enough resources … we only have one free computer lab … four classes on each line … we've had one lesson on computers and the rest has been from books. Obviously we are building up books, [but it] will probably take a couple of years before we have enough books (Scoping interview).

*Kylie's school.* The school where Kylie taught was located in a regional city where the main industry was mining. The school was classified as being in an average socioeconomic area and had around 1,000 students who came from both metropolitan and rural areas. School NAPLAN results for numeracy had been close to the Australian schools' average but those for some aspects of literacy, although close to the Australian schools' average, had declined over the last couple of years. This had resulted in "such a focus in English to prepare students for NAPLAN" (Scoping interview).

In the final year of the study, the school had set up a number of committees and each teacher was asked to join one. As Kylie had participated in the Numeracy Project and had taken on the role of Literacy Coach, she joined the Literacy and Numeracy Committee. The task for this committee was to track implementation of literacy and numeracy strategies in the school in order to evaluate their impact on NAPLAN data. In light of a decline in NAPLAN results for literacy, the focus of the committee had been on implementing a whole school approach to literacy. A similar approach was not considered necessary for numeracy: "The numeracy people, the Maths department, feels that on their level they've achieved this prize for what they are doing" (Final interview).

*Numeracy Project.* Kylie and three other teachers from her school participated in the Numeracy Project. This project investigated the potential of professional development based on Goos et al.'s (2014) numeracy model for supporting teachers to promote numeracy learning across the curriculum. Teachers across a range of disciplines had been recruited from primary and secondary schools in Queensland and Victoria. During the project (2012-2014), the teachers participated in cycles of professional development workshops followed by visits to the school by researchers who observed lessons where teachers implemented activities to support numeracy learning and interviewed the teachers.

## Knowledge Domain

Although Kylie felt that she "probably need[ed] a refresher for a lot of [the mathematical knowledge]" (Scoping interview) required for embedding numeracy in history, her mathematics background (as outlined earlier in the section on her Life History domain) had probably given her the requisite MCK. With a major in Ancient History, Kylie had a strong discipline background. However, as the history curriculum was still relatively new, it may take time for her to develop the CK needed to identify where numeracy can be used to support discipline learning in history.

Prior to her participation in the Numeracy Project, Kylie had not had any opportunities to learn about embedding numeracy in history. Early in this study, Kylie thought that she needed to learn how to "adequately incorporate numeracy without losing the focus on historical issues" (Scoping interview). However, by the end of this study, she had demonstrated some PCK through her classroom practice. For example, she described a lesson where she utilised a scaled timeline to assist students to understand that historical events had duration and could be concurrent.

> I was trying to get them to think about timelines because my students, like, we have been trying timelines since we started this unit at the end of last term and we have done two or three and they are just [pause] having trouble with the times themselves, like, they're having troubles conceptually understanding when things happened. So we did a whole world timeline about all the ideas we could think of. Like, 'When was the relationship between the Black Plague and the Age of Discovery?' And, 'When was Captain Cook and the Age of Slavery?' And, 'When, you know, what was happening in Australia at this time?' But they're just [pause]; to them 1400 to 1600 is just this blurry blob in the middle of nowhere. They just have no idea what's going on (Final interview).

## *Affective Domain*

Kylie reported that before her participation in the Numeracy Project, she did not "have an awareness of what numeracy was … [and was] probably one of those teachers who was like, 'Numeracy, well I'm sure they'll cover that in maths'" (Scoping interview). However, even in the early stages of the Numeracy Project, Kylie felt that her ideas about numeracy were changing as numeracy became more obvious to her. Initially, she thought that numeracy was important, although not as important as literacy, but had come to believe that "if you are innumerate, that's on a level with not being able to read" (Final interview). Kylie felt that embedding numeracy in subjects across the curriculum required explicit attention to numeracy within subjects and breaking down the view, held in Kylie's opinion by many teachers and students, that each subject has its own knowledge and practices that are only applicable within that subject.

Kylie thought that there were many opportunities to use numeracy to develop students' conceptual understanding of history. For example, she thought that using representational tools enabled students to gain a better understanding of some of the data that was encountered in history.

> We spend a lot of time discussing the concepts, like, 'What percentage here? What percentage there?' … We don't spend a lot of time transferring that into easy to look at information … We don't particularly follow through with those kinds of tools like turning it into a pie chart, into a graph (Scoping interview).

Kylie also described how she had used numeracy to a The purpose of the paper is to test the existing framework for identity as an embedder-of-numeracy with empirical data. ssist students to understand what it was like in medieval times.

> [W]e look at the Black Plague and how many were affected and if, what percentage of people in the world today. Like, we did how many people in the world would have been killed, one to two thirds, one to two thirds of the world, of Europe and then we looked at the school and then we looked at the classroom and decided who gets killed by the Black Plague. They all re-enacted it with disgusting accuracy and so it's much simpler. They just needed to understand how bad the Black Plague was. So it was a very easy concept to apply numeracy to … we said it was devastating and I think the problem was that they didn't understand, like, they have a lot of difficulty identifying the concepts in the medieval world … it was trying to build their understanding (Scoping interview).

Kylie was reasonably confident that she could deal explicitly with the mathematical content in history lessons: "Once I look at it I can probably do it as long as it's not too complicated" (Scoping interview).

## *Social Domain*

As teachers at Kylie's school were allocated to staffrooms based on their discipline, Kylie shared her staffroom with other English teachers as well as with Business and Information Technology teachers. She reported that some of her English teaching colleagues found it strange that she had participated in a research project on numeracy and that the general feeling in her staff room was that there was no difference between numeracy and mathematics. Although there were three other teachers at Kylie's school who participated in the Numeracy Project, opportunities to work with these teachers had been limited because they were located in other staffrooms. Kylie expressed a desire for more internal professional learning within her school community and more integrated planning across disciplines, which she felt, could be achieved by having:

a general meeting at the beginning [of the year] and just that awareness and that way it would open those communication lines … breaking down those kid's ideas … separate ideas, separate subjects, separate skills. When it's not. It's one subject, one skill (Final interview).

Apart from her interactions with researchers and teachers from other schools who were also participants in the Numeracy Project, opportunities for Kylie to network with others outside her school community were limited. She was not involved in any professional associations for history and, although she had seen advertisements for a small number of professional development workshops about numeracy, the majority of these were offered in the state's capital city or another regional city, both about 500 kilometres from her school. Kylie had discussed her plans for embedding numeracy in history with a mathematics teacher from another school whom she lives with. She had found these discussions useful, even though were limited to whether students in a particular year level could be expected to understand the mathematics needed for the tasks she was planning.

## Discussion

Kylie's EoN Identity included affordances and constraints on her capacity to embed numeracy into the discipline of history. Kylie's life history domain has contributed to the current state of her knowledge and beliefs. Within her knowledge domain, she seemed to have the appropriate MCK and her CK is likely to develop over time as she becomes familiar with the new curriculum. However, the absence of a focus on numeracy across the curriculum during her pre-service teacher education program suggests that she may need support to develop the appropriate PCK. Kylie's affective domain was supportive of an across the curriculum approach to numeracy. Although her initial understanding of numeracy was focused on mathematics, only one of the five dimensions in Goos et al.'s (2014) numeracy model, her personal conception of numeracy appeared to be broadening as a result of her participation in the Numeracy Project. She provided evidence that she saw a need for numeracy in supporting students' learning in the discipline of history, in a similar way to that described by Blow et al. (2012), and expressed confidence that she had the mathematics ability to support this. Within Kylie's context domain, the new history curriculum and her participation in the Numeracy Project provided support for an across the curriculum approach to numeracy. However, Kylie must overcome the challenges that implementation of the new curriculum brings in a school environment where the focus is primarily on improving students' NAPLAN performance in literacy: a focus that can influence pedagogy (Hardy, 2014). Kylie's social domain, apart from her interactions with those associated with the Numeracy Project, although not negative, did not actively promote an across the curriculum approach to numeracy.

This analysis suggests that there are several ways that Kylie could be supported to strengthen her EoN Identity. Within her knowledge domain, her main need appeared to be increasing her PCK to enable her to design tasks that support numeracy learning while at the same time enhancing conceptual understanding in history. However, there are also changes that could be made within her context and social domains to facilitate this learning. For example, within her context domain the Literacy and Numeracy Committee could put greater emphasis on a whole of school approach numeracy or within her social domain, the expertise of the mathematics department could be utilised to assist teachers of other disciplines in their planning for numeracy.

# Concluding Remarks

In this paper, the EoN Identity framework (Bennison, 2015) has been used to describe Kylie's EoN Identity and identify some ways to support her to embed numeracy into the discipline of history. However, as identity is dynamic (Wenger, 1988), the EoN Identity framework provides a snapshot Kylie's EoN Identity at one point in time and her current needs to support embedding numeracy into history. At a different time in her career, and for other teachers, the aspects of the domains of influence will be different: resulting in different EoN Identities and needs. One of the strengths of the EoN Identity framework is that it accommodates the temporal nature of identity because the domains of influence overlap and are continually changing.

The purpose of the empirical phase of the study reported on in this paper was to test the framework for EoN Identity that was developed from a theoretical perspective (see Bennison, 2015). Therefore, extensive data collection was warranted. However, a potential practical limitation of the EoN Identity framework is the time required to collect sufficient information to describe a teacher's EoN Identity. Therefore, further research in needed to fully test the EoN Identity framework with the case studies of the other teachers participating in the study and to develop a streamlined means of collecting adequate information for describing a teacher's EoN Identity.

# References

Australian Curriculum Assessment and Reporting Authority [ACARA]. (2014). Australian Curriculum (Version 7.0). Retrieved 6 August 2014, from http://www.australiancurriculum.edu.au/Download/F10

Bennison, A. (2015). Developing an analytic lens for investigating identity as an embedder-of-numeracy. *Mathematics Education Research Journal*, *27*, 1-19. doi:10.1007/s13394-014-0129-4

Blow, F., Lee, P., & Shemilt, D. (2012). Time and chronology: Conjoined twins or distant cousins? *Teaching History, 147*, 26-34.

Department of Employment Education Training and Youth Affairs [DEETYA]. (1997). Numeracy = everyone's business. The report of the Numeracy Education Strategy Development Conference. Adelaide: Australian Association of Mathematics Teachers.

Enyedy, N., Goldberg, J., & Welsh, K. M. (2005). Complex dilemmas of identity and practice. *Science Education, 90*, 68-93. doi:10.1002/sce.20096.

Goos, M., Geiger, V., & Dole, S. (2014). Transforming professional practice in numeracy teaching. In Y. Li, E. Silver, & S. Li (Eds.), *Transforming mathematics instruction: Multiple approaches and practices* (pp. 81-102). New York: Springer.

Hardy, I. (2014). A logic of enumeration: The nature and effects of national literacy and numeracy testing in *Australia. Journal of Educational Policy*. doi: 10.1080/02680939.2014.945964

Organisation for Economic Co-operation and Development [OECD]. (2013). PISA 2012 Assessment and analytical framework: Mathematics, reading, science, problem solving and financial literacy. Retrieved 6 August 2014, from http://dx.doi.org/10.1787/9789264190511-en

Quinnell, R., Thompson, R., LeBard, R. J. (2013). It's not maths; it's science: Exploring thinking dispositions, learning thresholds and mindfulness in science learning. *International Journal of Mathematical Education in Science and Technology*, *44*(6), 808-816. doi: 10.1080/0020739X.2013.800598

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-21.

Stake, R. E. (2003). Case studies. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Stategies of qualitative inquiry* (2nd ed., pp. 134-164). Thousand Oaks, CA: Sage.

Steen, L. A. (2001). The case for quantitative literacy. In L. A. Steen (Ed.), *Mathematics and democracy: The case for quantitative literacy* (pp. 1-22). Princeton, N.J.: National Council on Education and the Disciplines.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. Cambridge: Cambridge University Press.