

make your school's numeracy- across-the-curriculum policy

John Gough

Deakin University

<jugh@deakin.edu.au>

Has your school already made a literacy policy, and cleaned up its literacy-across-the-curriculum practices? If so, what about numeracy? What is “numeracy”? What is your school doing about numeracy; or what does your school intend doing about it? This paper considers steps towards a policy and practice.

Sketching a policy

Imagine a secondary school (although comparable arguments apply to primary schooling): a Numeracy Coordinator has been newly appointed to work alongside the existing Literacy Coordinator. The new Numeracy Coordinator has had some preliminary discussion with the Literacy Coordinator and some of the other staff, and has developed a draft school numeracy policy. This is now being presented to a meeting of all the teachers.

The challenge the Numeracy Coordinator faces is to state the draft policy clearly, explain it, justify its features, and illustrate its practical application with two or three well-chosen convincing examples. That is, the Numeracy Coordinator needs to convince the audience that:

- numeracy matters;
- numeracy is... this-and-that — whatever we agree we say it is (including *not* just “numberacy” — the number and computation and measurement stuff);
- *all* teachers, not just specialist mathematics teachers share responsibility for handling the numeracy needs of their students; and,
- all of this is sensible and feasible, and perhaps not much different from the school’s current practice, slightly refocussed, critically examined and supported, and re-expressed.

Such a draft school numeracy policy might look a little like the one over-leaf. I imagine this draft numeracy policy as a double-page briefing summary. One side of the A4 sheet contains policy dot-points including a definition of numeracy (with references, to give it formal academic authority) as well as statements such as:

Erehwon (Secondary) School Numeracy-Across-the-Curriculum Policy

Definition of numeracy

"Numeracy" is the use of primary school mathematics outside of mathematics classes, and outside of school, possibly including using mathematics in everyday situations at home and during recreation, and in common non-technical non-specialist workplace circumstances.

Rationale for whole school action

This definition of numeracy identifies the crucial importance of good mathematics knowledge and skills beyond the mathematics class, in other school subjects (Key Learning Areas — KLAs), and, beyond school, in family life, recreational time, and later adult working life. The broad demand for mathematics to be effectively and flexibly applied in a very wide range of circumstances requires *all* teachers, not just mathematics teachers, to take responsibility for ensuring students transfer mathematics-classroom learning to non-mathematics-classroom situations.

In accordance with Erehwon (Secondary) School's Vision Statement this school confirms the value of numeracy, alongside literacy, and other life-goals of schooling, and the development of locally, and globally humane, responsible citizens.

Policy

Teachers at Erehwon (Secondary) School will:

- integrate numeracy in all KLAs;
- take responsibility for teaching applied mathematics uses in non-mathematics KLAs;
- regularly coordinate the school's numeracy curriculum, instruction, and assessment across all KLAs;
- liaise with local primary feeder schools for Erehwon (Secondary) School students on issues of numeracy, primary mathematics curriculum, and primary-to-secondary transition generally;
- consult on numeracy issues with major business, community, recreational and family groups;
- develop professionally with regard to numeracy;
- assess the entry-level numeracy skills of all Erehwon (Secondary) School students;
- assess progressive development of skills in numeracy across the curriculum, as an integral part of assessment in each KLA;
- report on individual students' numeracy strengths and weaknesses; and,
- remediate students at-risk in important numeracy skills.

Practical exemplars

Use of mathematics (numeracy) in Language Skills, Communication, English, Literature, and Humanities, etc. Typical essential mathematics (numeracy) tasks in reading (many) books include:

- locating the historical, geographical, political, and cultural context of the content of the book;
- locating the historical, geographical, political, and cultural context of the author of the book (Who wrote it? Where? When? Why? What are the author's life and times?);
- using or making a map of the places mentioned in the book;
- using or making a time-line of events in the book;
- using or constructing a family tree for characters and their relationships;
- understanding and interpreting simple measurements (e.g., times, costs, distance, speed);
- understanding descriptions of machinery, rooms, and objects;
- logical reasoning and problem solving about cause and effect between events, and the nature and motivation of characters; and,
- clarifying successive ages of a character, or other durations of elapsed time

Consider, as a specific piece of English, or Literature curriculum, the award-winning young adult novel Melina Marchetta's *Looking for Alibrandi* (1992); or consider as a piece of Drama, Media or Multimedia curriculum, the popular and award-winning film version. The book, faithfully filmed, is about a Year 12 girl experiencing problems of end-of-secondary exams, parental expectations, youth suicide, single-parenthood, religious faith versus non-belief, separated parents, cultural conflict, migrant experience, convent schooling, personal relationships, and burgeoning sexuality. Oddly, given its late-adolescent concerns, the book and the film are widely prescribed at lower and middle secondary levels, and are well respected by teachers and adults.

Our reading of the book, or our watching of the film, is enriched *if* we have some awareness of where the grandmother came from, the social and cultural circumstances she left in Italy and encountered when she migrated to Australia. Similarly we need to have some historical awareness of Australia's changing cultures, to understand the convent school context, and the earlier stigma of illegitimacy contrasted with the increased public acceptance of single-parenting. Crucially the meaning of the book or film depends on a major piece of mathematical reasoning, applied in a biological context. If this is *not* understood, then we fail to understand the way the book solves one of its central problems; that is, mathematics is a *necessary* part of reading and understanding this book!

- this school values numeracy, alongside literacy, and other life-goals of schooling;
- numeracy is the responsibility of *all* teachers (generalists *and* specialists);
- all teachers are required to include some numeracy-related items in their formal assessment demands;
- all teachers will report on their students' numeracy skills in each KLA;
- teachers will meet X times a year to discuss and coordinate numeracy issues and particular student needs;
- teachers will engage in numeracy-related Professional Development (PD); and,
- all entering students (e.g., new, Preparatory, and Year 7 students) will be screened on entry, or before, to identify levels of numeracy skill, and identify any at-risk students, who will then be assigned extra remedial intervention;

and so on, but that probably covers everything a policy needs.

The other side of the A4 policy sheet could outline two or three non-mathematics-KLA curriculum examples that convincingly illustrate the way numeracy arises in a particular classroom activity, textbook exercise or project, either as an essential requirement for understanding the non-mathematics learning being considered, or as a way of expanding and enriching the understanding of this non-mathematics topic. Each of these curriculum examples should be from one of the school's textbooks or equivalent school materials.

These examples will be preferably at lower secondary or middle secondary level, rather than at secondary-exit level. Why? Inevitably, given the formal specialised and technical academic demands of final years and secondary-exit study, numeracy (mathematical thinking and skills) is endemic in all KLAs in these last years of secondary schooling. In the case of a primary school, the non-mathematics KLA examples will be at a range of year-levels, to indicate the academic and technical scope of numeracy through primary schooling.)

For each curriculum example, the particular KLA's learning outcome (and strand, sub-strand, and level) for that non-mathematics KLA will be linked with one or more corresponding particular mathematics learning outcomes, or samples of mathematics curriculum. This will show that this non-mathematics curriculum example is a legitimate part of the school's (or the state's) curriculum, and that it requires specific mathematics for the example to be properly understood. The actual mathematics needed to learn the non-mathematics-KLA example will be highlighted.

This means that the whole school staff, especially non-mathematics KLA teachers will accept that this example is genuinely part of their curriculum. They will also clearly see the mathematics it uses.

In most cases it will become clear that this mathematics will already (usually at a lower school level) have been taught in helpful mathematics-related ways by the mathematics teachers. However it is unlikely that the specialist mathematics teachers will have been able or had the time to apply this piece of mathematics to the particular non-mathematics KLA being considered. There are too many non-mathematics KLAs, and too great a diversity of possible contexts that require mathematics to be applied, for a mathematics specialist to be able to cover all the non-mathematics KLAs and anticipate all contexts. Mathematics specialist teachers can, and should, attempt to show the potential and sometimes necessary applicability of the mathematics they are teaching to non-mathematics contexts. However non-mathematics-specialist teachers *must* take responsibility for

covering *most* of the contexts and mathematical applications that arise in their own non-mathematics KLA.

It is then the non-mathematics KLA teacher's responsibility to draw on the prepared mathematical background, to review, consolidate, and generally apply the (probably already-taught) mathematics to the non-mathematics KLA's need for numeracy.

Moreover, parents becoming familiar with the school's numeracy policy will see these two or three examples, and be easily convinced that these examples resemble what they might recall of their own learning at school, or that these examples are similar to classroom and homework activities they have seen their children studying at home. They will also appreciate the way numeracy is naturally embedded in a great deal of their own everyday life and recreational interests, beyond just shopping, budgeting and scheduling, where their everyday uses of mathematics (mainly "numberacy") are obvious.

Everyone is convinced. Numeracy matters, and the school is well coordinated to handle the issues and numeracy needs effectively. Easy? Well, all you have to do is fill in the details:

- What is numeracy?
- How can we specify non-mathematics curricula (or KLAs)?
- Identify the numeracy that is needed to handle this non-mathematics learning.
- Identify the opportunities for enriching non-mathematical KLA learning by exploring the potential or implicit (but not unavoidable) numeracy in these non-mathematical areas.
- Finally, ensure that numeracy is taught, assessed and reported by non-mathematics teachers.

Defining numeracy

Numeracy means more than the kind of everyday arithmetic a person (a competent independent adult) needs to handle whole number (and simple decimal) calculations; e.g., money, time, and simple measurement. To highlight the distinction here, we can use the word "numberacy" to refer to such number-related mathematics, and emphasise that non-number-related aspects of mathematics (as a whole body of knowledge or subject area) are also crucial in "numeracy."

Importantly, aspects of numeracy arise in any everyday task or question which involves mathematical thinking, including logical reasoning, critical analysis, categorisation and sorting, and problem-solving. Numeracy also includes spatial thinking, visual representation, analysis of cause and effect and randomness in events, and data-handling, which arise in many seemingly non-mathematical parts of the school curriculum, the non-mathematics key learning areas such as Science, Social Sciences or Humanities, Arts, Technology, Physical Education and Languages.

Wherever people are working with alphabetical and numerical orders, systems of categories and classifications, logical reasoning, patterns (and chaos), cause-and-effect relationships, maps, time-lines, indices (powers), diagrams and graphs, and tables of data we need to use basic numeracy skills. Equally, whenever we attempt to make sense of raw data or to estimate the likelihood of a particular probabilistic event, we need numeracy.

Too often, attempts to define "numeracy" result in hopelessly vague definitions of numeracy that are either unusably unclear or overlap so

extensively with “mathematics” or “number sense and problem solving” that we add nothing to the discussion by using the new word “numeracy” to re-label a perfectly acceptable existing term, such as “mathematics.”

Lynn Arthur Steen notes:

Some of the confusion [in terminology] is simply about semantics. Words like “numeracy”, “mathematics”, “maths”, “quantitative literacy”, “mathematical literacy”, and “quantitative reasoning” have no clear or fixed meaning. Moreover, their usage varies among the different English-speaking countries.

Steen then suggests there are five overlapping kinds of “numeracy”, each of which suggests a different kind or purpose for mathematics: “As language arts specialists often speak of multiple literacies, so increasingly we hear people talk about “multiple mathematics.” I often think of numeracy as a Venn diagram of five interlocking circles representing different perspectives that loosely track the traditional levels of mathematics education: practical, civic, professional, leisure, and cultural.” (Steen, n.d., citing Steen, 1990).

My own definition tries to explain how “numeracy” relates to “school mathematics,” while identifying its purpose as being used in everyday real-world situations; but I see “numeracy” as a much larger chunk of “mathematics” than mere everyday arithmetic — what I refer to as “numberacy”, a kind of everyday number sense mixed with computation skill — which neglect other aspects of numeracy. (After all, mathematics itself is much more than just arithmetic!)

I think of “numeracy” as whatever (mainly primary school) mathematics is needed by ordinary people for ordinary everyday life. This is distinct from less everyday aspects of school mathematics, especially as it emerges during secondary school, including algebra, trigonometry and surds. It is also distinct from more specialised and technical mathematics (learned after secondary schooling ends, often on the job), used for earning a living. My everyday approach to “numeracy” sees it arising in:

- probability (figuring everyday likelihood or odds);
- spatial thinking (e.g., working out how to pack a suitcase efficiently, or whether a sofa will fit in a room with other furniture);
- logical reasoning (at the level of commonsense argument and Holmesian deduction of logical consequences from observed evidence or other sources of information); and, very importantly,
- reading and interpreting graphs, tables and other non-computation-focused displays of mathematical information (see Gough, 2001).

My working definition of “numeracy” is this:

“Numeracy” is (most of) primary school mathematics, used outside the mathematics classroom.

This tells me that numeracy is (in set-theory terminology) properly contained *within* the larger curriculum of school mathematics.

Importantly, there are some things that we know are part of “mathematics” as a vast body of knowledge, which are *not* part of “numeracy.” Let me cite calculus and matrix theory as two examples of subject-matter that are unquestionably part of mathematics, but which no one would ever suggest that most people ought to know, or that most people use in everyday life.

Exercise: Consider how much of the standard secondary mathematics curriculum falls *outside* the more limited body of mathematical knowledge that we want to include in “numeracy.”

My definition also alerts me to the fact that numeracy is a collection of

lower-level mathematics skills that are used widely in other non-mathematics school subject areas (so called KLAS, or Key Learning Areas). Numeracy is also used outside school altogether, in everyday life at home, and in recreation, and in ordinary non-specialised non-technical aspects of adult work. However, this present discussion will not consider numeracy needs of everyday life, but will deliberately attempt to consider questions about what numeracy or mathematics is needed to be able to cope with non-mathematics school subjects.

Let me stress, again, that numeracy is more than the *Third R* (i.e., 'Rithmetic) of the traditional *Three Rs*: that is,

numeracy > numberacy

In fact, numeracy includes not only number sense, but also other aspects of mathematical knowledge and thinking, including:

- using number skills in applied measurement situations;
- algebraic and pattern-related thinking;
- geometric and spatial thinking;
- data-handling (statistics and graphing);
- figuring the odds of events;
- logical analysis and argument; and,
- problem solving. (Have I left anything out?)

Why do I adopt this definition? I think it is essential that a definition of “numeracy” should make a reasonably clear distinction between its own limited scope, and the vast conceptual (and tool-kit) territory of “mathematics.” I want to know, quite specifically, what aspects of mathematics I will include *inside* numeracy, and what aspects of mathematics will be left outside, as instances of “mathematics” which are not counted as part of “numeracy.” I exclude from “numeracy” any mathematics that *most* people do not ordinarily need. We need to consider what aspects of mathematics a large majority of competent independent adults *do not* use, and omit these aspects from “numeracy.” For example, most people do not ordinarily use algebra, trigonometry, coordinate geometry, surds, or combinatorics (except at an almost trivial level of choosing different combinations of clothes or menu items) — in short, in my view, most of secondary school mathematics. Similarly, those adults who do genuinely need and use secondary mathematics, and more, are in a small minority. Moreover, this small specialist minority uses these advanced aspects of mathematics *only* in highly specialised technical salaried work — not ordinary everyday use. Importantly, often the version of specialised mathematics they use is very different in form and use from any school-taught counterpart. The calculus used in economics, for example, is expressed in language and terminology that has no resemblance to school discussion of increments and limits, or deltas and epsilons.

From my definition we can also see that most of the mathematics that most people use for everyday life, outside of mathematics classrooms, is contained in primary school mathematics. By contrast, most if not all secondary mathematics (not including any large slabs of Year 7 and Year 8 mathematics that simply revise and consolidate what is supposed to have been soundly established during primary years) is needed *wholly* for the sake of later study in mathematics classrooms, or in specialised areas of study — that is, not for everyday use!

Why do students start learning algebra or trigonometry in Years 8 and 9? Not for everyday adult life but because they *might* need it later, in higher years of Mathematics (or closely related subjects such as Physics), or in specialised technical workplaces (such as surveying, or psychology — this

latter subject making extensive use of statistics). Incidentally, we can also exclude from “numeracy” the not-needed-for-everyday-life enrichment topics in primary or secondary mathematics such as tessellation, symmetry, history of mathematics, primes, exotic polygons and polyhedra, or fractals and chaos theory.

Numeracy across sample KLAs

We know that mathematics matters in many non-mathematics subject areas. In Science, for example, the argument is almost trivial: classifying species in Biology, or atomic particles, elements and molecules in Chemistry and Physics; conducting experiments that generate numerical data; making and reading data tables and graphs; using algebraic formulas and calculus in electricity, particle motion, acceleration and force — the need for mathematics is obvious. Similarly in Geography, History and related subjects there is an obvious need for mathematics in the use of maps and timelines, currency and trade, cause and effect, tabulating and graphing data.

Engaging with non-fiction, generally, entails mathematical reasoning, specific mathematics concepts, and skills.

I have argued elsewhere that mathematics, perhaps oddly, is also often a central aspect of simply reading novels and poetry, or watching films and plays (e.g., Gough, 1996; 1999; 2002). Consider the important role and mathematical nature of maps, timelines, and who’s-who classifications in appreciating, for example, popular recent films, and their associated books, such as *Lord of the Rings*, *Master and Commander: The Far Side of the World*, *The Last Samurai*, *I Capture the Castle*, *Troy* and *Cold Mountain*. These can be watched and enjoyed simply for the events and characters literally depicted on the screen. However, we appreciate them much more if we are familiar with the geography and history of Middle Earth, General Custer and the Little Big Horn, the American Civil War, Admiral Perry forcing the opening of Japanese ports, Darwin’s voyage on the *Beagle*, the geography of South America, Napoleon and his exploits, the Dardanelles, the development of the Gatling gun, the long-bow archers of Agincourt, surgery, anesthesia and antisepsis in the nineteenth century, etc. We would struggle mentally to make any sense at all of the novel *Cold Mountain* if we knew little of American history, and did not, at least mentally, reconstruct and interconnect the separate, fragmented narrative timelines presented in this novel.

Numeracy across a sample KLA — the Arts

For the sake of brevity, and specificity, I will refer to my own Victorian context in the following discussion. However, a similar argument could be mounted, based on curriculum materials from other states and other countries.

Consider as just one possible example, the Curriculum and Standards Framework (CSF) which has been used, in several versions, in Victoria for more than a decade. (The latest version is available online through the Victorian Curriculum and Assessment Authority (VCAA) website at www.vcaa.vic.edu.au/prep10/csf). Note that the Mathematics CSF has not been replaced, but is allowed to stand alongside newer materials, in particular, the Victorian Essential Learning Standards (VELS). All can be found

under the one new label of Mathematics Developmental Continuum, which encompasses all these evolving materials under one heading at www.education.vic.gov.au/studentlearning/teachingresources/maths/mathscontinuum/

Whatever curriculum outline or benchmark collection you use (e.g., the Department of Employment, Science and Training's *National Literacy and Numeracy Benchmarks* (DEST, n.d.)), any Victoria-specific and CSF-related examples and remarks may be taken as a guide for using VELs (etc.) or any other state's system.

Here are some Arts-related CSF learning outcomes (N.B. similar arguments apply for Levels 5, and 3).

The Arts — Level 4 [to be achieved by the end of Grade 6; students aged about 11 to 12:

Art — (this is divided into two parts, *practice* and *response*)

With support and guidance from teachers, students develop and apply their skills and knowledge to communicate visually their feelings and their understanding of themselves and other people. They explore and use a variety of sources for inspiration and ideas in a broad range of art forms, drawing upon experiences, direct observation and imagination.

They make two- and three-dimensional art works combining and manipulating art elements (for example, line, shape, tone, space, texture, color and form) and principles (for example, pattern, contrast, repetition and symmetry). They use a variety of media and techniques to produce art works that explore the possibilities of art concepts, such as movement, proportion and perspective, to express ideas such as the effects of mood or a particular viewpoint...

Arts practice — ideas, skills, techniques and processes

4.1 ARAR0401

Demonstrate the ability to experiment with ideas in making and presenting art works.

This is evident when the student is able to:

- develop art works that communicate experience and observation of own environment
- apply skills in using knowledge of a range of materials, techniques and processes to communicate clearly developed ideas in visual ways
- use a range of presentation skills to plan and display arts works individually and collaboratively.

4.2 ARAR0402

Demonstrate skill in manipulating art elements and principles.

This is evident when the student is able to:

- select and combine art elements to demonstrate understanding of art principles
- select and use a variety of materials in a range of art forms to express art principles and concepts
- use specific skills and techniques to develop art works individually and collaboratively.

Responding to the Arts

Teachers introduce students to the concepts of personal style and styles of works from different cultures or historical periods...

4.3 ARAR0403

Describe personal observations about the content and structure of art works.

This is evident when the student is able to:

- identify and describe the use of the art elements, principles and expressive qualities of art works
- compare personal opinions about art works
- use appropriate terminology in describing own and others' art works.

4.4 ARAR0404

Distinguish features of art works that locate them in a particular time, place or culture.

This is evident when the student is able to:

- identify some of the stylistic features of contemporary and traditional art works
- compare art works from different times, places or cultures
- identify various purposes for art works in different times, places or cultures.

Where is the numeracy here? Even without considering specific classroom activities, it should be immediately obvious that these learning outcomes and their performance indicators implicitly involve such numeracy-related matters as:

- geometric shapes and vocabulary
- distinguishing features and terminology, used for sorting and classifying
- timelines, and knowledge of historical and biographical periods of time
- awareness of the map of the world, and geographic locations of countries.

I have not gone the extra step of identifying specific Mathematics learning objectives or performance indicators from Victoria's Mathematics CSF, because this is an easy task for mathematics teachers.

The harder task, for the whole school staff, is to coordinate the mathematics and non-mathematics curriculum and learning outcomes, and hence to satisfy everyone that:

- numeracy matters; and
- every teacher is a teacher of numeracy.

Importantly we cannot leave the challenge of numeracy across the curriculum just to the mathematics teachers because they are busy enough teaching their own flavour of mathematics. This is a large, demanding subject in its own right. Specialist teachers of mathematics do not have the time, nor the non-mathematics expertise to be able to translate their subject so that it is evident, and needed, in non-mathematics areas. What we need is a team-effort — but mathematics teachers can be leaders in meeting this challenge!

References

- Department of Employment, Science & Training [DEST] (n.d.). *National Literacy and Numeracy Benchmarks*. Accessed 23 July 2007 at http://www.dest.gov.au/sectors/school_education/policy_initiatives_reviews/key_issues/literacy_numeracy/national_literacy_and_numeracy_benchmarks.htm
- Gough, J. (1996). A novel approach to mathematics: Or a mathematics approach to novels. In H. Forgasz, et al. (Eds), *Mathematics Making Connections* (pp. 112–116). Melbourne: Mathematical Association of Victoria [MAV].
- Gough, J. (1999). Linking mathematics, problem solving and books for teenagers. *The Australian Mathematics Teacher*, 55(4), 38–44.
- Gough (2001). Here they come, ready or not, but teacher's on the lookout! — Assessing numeracy across the curriculum at Year 7 level. *Vinculum*, 38(4), 13–20.
- Gough, J. (2002). Reading Ruth Park's *Playing Beatie Bow* — Warning: Mathematics ahead! *Journal for Literacy and Numeracy Studies*, 12(1), 91–102.
- Marchetta, M. (1992). *Looking for Alibrandi*. Melbourne: Puffin Books.
- Steen, L. A. (1990). Numeracy. *Daedalus*, 119(2), 211–231.
- Steen, L. A. (n.d.) *Seeking Numeracy*. Accessed 25 June 2003 at <http://www.stolaf.edu/people/steen/Papers/aamt.html>