Auditing the Numeracy Demands of the Australian Curriculum

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Numeracy is a general capability to be developed in all learning areas of the Australian Curriculum. We evaluated the numeracy demands of the F-10 curriculum, using a model of numeracy that incorporates mathematical knowledge, dispositions, tools, contexts, and a critical orientation to the use of mathematics. Findings of the history curriculum audit, presented in this paper, highlight the distinction between the numeracy demands and opportunities of the curriculum, and uncover mismatches between claims made about numeracy in the curriculum materials.

The term *numeracy* is used in many English-speaking countries to describe the capacity to deal with quantitative aspects of life. *Quantitative literacy* and *mathematical literacy* are alternative terms that have similar meaning to numeracy. Steen (2001) proposed that the elements of quantitative literacy include: confidence with mathematics; appreciation of the nature and history of mathematics and its significance for understanding issues in the public realm; logical thinking and decision-making; use of mathematics to solve practical everyday problems in different contexts; number sense and symbol sense; reasoning with data; and the ability to draw on a range of prerequisite mathematical knowledge and tools. Many of these elements are also visible in the Programme for International Student Assessment definition of mathematical literacy as:

> an individual's capacity to identify and understand the role mathematics plays in the world, to make well-founded judgments, and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen. (Organisation for Economic Cooperation and Development, 2004, p. 15)

The idea of numeracy is not new. The term first appeared in the Crowther Report of 1959 (Ministry of Education, 1959), and many subsequent reports and investigations in Australia have emphasised the importance of numeracy as a key to social and economic well-being (e.g., Council of Australian Governments, 2008; DETYA, 2000; Vincent, Stephens, & Steinle, 2005). Steen (2001) insists that, for numeracy to be useful to students, it must be learned in multiple contexts and in all school subjects, not just mathematics. Although developing numeracy across the curriculum is a notion that has so far gained little ground in Australia (Thornton & Hogan, 2004), the introduction of the Foundation-Year 10 (F-10) Australian Curriculum may provide new impetus to tackle this important issue.

The Australian Curriculum, currently being developed for the learning areas set out in the *Melbourne Declaration on Educational Goals for Young Australians* (MCEETYA, 2008), identifies numeracy as one of seven general capabilities that apply across all discipline content, not just in mathematics. Version 3.0 of the Australian curriculum (ACARA, 2012a) offers some support for recognising the numeracy demands of different learning areas, for example, by providing a numeracy learning continuum together with icons and filters that link numeracy capabilities to relevant curriculum content. Yet the Australian Curriculum still lacks a theoretically informed model for characterising numeracy, and as a result teachers have little guidance in recognising the numeracy

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demands of subjects other than mathematics and in embedding numeracy learning opportunities across the whole curriculum.

This paper reports on the early stages of a project that will implement, evaluate, and refine a rich model of numeracy across the curriculum. The aim of the paper is to demonstrate how the numeracy model can be used to evaluate the numeracy demands and opportunities of learning areas in the F-10 Australian Curriculum. We present an initial numeracy audit of the *Australian Curriculum: History* and compare the findings with claims made about numeracy in the published curriculum documents.

Numeracy Model

Elsewhere we have argued that researchers and educators need to embrace a description of numeracy that recognises the intellectual, affective, contextual, and technological demands of becoming a numerate person in the 21st century (Geiger, Goos, & Dole, 2011a; Goos, Dole, & Geiger, 2011). We developed the model shown in Figure 1 to affirm the value of current definitions of numeracy (e.g., Australian Association of Mathematics Teachers, 1997), while introducing a greater emphasis on tools as mediators of mathematical thinking and action (Sfard & McClain, 2002) and a critical orientation to the ways mathematics is used to support arguments and influence opinions (Jablonka, 2003). Our previous research demonstrated how the model provided teachers with an instrument for planning and reflection, and how it could be used to analyse changes in teachers' classroom practice and personal conceptions of numeracy (Geiger, Goos, & Dole, 2011b; Goos, Geiger, & Dole, 2011). The elements of the model are summarised in Table 1 and elaborated below.

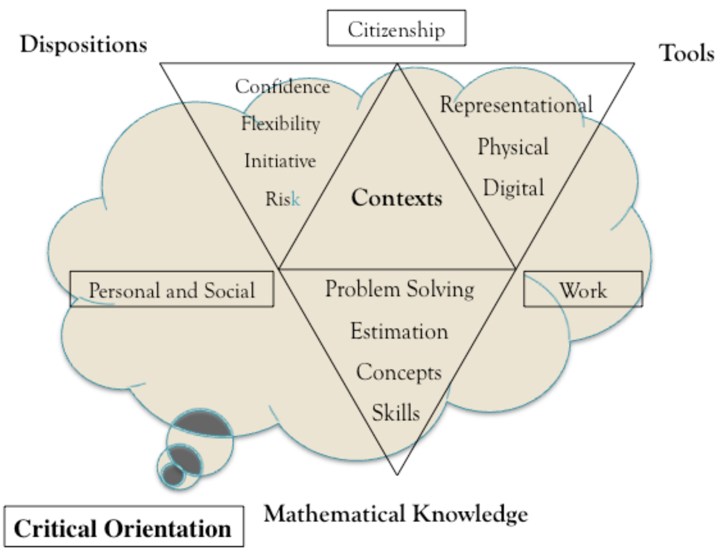

Figure 1. A model for numeracy in the 21st century.

A numerate person requires *mathematical knowledge*. In a numeracy context, mathematical knowledge includes not only concepts and skills, but also problem solving strategies and the ability to make sensible estimations (Zevenbergen, 2004).

A numerate person has *positive dispositions* – a willingness and confidence to engage with tasks, independently and in collaboration with others, and apply their mathematical knowledge flexibly and adaptively. Affective issues have long been held to play a central role in mathematics learning and teaching (McLeod, 1992), and the importance of developing positive attitudes towards mathematics is emphasised in national and international curriculum documents (e.g., National Council of Teachers of Mathematics, 2000; National Curriculum Board, 2009).

Table 1
Description of Elements of the Numeracy Model

Element	Description
Critical orientation	Use of mathematical information to: make decisions and judgements; add support to arguments; challenge an argument or position.
Contexts	Capacity to use mathematical knowledge in a range of contexts, both within schools and beyond school settings.
Dispositions	Confidence and willingness to use mathematical approaches to engage with life-related tasks; preparedness to make flexible and adaptive use of mathematical knowledge.
Mathematical knowledge	Mathematical concepts and skills; problem solving strategies; estimation capacities.
Tools	Use of material (models, measuring instruments), representational (symbol systems, graphs, maps, diagrams, drawings, tables, ready reckoners) and digital (computers, software, calculators, internet) tools to mediate thinking.

Being numerate involves using *tools*. Sfard and McClain (2002) discuss ways in which symbolic tools and other specially designed artefacts “enable, mediate, and shape mathematical thinking” (p. 154). In school and workplace contexts, tools may be representational (symbol systems, graphs, maps, diagrams, drawings, tables, ready reckoners), physical (models, measuring instruments), and digital (computers, software, calculators, internet) (Noss, Hoyles, & Pozzi, 2000; Zevenbergen, 2004).

Because numeracy is about using mathematics to act in and on the world, people need to be numerate in a range of *contexts* (Steen, 2001). All kinds of occupations require numeracy, and many examples of work-related numeracy are specific to the particular work context (Noss et al., 2000). Informed and critical citizens need to be numerate citizens. Almost every public issue depends on data, projections, and the kind of systematic thinking that is at the heart of numeracy. Different curriculum contexts also have distinctive numeracy demands, so that students need to be numerate across the range of contexts in which their learning takes place at school (Steen, 2001).

This model is grounded in a *critical orientation* to numeracy since numerate people not only know and use efficient methods, they also evaluate the reasonableness of the results obtained and are aware of appropriate and inappropriate uses of mathematical thinking to analyse situations and draw conclusions. In an increasingly complex and information drenched society, numerate citizens need to decide how to evaluate quantitative, spatial or probabilistic information used to support claims made in the media or other contexts. They also need to recognise how mathematical information and practices can be used to persuade, manipulate, disadvantage or shape opinions about social or political issues (Jablonka, 2003).

Curriculum Audit Methodology

The numeracy audit used a similar approach to that employed in our earlier audit of the South Australian Curriculum, Standards and Accountability Framework (see Goos, Geiger, & Dole, 2010). Each member of the research team independently read the full text of the *Australian Curriculum: History* (ACARA, 2012b) and evaluated its numeracy demands by reference to one of the elements of the numeracy model shown in Figure 1: mathematical knowledge, contexts, dispositions, or tools. The team met for a full day to discuss each person's findings and to collectively identify evidence of a critical numeracy orientation in the curriculum document. Evidence addressing each element of the model was sought from the curriculum aims, rationale, description of content structure, statement of general capabilities, statement of links to the Mathematics learning area, and from the F-10 year level descriptions, content descriptions and elaborations. We also consulted the statement of *General Capabilities in the Australian Curriculum* (ACARA, 2012c) to become familiar with the nature and scope of the numeracy general capability and the organising elements of the numeracy learning continuum. The audit is qualitative rather than quantitative in that numeracy-related aspects of the published history curriculum are interpreted in terms of our numeracy model, without the need to assign scores or codes that can be counted. Initial findings of the audit are organised around the elements of our numeracy model.

Numeracy in the History Curriculum

Critical Orientation

The curriculum rationale explains that "history is a disciplined process of inquiry into the past" (ACARA, 2012b, p. 3), and one of the aims of the curriculum is for students to develop a capacity to undertake historical inquiry. The general capabilities section further claims that "critical thinking is essential to the historical inquiry process" (p. 10). The framework for developing students' historical knowledge and understanding is provided by inquiry questions set out for each year level, for example:

- How did Australian society change throughout the twentieth century?
- Who were the people who came to Australia? Why did they come? (Year 6)

It is apparent that a critical orientation to inquiry characterises the methods and procedures of history as it is represented in the Australian Curriculum. Skills used in the process of historical inquiry include some with a mathematical basis, such as chronology. However, the extent to which students are asked to use *mathematical* information to support the process of inquiry is at the discretion of the teacher: the numeracy demands here are not explicit, but rather depend on the learning opportunities that the teacher creates.

Contexts

In the *Australian Curriculum: History*, context is one of the organising devices for teaching the key historical concepts of evidence, continuity and change, cause and effect, significance, perspectives, empathy and contestability. Curriculum contexts become progressively broader throughout the years from Foundation to Year 10, moving from family, friends, and school to the local community and then national and international contexts. There is also scope for content to be taught using specific local contexts that align with students' own lives and interests. The curriculum explicitly identifies contexts for studying history, and it is not surprising that the numeracy demands of these contexts are not fully elucidated, beyond some examples accompanying the numeracy learning continuum. It is up to the teacher to create opportunities for students to use their mathematical knowledge in a range of historical contexts.

Dispositions

The *Australian Curriculum: History* supports discipline-specific dispositions by encouraging students to develop empathy for others and explore the perspectives, beliefs, and values of different societies and cultures. Activities that assist in cultivating these dispositions may well involve numeracy, but teachers would need to ensure that students also gain confidence in using appropriate mathematical knowledge and skills, and are able to apply these flexibly to investigate historical questions. Students' enjoyment of studying history does necessarily translate into a positive disposition to mathematics, and teachers may need to plan purposefully for numeracy learning opportunities that build mathematical confidence as well as historical empathy.

Mathematical Knowledge

Within the general capabilities section of the *Australian Curriculum: History*, numeracy is described as follows:

> Students develop numeracy capability as they learn to organise and interpret historical events and developments. Students learn to analyse numerical data to make meaning of the past, for example to understand cause and effect, and continuity and change. Students learn to use scaled timelines, including those involving negative and positive numbers, as well as calendars and dates to recall information on topics of historical significance and to illustrate the passing of time. (ACARA, 2012b, p. 10)

While this statement seems limited in its reference only to data analysis and time as key aspects of mathematical knowledge that support historical inquiry, the section of the curriculum with links to the Mathematics learning area proposes additional possibilities:

> Much of the evidence and reasoning in historical understanding is quantitative: chronology, demography, economic activity, changes in the movement of peoples and in the size and reach of institutions. All of these call for an appreciation of numerical scale and proportion. (ACARA, 2012b, p. 13)

In our analysis of the content descriptions and elaborations we found evidence, in most year levels, of use of mathematical knowledge for chronology and mapping of settlement and movement patterns, such as:

- <u>Sequencing</u> people and historical events, developments and periods in chronological order by developing an annotated timeline;
- <u>Mapping</u> settlement patterns in different regions, noting factors that shaped these patterns (e.g., geographical features, climate, water resources, transport);
- <u>Mapping</u> movement patterns of humans during historical periods (e.g., the movement of humans out of Africa, the transatlantic slave trade).

There is also an emphasis on data representation and interpretation (e.g., investigating the impact of the Industrial Revolution on population growth and distribution), and some evidence of use of measurement concepts (e.g., investigating how the pyramids of Gizeh were built). We characterise these explicit statements found in content descriptions or elaborations as indicating the numeracy *demands* of the curriculum. Numeracy demands are "tagged" by the numeracy icon found in the published curriculum and can be identified by applying the numeracy filter in the online version of the curriculum. However, it is also possible to recognise numeracy learning *opportunities*, or possibilities for treating the content that may depend on the teacher's choice of activities and are therefore not identified via this filtering process. Examples are provided in Table 2. The numeracy learning continuum (ACARA, 2012c) also offers examples of mathematical knowledge and skills that can be used in the study of history.

Table 2
Examples of Numeracy Learning Opportunities in the Australian Curriculum: History

History content	Related Mathematics content
Identifying the influence of cultural groups in the community as reflected in architecture and religious buildings (Year 3)	Geometry: make models of three-dimensional objects and describe key features (Year 3)
Identifying the reasons why people migrated to Australian in the 1800s, for example, those dislocated by events such as the Irish Potato Famine (Year 5)	Statistics: construct suitable data displays (e.g., of potato production, migration figures) from given or collected data, (Year 4)
Describing the importance of the River Nile to Egyptian society, such as through inundation and farming (Year 7)	Statistics: interpret and compare a range of data displays (e.g., rainfall) (Year 6)
Investigating the changes in working conditions during the Industrial Revolution, such as longer working hours for low pay and the use of children as a cheap source of labour (Year 9)	Statistics: identify and investigate issues involving numerical data collected from primary and secondary sources (Year 7)

Tools

Maps and timelines are the most common representational tools referred to in the *Australian Curriculum: History*. Maps are used to investigate settlement and movement patterns, and the size and influence of institutions such as the British Empire. Timelines are mentioned in almost every year level because of the importance of chronology in historical inquiry. Both of these tools require understanding of scale and proportion and, as mentioned previously, this is acknowledged in the section of the curriculum where links to the Mathematics learning area are discussed. However, nowhere in the content descriptions or elaborations is the importance of scale highlighted. In particular, timelines are used only to sequence people, events and historical periods rather than to indicate the time between events or their duration. This is surprising, not only because of the mathematical flaws in timelines that are not to scale, but also because such timelines do not allow certain objectives of the history curriculum to be achieved. For example, in Year 7 students learn about a range of societies in the ancient world. They are meant to use a timeline to identify the longevity of each civilisation, but this is not possible without attention to scale. Thus there is inconsistency between the content descriptions throughout the curriculum and the numeracy general capability statement that claims students "learn to use scaled timelines … to illustrate the passing of time" (ACARA, 2012b, p. 13).

Digital tools are mostly referred to as a means of representing and communicating ideas. Only one instance was found where there was explicit reference to using technology to analyse data: in Year 6, where it is suggested that students should process and record population data showing places of birth of Australia's people at different times in the past and today. However, although the numeracy *demands* of the curriculum appear to be under-represented with respect to digital tools, there are many other numeracy learning *opportunities*; for example, students can collect secondary data from websites and create data displays using Excel spreadsheets and charts to interpret historical events or support arguments based on this analysis of sources.

Conclusion

This initial audit of the *Australian Curriculum: History* suggests that history can provide an engaging and meaningful context for developing students' numeracy capabilities, and mathematics can provide analytical tools to support historical inquiry. However, the audit uncovered two issues – one specific to the history curriculum and another that applies to the Australian Curriculum in general. The first concerns the lack of alignment between claims about numeracy development in the different sections of the history curriculum (ACARA, 2012b), and the second is the materials associated with the numeracy learning continuum (ACARA, 2012c). According to some parts of the curriculum, creating timelines to make meaning of the past is meant to help students develop an understanding of *scale and proportion*, and yet the content descriptions focus exclusively on *sequencing* of people and events as the only skill involved in chronology. The second issue highlights the need to distinguish between the numeracy *demands* and numeracy learning *opportunities* in each learning area. While the curriculum explicitly identifies numeracy demands via use of icons and online filters, additional opportunities for developing students' numeracy capabilities are invisible unless one knows how to "see" them. The numeracy learning continuum offers glimpses of such opportunities by identifying mathematical knowledge and skills related to the learning area content, and contextualising these through examples (ACARA, 2012c). But numeracy involves more than mathematical knowledge and contexts: we have argued that tools, dispositions, and a critical orientation are also important. Our theoretical model directs attention to all these aspects of numeracy and provides a lens through which a clearer view of the numeracy learning demands and opportunities of the Australian Curriculum can be gained.

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