Numeracy: Connecting mathematics

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Outline

- An Australian perspective on connections
- What is 'numeracy'?
- What does it have to do with mathematics?
- Some Australian projects related to numeracy across the curriculum
- Numeracy and the *Australian Curriculum*
- Two other Australian connected activities

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Connections

Connections refer to the ability to see and make linkages among mathematical ideas, between mathematics and other subjects, and between mathematics and everyday life. This helps students make sense of what they learn in mathematics

- MOE (2006) Singapore Secondary Syllabuses, 2006, p. 4

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Numeracy and maths

Students develop numeracy, reasoning, thinking skills, and problem solving skills through the learning and application of mathematics.

MOE (2006) *Secondary Mathematics Syllabuses*, p. 1

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Aims for mathematics

(1) Acquire the necessary mathematical concepts and skills for everyday life, and for continuous learning in mathematics and related disciplines.

(4) Recognise and use connections among mathematical ideas, and between mathematics and other disciplines.

MOE (2006), *Secondary Mathematics Syllabuses*, p.1

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Mathematics in use

- What mathematics have ***you*** used in your 'everyday life' last week?
- NOT in your role as a specialist teacher of mathematics, but as a
  - Citizen or visitor
  - Employee or employer
  - Parent or Child
  - Neighbour or colleague
  - Consumer or manufacturer

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Do this now!

- Think about for about one minute now about your personal everyday use of mathematics
- Discuss with a person nearby to you
  - To what extent do you use mathematics everyday?
  - Where did you learn to do this?
  - What would your own students respond to these questions?

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Everyday numeracy

" household budgeting; understanding bank statements and fees; paying bills for power, water and rates; running a vehicle; filling in application forms; understanding prescription labels; buying appliances; and credit card use. People rent houses, buy houses, build houses or renovate houses. People buy, lease and rent cars. People shop and cook. They design, make and create things. They sew, design gardens and make furniture. They find their way around using street directories. They have hobbies like making clothes, designing a patchwork quilt and painting a landscape. All these activities involve decisions about competing demands of cost, budget and design solutions on the basis of what is necessary, desirable and feasible."

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…

People can engage with the mathematical demands of such tasks to a greater or lesser extent. Indeed, their perception of the task as being mathematical can be quite varied. Typically, tasks with significant numerical demands are seen as mathematical; those involving spatial knowledge or estimations are more likely to be seen as 'common sense'.

(*Numeracy across the curriculum*, 2006 p 26)

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Two personal examples

- Yesterday
- How much do things cost in Singapore?
  - One AU dollar = 1.30 SG dollars
  - Dividing by 1.30 is too hard
  - Multiplying by 0.8 is much easier
  - Mental, approximate, close enough
- How many stations on MRT?
  - Novena to Doby Ghaut
  - NS20 to NS24

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Personal numeracy

- As adults, we need to engage with mathematics in our everyday lives
- An extreme (life-and-death) example of this concerns medical diagnostic testing
- How well does our school mathematics prepare us to deal with this sort of context?
- Let's see …

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Mammography

- Consider mammography as a screening test for breast cancer in 50-70 year old women. For that age group (in the UK):
  - mammography detects approximately 85% of breast cancers
  - around 10% of women with no cancer will receive a positive result (in error)
  - 1 in 100 women have breast cancer
- Your test returns positive. ***How likely are you to have breast cancer?***

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Numeracy in practice?

- Many people struggle to understand the results of medical tests
  - Including some professionals and educated people!
  - See Gerd Gigerenzer's *Reckoning with Risk*
- An excellent version of this problem is on the *Understanding Uncertainty* website:
  - http://understandinguncertainty.org/node/182
  - About 8% of those with positive tests actually have breast cancer!

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Perspectives on numeracy

- The term 'numeracy' has had a range of meanings, unhelpfully
- Some (many non-professionals?) regard it as a synonym for elementary arithmetic
- Others recognise that it's more than mathematics
  - Including contextual knowledge
  - Including strategic thinking

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Common understandings?

- Literacy and numeracy are distinct
- Numeracy is more than number sense
- Numeracy not a synonym for school mathematics, but clearly is related to it
- Numeracy is cross-curricular
  - So is not the responsibility of mathematics alone

Numeracy = Everyone's Business

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Numeracy = Everyone's Business

Numeracy Education Strategy Development Conference 1997 (AAMT, p.15)

> 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.
>
> In school education, numeracy is a fundamental component of learning, performance, discourse and critique across all areas of the curriculum. It involves the disposition to use, in context, a combination of:
>
> - underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical and algebraic);
> - mathematical thinking and strategies;
> - general thinking skills; and
> - grounded appreciation of context.

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AAMT Policy

- AAMT 1998 Policy on Numeracy Education in Schools Available online at:
  - http://www.aamt.edu.au/Publications-and-statements/Position-statements/Numeracy-Education
- Recognises that numeracy:
  - Is context-specific
  - Is relative
  - Involves all teachers
  - Requires school maths to be taught well

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A Numeracy Framework

- Three kinds of knowledge to be developed
  - Mathematical
  - Contextual
  - Strategic
- Three different roles
  - Fluent operator
  - Learner
  - Critic

(Willis & Hogan)

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Numeracy Across the Curriculum

- A project at Murdoch University
- Available online at
  - http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/numeracy_across_curriculum.htm
- Numeracy framework used
- For example, consider these questions numerate people ask

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Australian Curriculum

- Recently, Australia endorsed its first national curriculum in Mathematics
  - Also English, History and the Sciences
- Accepted by all state governments, for phased implementation in the near future
- Documents available online at ACARA
  - Australian Curriculum, Assessment and Reporting Authority
  - http://www.australiancurriculum.edu.au

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Australian Curriculum

- The *Australian Curriculum: Mathematics* comprises three Content Strands:
  - Number and Algebra
  - Geometry and Measurement
  - Statistics and Probability
- And four Proficiency Strands
  - Understanding
  - Fluency
  - Problem Solving
  - Reasoning

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Australian Curriculum

- *General Capabilities* are also identified in each learning area
  - Literacy
  - Numeracy
  - ICT competence
  - Critical and creative thinking
  - Ethical behaviour
  - Personal and social competence
  - Intercultural understanding

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Subject-specific numeracy

- In the Australian Curriculum, numeracy is identified as a general capability for all learning areas, including so far:
  - English
  - History
  - Sciences
  - Mathematics
  - *Arts*
  - *Languages Other Than English*

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Numeracy

"In the Australian Curriculum students become numerate as they develop the capacity to recognise and understand the role of mathematics in the world around them and the confidence, willingness and ability to apply mathematics to their lives in ways that are constructive and meaningful.

As they become numerate, students develop and use mathematical skills related to:

- Calculation and number
- Patterns and relationships
- Proportional reasoning
- Spatial reasoning
- Statistical literacy
- Measurement "

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Rationale for Numeracy

The complexity of contemporary society requires young people to be increasingly numerate. They need to recognise the mathematical basis of authentic problems and engage constructively in their solution.

The identification of mathematical demands in learning areas enables students to:

- transfer their mathematical knowledge and skills to problem solving in those learning areas
- recognise the interconnected nature of mathematical knowledge, learning areas and the wider world
- become confident and willing users of mathematics in their lives

(ACARA)

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Mathematics and Numeracy

The mathematics curriculum develops students' mathematical knowledge and skills, enabling them to become confident and creative mathematical thinkers. Numerate students then apply their mathematical understanding in other learning areas as they recognise, interpret and use the mathematics required to solve problems and achieve the intended outcomes for those learning areas. This requires teachers to:

- identify the specific numeracy demands of their learning area
- use the language of numeracy in their teaching as appropriate
- provide learning experiences that support the application of students' mathematical knowledge and skills.

(ACARA)

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Numeracy and sciences

Many elements of numeracy are evident in science, particularly in *Science Inquiry Skills*. These include practical measurement and the collection, representation and interpretation of data from investigations.

Students are introduced to measurement using informal units in the early years, then formal units; later they consider issues of uncertainty and reliability in measurement.

As students progress, both qualitative and, later, quantitative data are collected, analysed and represented in graphical forms. Students learn data analysis skills, including identifying trends and patterns from numerical data and graphs.

In later years, numeracy demands include the statistical analysis of data, including issues relating to accuracy, and linear mathematical relationships to calculate and predict values.

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Numeracy and history

Knowledge and skills in numeracy are evident in specific elements of the history curriculum.

Students need to organise and interpret historical events and developments and this may require analyses of data to make meaning of the past, for example to understand cause and effect, and continuity and change.

This requires skills in numeracy such as the ability to represent and interpret quantitative data.

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Numeracy and English

Numeracy can be addressed in English learning contexts across all year levels.

Students select and apply numerical, measurement, spatial, graphical, statistical and algebraic concepts and skills to real-world situations and problems when they comprehend information from a range of sources and offer their ideas.

When responding to or creating texts that present issues or arguments based on data, students identify, analyse and synthesise numerical information and discuss the credibility of sources and methodology.

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Numeracy: How might mathematics help?

- Sequencing and size
- Estimating quantities
- Calculation
- Proportional reasoning
- Studying relationships
- Collecting data
- Representing and interpreting data
- Measurement
- Estimation and error
- Visual representation

– Source: ACARA

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Numeracy in Singapore

- Word searches in syllabuses:
  - ➢Lower secondary science
    - Nothing
  - ➢Lower secondary social studies
    - Nothing
  - ➢Lower secondary geography
    - Nothing
- There is much material in these syllabuses for which mathematics is important, however

Numeracy in Social Studies

- Theme 2: *Growth of Singapore* requires a great deal of mathematical thinking:

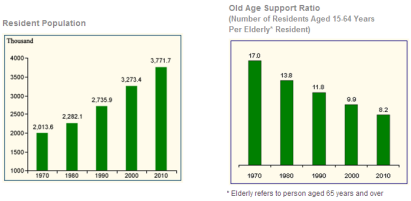
THEME 2 : GROWTH OF SINGAPORE

TOPICS	CONTENT	LEARNING OUTCOMES	CONCEPTS	VALUES/ATTITUDES
MANAGING POPULATION CHANGES	Managing population changes • **Managing rapid population growth** – post-war rapid population growth – measures to reduce population growth • **Managing slow population growth** – reasons for slow population growth – measures to increase population growth – effects of an ageing population – preparing for an ageing population e.g. encouraging healthy living and financial planning	Students will be able to: • understand the effects of population changes • describe the measures taken to manage population changes • explain the reasons for an ageing population • recognise the importance of keeping fit and planning for old age • understand the responsibilities of the community and the role of the government in caring for senior citizens • value the contributions of the senior citizens	• human resource • population growth • ageing population • social services	• appreciation of people as a valuable resource • respect for senior citizens • healthy living

(MOE, 2005, p.8)

Numeracy for learning

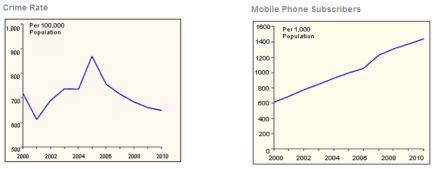
- Mathematics is required to interpret data on issues like population and ageing:



Source: Statistics Singapore website

Social data

Interpreting data requires mathematical thinking, as evidenced by these graphs:



Source: Statistics Singapore website

Graphs and tables

- Interpretation of graphs and tables is a key aspect of numeracy for learning
- There is an excellent chapter on this by Marian Kemp in AME's *Yearbook 2010*:
  - ➢Chapter 11: Developing Pupils' Analysis and Interpretation of Graphs and Tables Using a *Five Step Framework*
- The *Five Step Framework* provides systematic advice and specific help

Numeracy in Geography

- Mathematics is essential for Geography:

Theme	Content	Learning Outcomes	Concepts	Values/Attitudes
	a product of human's modification to the physical environment (e.g. Singapore) Environments Through Maps • Maps as graphical representations of the Earth • Types of maps and their uses (e.g. sources of information, records of changes in the environment, basis of planning and decision-making) • Importance of maps in the past and today • Map skills (i) Atlas – latitude (Equator, Tropic of Cancer, Tropic of Capricorn, Arctic Circle, Antarctic Circle, North Pole, South Pole) and longitude (Greenwich Meridian, International Dateline) – continents, oceans, countries, major cities, physical and human features (ii) Topographical map – location (four-figure, six-figure grid references) – straight line distances – direction (compass points, compass bearings)	• understand maps as graphical representations of the Earth • understand that maps have varied uses • use an atlas to locate specific places and features • interpret physical and human environments shown on topographical maps	• map • latitude • longitude • continent • ocean • country • city • physical feature • human feature • location • distance • direction • scale • symbol • legend • contour	• accuracy • being meticulous

MOE, 2006, Theme II, p. 20

Numeracy in science

- Mathematics is used a great deal in the physical sciences
  - Here are two examples (MOE, 2006, pp 6-7):

Measurement
Students should recognise the need for Man to quantify his interactions with the environment. Man makes estimations and also accurate measurements of quantities not just when he is engaged in scientific inquiry but also in everyday activities. The study of measurement would enable Man to plan the use of resources efficiently. In this theme, we examine how different instruments are used to measure different quantities accurately. Direct measurements of quantities include length, mass, volume and time and calculated quantities include density, speed and rate. Key inquiry questions in Measurement include:

- Why is it important to have clearly defined quantities and units?
- How does the system you want to study determine the way you take measurements?

Interactions
Students should appreciate that there are interactions between the living world and the environment at various levels: interactions which occur within an organism; between organisms; and between organisms and the environment. There are also interactions between forces and objects, and energy and matter. In this theme, we examine the interaction of forces and energy between and within living and non-living systems as well as with the environment. Examples of these interactions include transmission of heat, chemical changes, and energy flow through a food chain in an ecosystem. Key inquiry questions in Interactions include:

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Mathematics teachers and numeracy

- Numeracy for learning in other parts of the curriculum requires us to make some connections
  - Even if they are not written into syllabuses
- This might include
  - Reading other syllabuses
  - Discussions with other subject staff
  - Focusing on 'real' connections

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Two other projects

With the themes of communications, reasoning and connections, two other current Australian projects are noteworthy:

- *Reach for the stars!*
- *Maths by Email*

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Reach for the Stars!

The Australian Association of Mathematics Teachers has been conducting *Reach for the Stars* as part of National Literacy and Numeracy Week since 2003.

- classes collecting data locally
- submitting their results to a national data collection via the Internet
- exploring their own findings
- a summary of the data collected by participants from across Australia.

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Reach For The Stars 2009

- The focus in 2009 was on student's first names
  - This is a very strong 'connection' for students!
- There are many interesting ways to think about names
- Here is a brief glimpse.
- Here is a summary report

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RFTS year by year

- 2003 – height of boys and girls in each year level
- 2004 – travelling to school (distance, time and/or method of travel)
- 2005 – money trails (numbers of coins collected and lengths of trails, with additional interesting data set about the ages of 20 cent coins circulating in Australia)
- 2006 – balloon relays (measuring distance, time and number of people involved)
- 2007 – exploring the correlation between height and foot size
  2008 – looking at accuracy in throwing a coin onto a target, and the effect of school year level, throwing distance and other factors
- 2009 – collection and exploration of data associated with the lengths of and letters used in students' first names (known as "What's in a name?")
- 2010 – collection and exploration of data around the number of shuttles moved in running teams (known as "Fit for Thinking")

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Reach for the Stars! 2011

29 August – 4 September 2011

What does YOUR classroom look like?

In 2011, Australian students will be collaborating again to generate data from observations and measurements in their classrooms.

- Questions like "How big?" "What colour?" "How many?" "How do you know?" will be asked and answered.
- Students will count, group, categorise, order, measure, model, calculate, compare, contrast, predict, explain…

Teachers will find activities suited to all levels – from simple counting and direct comparisons through to more complex modeling and problem solving.

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Data and questions

- Students will collect their data and organise it to examine and compare their own classroom with classrooms from all over Australia.
  - How are we the same? How are we different? What statistical tools should we select?
  - "How big is your classroom?" "How many people could fit into it if the classroom was empty?"
  - What is on the teacher's desk?
  - "How many pens, pencils, textas and other writing implements are in your classroom?" "Who has the most in their pencil case?"

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Further information

- AAMT web site
  - http://www.aamt.edu.au/Activities-and-projects/Reach-for-the-Stars
- Commonwealth Government web site
  - http://www.literacyandnumeracy.gov.au
- Although it is not possible to register to participate, you can access all the materials online, including summaries, for some interesting comparisons!

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Maths by Email

- A free fortnightly newsletter sent via email to subscribers
- Launched in March 2010
- Published by CSIRO
- Supported during 2010 by
  - Australian Government (DEEWR)
  - Australian Mathematical Sciences Institute

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Accessing *MbE*

- Interested people can subscribe free online at
  - http://www.csiro.au/resources/Maths-by-Email.html
- There is also an archive of some materials online
  - But not of entire issues
- Issues are delivered by email, but can be accessed online by subscribers

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MbE issue contents

- Each fortnightly issue has a number of elements, including
  - Brief article
  - Hands-on activity
  - Brainteaser
  - Web links
- Most issues have a theme, usually connecting maths to a real world context
- Here is the current issue online

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Conclusions

- Thinking about numeracy is a strong way of thinking about connections
- It is unlikely that school mathematics will be sufficient to develop numeracy without attention being paid to it
- Australian experiences may be helpful for thinking in Singapore
- We need to work with colleagues elsewhere, not just in the maths department

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Thanks for listening!

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