Exploring the Demands and Opportunities for Numeracy in the Australian Curriculum: English

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Numeracy is a fundamental component of the Australian National Curriculum as a General Capability identified in each F-10 subject. In this paper we report on an aspect of a larger project aimed at investigating how effective cross-curricular numeracy practice can be implemented within the context of the Australian National Curriculum. Specifically, we draw on a numeracy audit of the English curriculum and on data collected via a semi-structured teacher interview to explore the numeracy demands and opportunities that exist in the teaching of English. Despite limited guidance for teachers in how to take advantage of numeracy skills within English, our investigation reveals that multiple opportunities to do so abound.

Numeracy is a fundamental component of the Australian school curriculum – in all subjects, not only mathematics. Being numerate involves more than mastering basic mathematics, because numeracy connects the mathematics learned at school with out-of-school situations that additionally require problem solving, critical judgment, and making sense of the non-mathematical context. The social burden of innumeracy is far-reaching (Paulos, 1988). Poor numeracy, more so than low levels of literacy, has been found to severely limit successful transitions from school and subsequent work opportunities, contributing to low self-esteem, poor health prospects, and lack of social and political participation (Bynner & Parsons, 2007; Council of Australian Governments, 2008). Thus, achieving an adequate level of numeracy is a basic right of all students exiting compulsory schooling.

The importance of a cross-curricular approach to the development of students' numeracy skills and capacities is emphasised by Steen who argues that in order for numeracy learning to be effective it must take place in multiple contexts and in all school subjects, not just mathematics (Steen, 2001). The view that students' development in numeracy requires a cross-curricular commitment by schools and systems is reinforced by a review of numeracy education undertaken by the Australian government (Council of Australian Governments, 2008) recommending:

> That all systems and schools recognise that, while mathematics can be taught in the context of mathematics lessons, the development of numeracy requires experience in the use of mathematics beyond the mathematics classroom, and hence requires an across the curriculum commitment. (p. 7)

A binding commitment to cross-curricular and contextual approaches to numeracy teaching and learning is embedded in the Australian Curriculum as numeracy is included as a General Capability in all subjects and is described in the following way.

In V. Steinle, L. Ball & C. Bardini (Eds.), Mathematics education: Yesterday, today and tomorrow (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia). Melbourne, VIC: MERGA.

> Students become numerate as they develop the knowledge and skills to use mathematics confidently across all learning areas at school and in their lives more broadly. Numeracy involves students in recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully.
>
> (Australian Curriculum, Assessment and Reporting Authority, 2013, p. 13)

Additional subject specific numeracy statements are also included within each Australian National Curriculum document. These statements, and the statements of content and elaborations within the curriculum documents, however, provide limited guidance on the numeracy specific demands of topic areas within subjects, and little advice on the numeracy opportunities that teachers might exploit.

This paper reports on the early stages of a project which aims to investigate the potential for improving numeracy teaching practice and student numeracy learning across the curriculum through the implementation of a program based on a rich model of numeracy. The specific purpose of this paper is to demonstrate how rich numeracy practice can be designed, and be manifest within the subject of English. We begin by presenting an outline of the numeracy model we developed to synthesise and extend previous work in this area and we have validated through a series of research projects. This is followed by a brief summary of a numeracy audit of the Australian Curriculum: English. An outline of the research methodology is then presented. A classroom vignette drawn from Year 9 English is analysed with reference to the numeracy model. Findings are then summarised and followed in a discussion of the implications for teachers.

Theoretical Framework

Current definitions of numeracy do not convey the type of reasoned action necessary to transform what is intended within curriculum documents into what is enacted in school classrooms. More recently, however, Goos (2007) proposed a model of numeracy (Figure 1) that encompasses four essential elements: attention to real-life contexts; the deployment of mathematical knowledge; the use of representational, physical and digital tools; and consideration of students' dispositions towards the use of mathematics. The development of a critical orientation is also emphasised in relation to numeracy practice, for example, the capacity to evaluate quantitative, spatial or probabilistic information used to support claims made in the media or other contexts. While the model was initially intended to inform teachers of the multi-dimensional nature of numeracy and so influence numeracy teaching practice, it evolved as a synthesis and extension of relevant research as set out below.

At the centre of the concept of numeracy is the key dimension of *context*. Typically, when mathematics is used in a context it is applied in a way different from how it is traditionally taught in school (Straesser, 2007), and so to learn to be numerate individuals must be exposed to using mathematics in a range of contexts (Steen, 2001).

Appropriate *mathematical knowledge* is required to act on problems within a given context. In a numeracy context, *mathematical knowledge* includes not only concepts and skills, but also higher order thinking such as problem solving strategies and the ability to make sensible estimations (Zevenbergen, 2004). How to interpret a problem from outside of mathematics in a mathematical way, and then how to choose which mathematical knowledge needs to be selected to engage with a mathematised problem, is a challenge that lies at the interface of *contexts* and *mathematical knowledge*.

The desire and confidence to apply mathematics in real world contexts is related to the *disposition* of an individual towards making use of mathematics. Gresalfi and Cobb (2006)

argue that it is not sufficient to focus only on the mathematical skills and capacities we want students to learn, but that teaching must take place with students' dispositions in mind if students are to develop an affinity with a discipline. These dispositions include not just confidence with mathematics but a willingness to think flexibly, to show initiative, and to take risks.

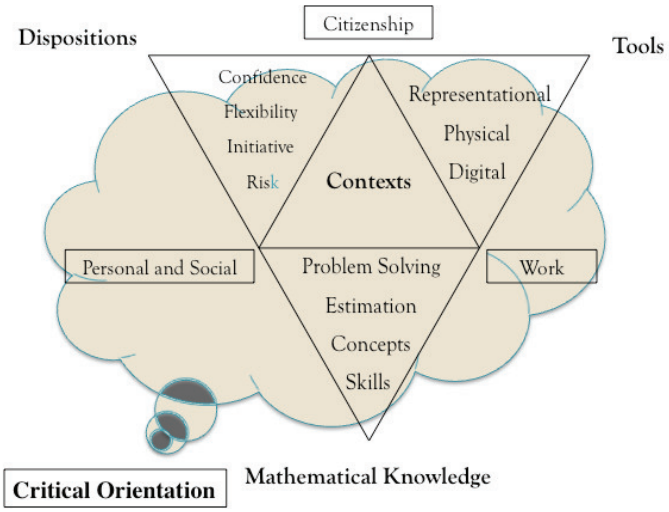

Figure 1. A model for numeracy in the 21st century (Goos, 2007).

An increasing number of studies identify tools as mediators of meaning making, reasoning, and action in relation to mathematical learning (e.g., Pea, 2004; Verillon & Rabardel, 1995). In school and workplace contexts, tools may be representational (symbol systems, graphs, maps, diagrams, drawings, tables, ready reckoners) and physical (models, measuring instruments), but increasingly tools are digital (e.g., Goos, Galbraith, Renshaw, & Geiger, 2003).

The elements of the Goos (2007) model are embedded in a critical orientation of the use of mathematical skills and concepts which emphasise the evaluative and judgemental aspects of numeracy practice. We view this critical orientation as a vital capacity for informed and participatory citizenship and for exercising effective and socially conscious decision making in an individual's personal life. This position is also consistent with that of Frankenstein (2001) and Jablonka (2003) who argue for the need to recognise how mathematical information and practices can be used to persuade, manipulate, disadvantage or shape opinions about social or political issues. The elements of the model and the critical orientation within which these elements interact are summarised in Table 1.

This model has been validated through a series of research projects related to improving teaching numeracy practices, has been used as a framework to audit school curricula (Goos, Dole, & Geiger, 2012; Goos, Geiger, & Dole, 2010) and also to analyse teachers' attempts to design for the teaching of numeracy across the curriculum (Goos, Geiger, & Dole, 2011).

Table 1
Descriptions of the elements and critical orientation of the numeracy model

Mathematical knowledge	Mathematical concepts and skills; problem solving strategies; estimation capacities.
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.
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 and shape thinking
Critical orientation	Use of mathematical information to: make decisions and judgements; add support to arguments; challenge an argument or position.

Methodology

The data presented in this paper are drawn from one aspect of a larger project aimed at investigating the potential of teacher professional learning opportunities based on a rich model of numeracy (Goos, 2007), and for enhancing cross-curricular numeracy teaching and learning practices. Teachers were recruited from 8 schools, 4 in Queensland and 4 in Victoria. Schools were selected with the intention of balancing sectors, socio-economic status and location (metropolitan versus regional). Schools nominated classes of students from Years 3 to 9 to participate in the project.

The project was initiated with a numeracy audit of the Australian Curriculum in the subjects English, History, Mathematics and Science. The audit was conducted using an approach piloted in our earlier work (Goos, Dole, & Geiger, 2012; Goos, Geiger, & Dole, 2010). Members of the research team were assigned an element of the numeracy model (contexts, dispositions, mathematical knowledge, tools or critical orientation) that they used as a lens for interrogating the published curriculum for at least two subjects. Evidence for the manifestation of each element of the numeracy model was obtained by scrutinising 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 of each curriculum document. The team met for a full day to share and discuss each member's findings. The audit is qualitative rather than quantitative as it interprets the numeracy richness of each curriculum document by determining how aspects of each coalesce around the elements of the numeracy model rather than the accumulation of numerical scores.

The design of the research and development component of the project was underpinned by the Loucks-Horsley, Love, Stiles, Mundry, and Hewson (2003) framework for teacher professional development. Teachers came together for an initial meeting to develop an understanding of the numeracy model and to participate in activities that exemplified and elaborated on ideas in the model. After this meeting, teachers returned to their schools to trial activities presented at the workshop with their own students, or developed and implemented activities of their own based on the numeracy model. Members of the research team then visited project teachers in their schools to observe lessons teachers

designed to highlight at least some aspect of numeracy, and to interview teachers about their initial experiences of implementing numeracy "active" tasks in mathematics and in other subjects.

The analysis and discussion presented in this paper are based on an audit of the Australian Curriculum: English, on data drawn from the transcript of a semi-structured interview of a teacher reporting on a recently conducted English lesson, as well as the PowerPoint presentation the teacher used to structure her lesson.

An Audit of the Australian Curriculum: English

While the restriction on space prevents the presentation of a detailed audit of the Australian Curriculum: English, we offer the following observations based on our analysis of this curriculum document. The curriculum includes a numeracy statement specific to the subject English as a General Capability (Australian Curriculum, Assessment and Reporting Authority, 2013) in which the potential use of numeracy skills "when interpreting, analysing and creating texts" and for presenting "issues or arguments based on data" (p. 13) are noted. Further, "Visual texts may present a range of numeracy demands" (p. 13) including the capacity to examine the relationships between constituents of a context. The principles identified in this statement, however, receive limited attention through the body of the document itself. The section devoted to *Links to other learning areas: Mathematics*, for example, makes reference to general concept terms in mathematics such as space and time, but rarely to specific mathematical knowledge. The Numeracy Continuum included with this curriculum makes reference to mathematical content, for example, decimal, percentages, and ratios without clearly identifying where this knowledge is relevant to the specific content and processes essential to English.

In summary, while the curriculum document provides a statement that gives teachers permission to incorporate numeracy skills into the teaching of English, there is little discipline specific advice about how to structure pedagogy in order to achieve this outcome.

A Numeracy Enhanced English Lesson

Andrea, a member of the literacy and numeracy support team within her school, described a lesson with her Year 9 English class. Her aim for the lesson was to develop her students' capacity to deconstruct advertisements and, in particular, to understand the various visual devices used by the media to promote the sale of products. At the beginning of the lesson, Andrea presented her class with the following expectations of what they would learn in order to provide structure for the activity that was about to take place.

- Written definition of: space, ratio, linear, juxtapose, foreground
- Two advertisement analyses identifying: target audience; what is fore-grounded; dominant reading; resistant reading; one ratio aspect; and one linear aspect

During the introductory phase of the lesson, Andrea revisited the concepts of ratio and shape then illustrated the application of these aspects of mathematics in a number of real life contexts. She then began an exploration of the visual device of foregrounding within the context of advertising.

> We talked about depth and the word foreground. I wanted the kids to to get the word foreground and what foreground means because that's in advertising. I wanted to look at shape and what role it plays in foregrounding images.

Andrea set her students the task of using the position of shapes on a computer screen to give the impression of depth on the display.

> We looked at 2d shapes – circles, and how can we make the image in an advertisement seem as though it is appearing further in front of other things, how it is foregrounded. So they got a natural understanding of the word foreground.

After allowing students time to explore the notion of foregrounding, Andrea provided an example of how this effect can be achieved with a s equence of overlapping circles (Figure 2).

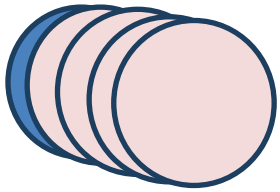

Figure 2. An example of the use of position to achieve the effect of foregrounding.

Andrea then made the connection between the geometrical expression of foregrounding to its use as a literary device by initiating a whole class discussion about prioritising and highlighting importance. In turn, this provided Andrea with the opportunity to introduce of the idea of juxtaposition. This concept was initially described to students via role play.

> I got one of the kids to hop up on the table and then make the most powerful pose she could. Then I crouched down on the ground like this [acting out her stance] and said 'I am subservient to you Emma, it is because her position she's juxtaposed to me, in a way that makes her seem like she's more powerful or greater than I am'. And so they got the natural understanding again for what juxtaposed meant.

After further discussion about juxtaposition, Andrea showed her class two shampoo advertisements (Figure 3) she had found in magazines around her house. The advertisements promoted different brands of shampoo and, as Andrea noted, were from different time periods – one from 2002 and the other very recent.

Andrea's students noted the similarity between the two promotions despite a difference in publication time of more than a decade. Andrea reported that her students were convinced the similarity of the two advertisements was due to a formula or standard procedure for promotions of this type. This allowed Andrea to instigate further discussion about juxtaposition and its association with ratios between colours and shapes. This led to an activity where students ruled squares across both advertisements and counted the number of squares of each different colour as well as white space. Ratios were then calculated for the coverage of each colour compared to the total number of squares for each advertisement. They discovered that the ratio of white space compared to citrus colours was "roughly the same" in both advertisements. This convinced students that their conjecture about the use of an underlying formula or procedure for generating such advertisements was correct.

At the end of the lesson, Andrea encouraged her students to make further observations about the similarities between the two advertisements. They drew attention to the central position and size of the models in both advertisements as well as the placement of the product name. They commented that position and placement are two devices used to foreground and prioritise a product so that it would be remembered.

> It's the last memory you have of it so when you go shopping you're looking for that. I thought that was interesting that they got to that

Figure 3. Examples of product promotions from two different eras.

In concluding the interview, the researchers asked Andrea where she had found the inspiration for the lesson. She said it was from the television program the Gruen Transfer – a program that deals with the deconstruction of advertising campaigns in a humorous way.

Discussion and Conclusion

Andrea's principal focus during the lesson described in this paper was on developing her students' understanding of the types of opinion influencing devices used by advertisers in the media. To achieve this aim, she assisted her students in making use of mathematical concepts and processes to deconstruct shampoo advertisements from different eras. This deconstruction emphasised the foregrounding and juxtaposing of different elements within these advertisements.

At the same time, Andrea addressed a range of numeracy opportunities through this deconstruction. She assisted her students to make use of *mathematical knowledge* within the *context* of an English lesson in which the literary devices of foregrounding and juxtaposing in promoting commercial products was investigated. In piquing students' interest by directing their attention to how they themselves might be being manipulated by the media, Andrea promoted students' *dispositions* towards the use of mathematics to explore a real world problem. This was achieved almost by stealth, as the primary focus of the lesson was English. Students made use of a variety of aspects of *mathematical knowledge* while engaging with the problem Andrea had set them: ratio; shape; proportion; perspective; and the language of location. The activity Andrea used to demonstrate how two-dimensional objects could be foregrounded and juxtaposed on the same plane made use of digital *tools* in the form of a computer and PowerPoint application. By challenging her students to look for any underlying principles that led to the similarities between shampoo advertisements of different eras, Andrea introduced a *critical orientation* into the activity. Students' use of a mathematical process to address this issue was carried out in a manner that blurred the boundaries between understandings in English and Mathematics.

While the Australian Curriculum: English provides little that teachers can identify as clear numeracy *demands*, the evidence presented in this paper indicates that numeracy *opportunities* abound in this subject. Given that Numeracy is a General Capability in each of the four subjects of the F-10 Australian National Curriculum, further research is necessary to identify where additional numeracy opportunities lie within English and also

in other subjects. Identifying such opportunities is a key to developing effective numeracy teaching and learning practice across the curriculum.

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