Teacher Identity and Numeracy: Evaluating a Conceptual Framework for Identity as a Teacher of Numeracy

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If teachers are to adequately support development of their students' numeracy capabilities then they need to have an identity as a teacher of numeracy. A preliminary evaluation of a conceptual framework (Bennison & Goos, 2013) developed for use in a two-year study that seeks to understand this construct is presented. Initial findings about an early career secondary science teacher are utilised to describe this teacher's identity as a teacher of numeracy, enabling the conceptual framework to be illustrated and critiqued.

In Australia it has been recognised for many years that teachers of all school subjects have a role to play in developing the numeracy capabilities of students (e.g., COAG, 2008; DEETYA, 1997). This is now explicit in the Australian Curriculum (ACARA, 2012) and Australian Professional Standards for Teachers (AITSL, 2012). The former includes numeracy as one of seven general capabilities to be developed across all curriculum areas, while the latter sets out what all teachers need to know and be able to do to effectively support students' numeracy development. However, for these documents to have an impact in the classroom, teachers must see themselves as teachers of numeracy; that is, teachers must develop an identity as a teacher of numeracy (Bennison & Goos, 2013). Such an identity, we have argued, involves having the knowledge, attitudes and beliefs, shaped by life history and interactions with others, that enables a teacher to identify and exploit the numeracy learning opportunities in the subjects they teach.

Improving the numeracy capabilities of students has been a priority for the Australian Government for over a decade (e.g., DETYA, 2000; DEETYA, 1997; MCEETYA, 2008). In spite of this, it could be argued that using comparisons of school results in the National Assessment Plan – Literacy and Numeracy (NAPLAN) with those of like schools as well as state and national averages as a measure of school performance and accountability can lead to a narrow focus on numeracy as mathematical skills. However, numeracy is much more than this and one of the problems associated with discussions about numeracy is that there are many definitions of numeracy and descriptions of what it means to be numerate (e.g., Cockcroft, 1982; DEETYA, 1997; OECD, 2012; Steen, 2001; Willis, 1998). These definitions try to capture the complexity of numeracy and emphasise different aspects but generally share the notion that numeracy involves having the disposition to critically use mathematics in a range of contexts. Yet it is not always clear what this means in practice. Goos (2007) drew on a number of widely accepted definitions to develop a model of numeracy for the twenty-first century. According to this model, to be numerate a person needs to have the *disposition* to be confident and willing to use the requisite *mathematical knowledge* and appropriate *tools* in a given *context*. They must also be able to take a *critical orientation* in order to evaluate their results and information presented to them. In her model of numeracy, Goos makes the meaning of each of these five aspects explicit (e.g., *tools* encompasses representational, physical, and digital tools and that these three types of tools include maps and tables, models and measuring instruments, and computers

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and calculators, respectively). For further elaboration of the model see Goos, Dole and Geiger (2011).

In this paper previous research is extended by exploring how empirical data can be mapped onto a conceptual framework for identity as a teacher of numeracy (Bennison & Goos, 2013). The purpose of the paper is to evaluate this framework by utilising some initial findings from a two-year study that aims to develop an understanding of this construct. While the framework was developed from a theoretical perspective, identification of strengths and weaknesses in the framework is only possible when it is tested with empirical data. Specifically, the paper addresses the question of whether the domains of influence present in the framework provide an adequate conceptual framework for identity as a teacher of numeracy.

Identity as a Teacher of Numeracy

There has been increased interest in using teacher identity as a construct for investigating the knowledge, affect, and practices of teachers over the last decade. However, one of the challenges associated with research in this area is that of developing a framework that is both comprehensive and at the same time amenable to empirical studies (Enyedy, Goldberg, & Welsh, 2005). One possible approach is to develop a framework that is situation specific such as that which we developed for identity as a teacher of numeracy (see Bennison & Goos, 2013 for a full discussion of how the framework was developed). Drawing on Van Zoest and Bohl's (2005) framework for mathematics teacher identity, as well as other literature on teacher identity, this conceptual framework (summarised in Table 1) is organised around four interconnected domains of influence. These are a knowledge domain, an affective domain, a social domain, and a life history domain. Within each of these domains of influence there is a focus on those characteristics that are particularly relevant in the context of a teacher providing opportunities for students' numeracy development. For example, within the knowledge domain three types of knowledge are considered necessary. A teacher needs mathematical content knowledge (MCK) relevant to their subject area, knowledge of the curriculum (CK) that enables them to identify when and how mathematics can be used to support students' understanding of the subject, and pedagogical content knowledge (PCK) necessary to design appropriate learning activities.

Table 1
Framework for Identity as a Teacher of Numeracy

Domains of influence	Characteristics
Knowledge	Mathematics content knowledge (MCK)
	Pedagogical content knowledge (PCK)
	Curriculum knowledge (CK)
Affective	Confidence
	Beliefs
Social	School communities
	Professional communities
Life History	Past experiences of mathematics and teaching

Research Design and Methods

Karen, the teacher who is the focus of this paper, is one of eight teachers participating in a two-year study (2013–2014) designed to gain an understanding of identity as a teacher of numeracy. While the study is non-interventionist, the teachers participating in the study were recruited because they had previously agreed to participate in a larger study (hereafter referred to as the *Numeracy Project*) designed to investigate the potential of professional learning opportunities based on the model of numeracy described earlier (Goos et al., 2011). The teachers have differing disciplinary backgrounds and experience and are from two Queensland secondary schools, one in a metropolitan area and the other located in a regional area. In this paper data collected in the first year of the study are utilised to provide a preliminary evaluation of the conceptual framework for identity as a teacher of numeracy described in the previous section.

During three visits to Karen's school in 2013 at least two lessons were observed and Karen was interviewed about the task that she used, student learning, and her own learning. Karen also participated in a scoping interview to ascertain information about her background, beliefs about numeracy, school context, and the opportunities she has had to learn about supporting her students' numeracy development through the subjects she teaches. Additionally, at the beginning of the study, Karen completed a survey that sought information about her confidence related to numeracy, and engaged in a task designed to assess her understanding of numeracy. If the framework for identity as a teacher of numeracy (Bennison & Goos, 2013) is an adequate conceptual framework for the study, then it should be possible to map information from these data collection events onto the four domains of influence and describe Karen's identity as a teacher of numeracy.

Karen's responses to questions in the scoping interview were allocated to one of the four domains of influence that comprise the conceptual framework. Her answers to questions about her pre-service education and professional development experiences to date contributed to her knowledge domain as these responses gave some indication of her MCK and PCK. Karen's replies to questions about what she believes numeracy is, about her colleagues, and how she came to be a teacher contributed to her affective domain, social domain, and life history domain, respectively. Observations of Karen's classroom practice and the subsequent post-lesson interviews, as well as the other data collection events supplemented this information. Drawing on these data, the next section presents a case study of Karen so that her identity as a teacher of numeracy can be discussed in the subsequent section.

Karen's Story

Background

Karen is an early career science teacher from the metropolitan school. She is currently in her third year of teaching and has been at her present school since she graduated in 2010. As well as a Bachelor of Education, Karen completed a Bachelor of Applied Science, majoring in Biology as part of a dual degree program. However, Karen has had limited experience teaching science. Despite having completed only one first year mathematics subject and a mathematics curriculum subject designed to prepare pre-service teachers to teach junior mathematics (Years 8–10) and Mathematics A (a non-calculus based subject that can be taken in the final two years of high school), Karen's teaching experience has

been mainly with mathematics classes. However, in 2013 she did have a Year 9 Science class and this class was the focus of lesson observations and post-lesson interviews during the school visits.

School Context

The school where Karen teaches is located in a low socioeconomic area in metropolitan Brisbane. There are approximately 900 students; of which 8% had Indigenous backgrounds and 5% had a language background other than English. While student performance on the National Assessment Program – Literacy and Numeracy (NAPLAN) for 2012 was close to schools with students who have a similar average level of educational advantage, it was substantially below the Australian schools' average. As part of efforts to address this issue, the principal of the school is keen to promote an across the curriculum approach to numeracy and has agreed to the schools' participation in the *Numeracy Project*.

In Year 8 and Year 9 classes are arranged in "POD groups" where students have one teacher for mathematics and science and another teacher for English and history. Students in these year levels study history for one semester per year while the remaining core subjects (mathematics, science and English) are taken in both semesters. The school day is structured with four seventy-minute lessons, which means that three lessons per week are devoted to each of the four core subjects.

Understandings and Experiences

According to Karen, numeracy is "mathematical concepts but in the context of real life … maths is the subject and numeracy is the application." Karen reported that none of her university courses had provided her with opportunities to learn how to incorporate numeracy into the science curriculum and she had not had any formal professional development in this area prior to her participation in *Numeracy Project*. Despite this, she believes that "Science really lends itself to numeracy because the context is already there and you've just got to make the opportunities". She thinks that developing students' numeracy capabilities through science "can happen quite naturally, it doesn't have to be contrived." Karen wants to develop her skills in this area and "jumped at the opportunity" to participate in the *Numeracy Project*.

Karen finds that students in her Year 9 class "struggle with any activity that is out of the ordinary or out of their routine or involves them having less guidance … anything outside the routine just kind of scares them and rather than failing they'd rather not try." For Karen, this means feeling a need to provide students with highly structured tasks. Karen also reported a high level of student absenteeism, resulting in many students having gaps in their knowledge and experiencing a sense of discontinuity, a problem exacerbated by only having three science lessons a week.

Lack of access to technology has resulted in some restrictions on what Karen is able to do in the classroom. For example, in one of the observed lessons Karen investigated the decay of radioactive isotopes using a physical simulation. She would have liked her class to explore this further by getting students to use an electronic simulation, available through the Internet, which enabled the process to be observed for a much large number of atoms. However, this was not possible because only a few students had laptops and there were no computers in the classroom, except for the one available to the teacher. Laptops were

accessible to students through an optional school hire scheme but not many students had utilised this facility.

Karen finds that her Heads of Department for both science and mathematics are really supportive, with the former having a strong literacy focus and the latter providing resources related to numeracy. Although Karen's responses to the survey seeking information about her confidence in teaching numeracy were generally positive, she did express uncertainty in her ability to promote active engagement in numeracy learning, utilise multiple representations of mathematical ideas, and provide assessment opportunities that enable students to demonstrate their numeracy knowledge.

Classroom Practice

Observations of Karen's Year 9 science class provide evidence of how she was able to develop the numeracy capabilities of her students through the science curriculum. One lesson that was observed was part of an Earth Science unit. Karen introduced the concept of geological time by asking students to map events in the history of the Earth onto a timeline created with a roll of paper towel.

Students were presented with a table that listed a number of biological and geological events that had occurred since the formation of the Earth 4,600 million years ago. Some of this information is presented in Table 2. Students' first task was to decide on an appropriate scale for their timeline. After some teacher-led discussion they came to a consensus that they should use 1 metre to represent 1,000 million years. One student was asked to measure out 4.6 metres of paper towel and label this initial point of the timeline as "Formation of the Earth".

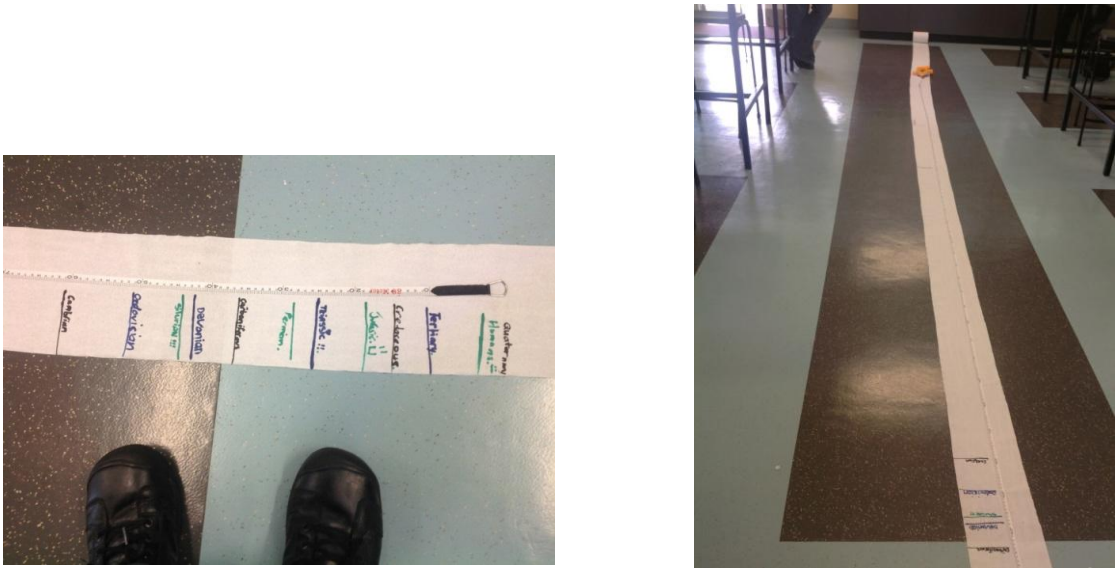
Table 2
Events in the History of the Earth

Event	Years ago (Millions of years)
Formation of the Earth	4,600
First bacteria	3,500
First fish	505
Extinction of the dinosaurs	65
First humans	2

Karen continued to elicit the position of various biological and geological events and then ask a student to mark and label this point on the timeline. Difficulties arose with the appearance of the first fish and the extinction of the dinosaurs. Calculations for these events required students to convert the distance calculated to centimetres before they could add these events to their timeline. The final event, the appearance of the first humans, 2 million years ago, was marked 2 millimetres from the end of the timeline. The task is illustrated in Figure 1.

Karen used this activity to help students to understand that biological events are relatively recent in the context of the history of the Earth. She commented that "using the timescale just put it in perspective a lot more" and enables students "to realise that human history is just a sliver on the end of the timeline". According to Karen, "the emphasis is

placed on what is happening at the end of the timescale so it seems to be proportionally bigger than what it is". Karen also thought that when these data are presented in a table it is misleading because the sizes of the rows are usually about the same and this gives the false impression that geological time periods were of similar lengths.



(a) Beginning of the timeline (b) Length of the timeline

Figure 1. Illustration of the task Karen used.

While this activity enables students to develop an understanding of the scientific concept of geological time, it also provides students with opportunities to develop their numeracy capabilities. In terms of the numeracy model (Goos et al., 2011), the task has a *context* within the science curriculum and incorporates *mathematical knowledge* that includes measurement and ratio. Students use *representational tools* when they read information from a table and create a timeline using the *physical tools* of a measuring tape and a ruler. The task also fosters positive *dispositions*, as evidenced by students putting the timeline on the notice board and wanting to sign their names on it because "they were all really proud of it". However, the opportunity for students to develop a *critical orientation* was limited because of the highly structured way that Karen implemented the task. Although students must decide on an appropriate scale and make a transition from measuring in metres to centimetres to millimetres, there was little opportunity for individual students to decide on scale and justify their choice. In the lessons that follow students will study the formation of the continents. Karen has diagrams that illustrate the positions of the continents at significant times in their development. She plans to place these on the timeline to enrich students' understandings the history of the Earth.

Other lessons that were observed included Karen getting students to draw a scaled diagram of the structure of the Earth to overcome the "common misconception that the crust we dig into all the time is really thick and protective", and using a simulation to model radioactive decay.

Discussion

Karen's pre-service education and lack of formal professional development opportunities suggest that her knowledge domain may have limited MCK and PCK, although her participation in the *Numeracy Project* and the mentoring provided by her immediate supervisors may support growth in this area. Within the affective domain Karen's personal conception of numeracy, as expressed during interviews, focuses on *mathematical knowledge* and *contexts*, only two of the five elements in the numeracy model (Goos et al., 2011). She believes that numeracy exists in science but she did not fully exploit the numeracy learning opportunity she had identified within the science curriculum through the activity described above, perhaps because of her personal conception of numeracy and/or limited PCK for designing activities that promote numeracy learning. When prompted, Karen acknowledged that students used representational and physical *tools*, the table and measuring instruments, respectively and that the task supported positive *dispositions* towards the use of mathematics; however, she did not appear to have considered these aspects of the task when she was planning the lesson.

Mentoring from her immediate supervisors and her interactions with students constitute the social domain for Karen. While the former supports development of her identity as a teacher of numeracy, the student characteristics she described are a constraint on what she feels she is able to do in the classroom and result in her teacher-centred approach. Coupled with her lack of confidence in some areas of teaching numeracy, this limits her ability to provide students with opportunities to develop a *critical orientation* and build their confidence in using mathematics, taking risks, and displaying initiative (*dispositions*). As an early career science teacher, Karen's life history domain mainly comprises her pre-service education and initial teaching experiences. She has had limited opportunities to develop her MCK and PCK through education (both pre-service and in-service) and within the classroom but is keen to do so as evidenced by her willingness to participate in the *Numeracy Project*.

The analysis presented here illustrates that it is possible to use Karen's case study to "fill in" the domains of influence present in the conceptual framework for identity as a teacher of numeracy. However, it is also apparent from the analysis that there are some factors that influence Karen's identity as a teacher of numeracy that are beyond her control and not part of her knowledge, affective, social, or life history domains. These elements include the structure of the school day, availability of computer resources, and the school focus on numeracy across the curriculum. For example, only seeing students three times a week coupled with the high level of absenteeism presents Karen with a dilemma. She conceded that the tasks that were observed took much longer that she expected and while she saw value in using them, she must also ensure that she *covers the content*. Therefore the conceptual framework provides a partial picture of Karen's identity as a teacher of numeracy and there is a need to situate the domains of influence in the framework within a fifth domain that accounts for these factors – a contextual domain.

Concluding Remarks

If the objectives of the Australian Curriculum (ACARA, 2012) and the Australian Professional Standards for Teachers (AITSL, 2012) are to be realised, it will be important for all teachers to develop an identity as a teacher of numeracy. In order to assist teachers to develop such an identity, it is first necessary to understand this construct. Drawing on data

collected in the first year of a two-year study that seeks to develop such an understanding, a preliminary evaluation of the conceptual framework developed for the study (see Bennison & Goos, 2013) is provided. A case study of Karen, an early career secondary science teacher, is presented and her identity as a teacher of numeracy is described in terms of her knowledge, affective, social, and life history domains. Testing the conceptual framework with empirical data has illustrated that it can be effectively used to describe identity as a teacher of numeracy. However, the analysis has also highlighted the need to set the four domains of influence within a contextual domain. This additional domain recognises the influence that factors outside Karen's direct control have on her identity as a teacher of numeracy. Further work is needed to develop this case study and those of the other teachers participating in the study. This will enable the identity as a teacher of numeracy of each of the teachers to be described, as well as allow ongoing evaluation of the conceptual framework. Cross-case analysis can then be used to identify similarities and differences between the teachers, and thus gain a better understanding of identity as a teacher of numeracy.

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