numeracy across the curriculum

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This series of articles tells the stories of four teachers who participated in a year long research and development project that developed strategies for teaching numeracy across the curriculum in the middle years of schooling. We will let the teachers tell their own stories, in their own voices. The purpose of this introductory article is to explain our model of numeracy and outline how the project was conducted.

Numeracy for the 21st century

The idea of numeracy is a relatively recent one. The term was first introduced in the UK by the *Crowther Report* (Ministry of Education, 1959) and was defined as the mirror image of literacy, but involving quantitative thinking. Another early definition proposed by the *Cockcroft Report* (Cockcroft, 1982) described being numerate as possessing an at-homeness with numbers and an ability to use mathematical skills to cope confidently with the practical demands of everyday life.

Although numeracy is a term used in many English speaking countries, such as the UK, Canada, South Africa, Australia and New Zealand, in the USA and elsewhere it is more common to speak of quantitative literacy or mathematical literacy. Steen (2001) described quantitative literacy as the capacity to deal with quantitative aspects of life, and proposed that its elements included: 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. The Organisation for Economic Cooperation and Development (OECD) (2004) PISA program offers a similarly expansive 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. (p. 15)

Steen (2001) maintains that, for numeracy to be useful to students, it must be learned in multiple contexts and in all school subjects, not just mathematics. This is a challenging notion, but the review of numeracy education undertaken by the Australian government (Human Capital Working Group, Council of Australian Governments, 2008) concurred, 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)

In Australia, educators and policy makers have embraced a broad interpretation of numeracy similar to the OECD definition of mathematical literacy. The definition proposed by a 1997 national numeracy conference, "To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life (Australian Association of Mathematics Teachers, 1997, p. 15), became widely accepted in Australia and formed the basis for much numeracy-related research and curriculum development.

The recently released version of the Australian Curriculum: Mathematics (V 3.0) includes numeracy as one of the General Capabilities that must be observed while teaching and learning mathematics stating:

> In the Australian Curriculum, 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, 2012)

However, we would argue that a description of numeracy for new times needs to better acknowledge the rapidly evolving nature of knowledge, work, and technology (Goos, 2007). We developed the model shown in Figure 1 to represent the multifaceted nature of numeracy in the twenty-first century. This model was designed to capture the richness of current definitions of numeracy while introducing a greater emphasis on tools as mediators of mathematical thinking and action. The model was intended to be readily accessible to teachers as an instrument for planning and reflection (Goos, Dole & Geiger, 2011a; Geiger, Goos & Dole, 2011b) and has been used as a framework to audit mathematics curriculum designs (Goos, Geiger &

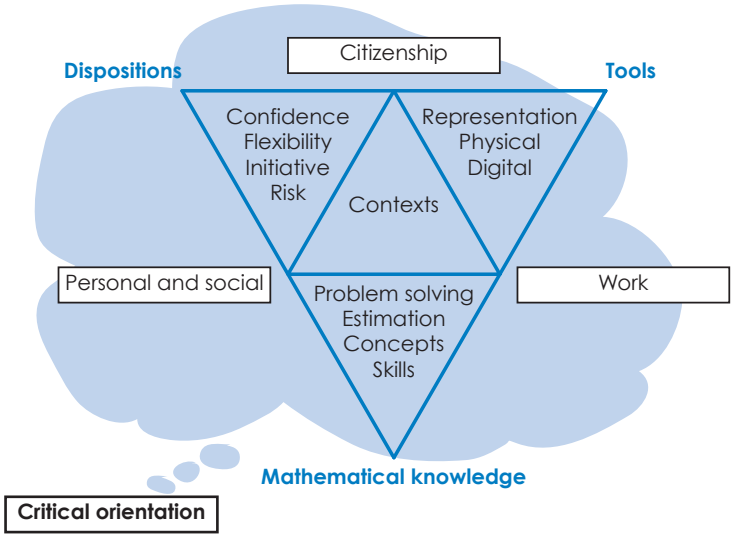

Figure 1. A model for numeracy in the 21st century (two dimensional).

Dole, 2010); however, its development was also informed by relevant research, as outlined below.

A numerate person requires mathematical knowledge. This 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. 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; OECD, 2004).

Being numerate involves using tools. In school and workplace contexts, tools may be representational (symbol systems, graphs, maps, diagrams, drawings, tables, ready reckoners), physical (models, measuring instruments), and/or 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). A numerate person can organise their finances, make decisions affecting their personal health, and engage in leisure activities that require numeracy knowledge. All kinds of occupations require numeracy. Many examples of work-related numeracy are specific to the particular work context, and often the mathematics used is either invisible to the user or is used in different ways from how mathematics is taught at school (Noss et al., 2000). Informed citizenship depends on the ability to interpret data, make projections, and engage in 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 rich 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 (Frankenstein, 2001).

Although the model is represented in two dimensions in Figure 1, this can also be imagined as the net of a tetrahedron. So if you imagine folding along the lines formed by the sides of the inner triangle, a tetrahedron results (Figure 2). In this three dimensional representation, the all pervasive critical orientation is shown as a transparent sphere surrounding the tetrahedron.

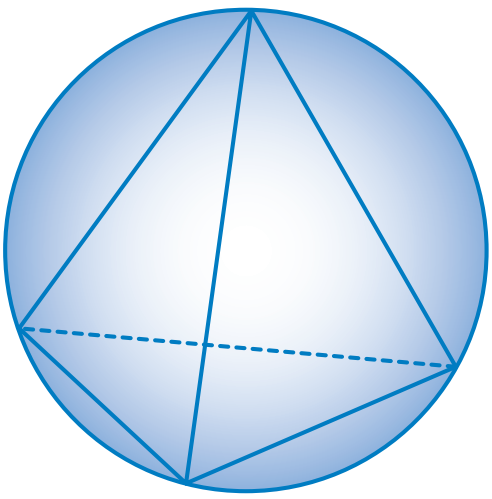

Figure 2. A model for numeracy in the 21st century (three dimensional).

The project

Ten pairs of teachers from ten schools in city, regional and rural locations in South Australia participated in the Numeracy in the Learning Areas Project funded through the South Australian Department of Education and Children s Services (DECS). These included primary schools, secondary schools, Area Schools in rural locations with Years 1 12, and a school with Years 6 12. The teachers had a range of subject specialisations and classroom teaching experience, from 30 years through to one year. Some currently held, or had previously undertaken, leadership positions in their schools as literacy coordinators, numeracy coordinators, Coordinators of the Middle School, Heads of Departments, or year level coordinators. They participated in three whole day professional development meetings in February, August, and November 2009, and two action research cycles between these meetings. The action research cycles comprised goal setting, curriculum planning that was guided by the numeracy model, implementing numeracy tasks and units of work, evaluating their effectiveness, and setting new goals for the next cycle. We visited all the teachers on two occasions, once during each action research cycle, to discuss their progress, observe lessons, and interview groups of students.

The outcomes

From our observations and discussions with all the teachers throughout the project, we could see that most teachers were comfortable with identifying the mathematical knowledge in the lessons and activities they offered students and expressed a desire to improve students dispositions. Initially they used only a limited range of tools to develop numeracy, but this improved over time, especially in relation to digital tools such as spreadsheets. Teachers recognised the importance of contexts as a distinguishing feature of numeracy and most made progress in incorporating numeracy rich contexts into their lessons. However, it was often a challenge for teachers to take advantage of unplanned numeracy moments , which suggests that it may be a challenge to see numeracy opportunities as they arise. Although initially there was little evidence of a critical orientation in lessons, this developed in some teachers after they worked with examples we provided. However, integrating a critical orientation into learning activities was the most challenging aspect of numeracy for most teachers.

At the start and end of the project, teachers completed a survey to self-assess their confidence in numeracy teaching in terms of the professional knowledge, professional practice, and professional attributes needed to support numeracy learning. The survey was based on the Numeracy Standards for Graduates of Pre-Service Teacher Education Programs published by the Queensland Board of Teacher Registration (2005). The Numeracy Standards, in turn, draw on the *Standards for Excellence in Teaching Mathematics in Australian Schools* formulated by the Australian Association of Mathematics Teachers (2006).

When we analysed survey responses, we found that teachers began the project with some confidence in their professional knowledge about numeracy, but lacked confidence in most aspects of professional practice for numeracy teaching (planning, teaching, assessing, creating an appropriate learning environment). By the end of the project, however, this group of teachers had experienced a substantial increase in confidence in almost all aspects of numeracy teaching.

The teacher stories

In the articles that follow, four teachers tell their numeracy stories. Each is different, but together they provide a powerful, and challenging, account of professional learning.

Acknowledgements

The Numeracy in the Learning Areas project was funded by the South Australian Department of Education and Children s Services. We are grateful to John Bleckly and Susan Miels for their collegiality and guidance throughout the project, and we thank all the teachers and students who shared their numeracy journeys with us.

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