



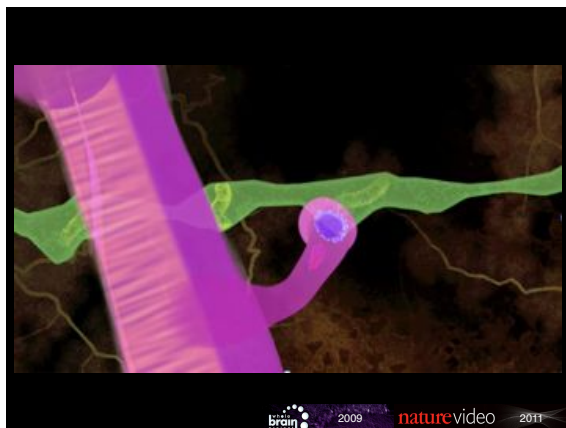
Creating Mathematics Capacity

cognitive neuroscience and learning in mathematics

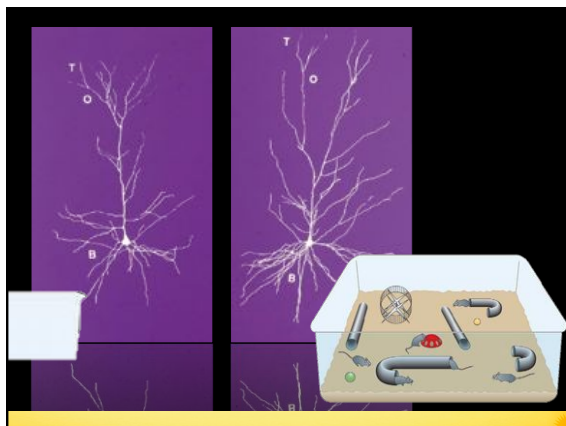
Prof Martin Westwell
martin.westwell@flinders.edu.au

Bits of your brain

Creating Capacity

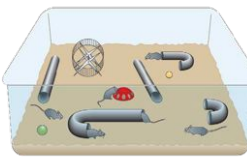
(i) interconnectedness (relational thinking)

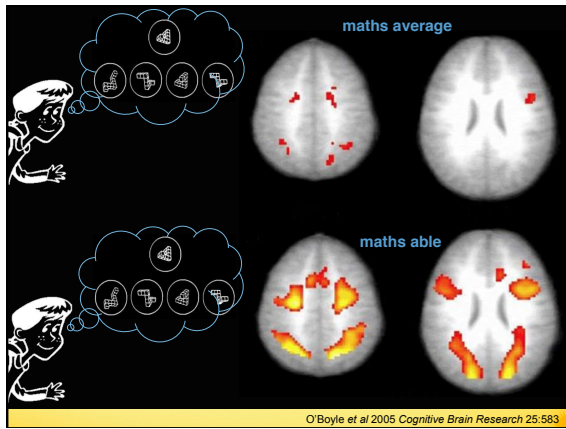


Enriched environment?

WARNING! NEUROMYTHS!

- multi-sensory **VAK preferred learning styles**
- relevant
- emotional content
- interpersonal interaction
 - interdependent learning
 - parental engagement
- exercise **Brain Gym**
- nutrition / hydration **Water makes you smart**
- blue light ?
(natural light and late-night TV)





Finding Rates of Change

CA Standards Investigation Exploring Rate of Change

The diagram at the right shows the side view of a ski lift.

1. What is the vertical change from A to B? From B to C? From C to D?
2. What is the horizontal change from A to B? From B to C? From C to D?
3. Find the ratio of the vertical change to the horizontal change for each section of the ski lift.
4. Which section is the steepest? How does the ratio for that section compare to the ratios of the other sections?

http://www.ted.com/talks/lang/eng/dan_meyer_math_curriculum_makeover.html

compelling answer

compelling question

“...paving smooth straight path from one to the other and congratulating our students for how well they can step over the small cracks in the way.”

How many senses do we have?

learning versus being taught

Isaac Newton Institute, Cambridge University

Chemistry department, Oxford University


Importance of tea-room conversations in learning

Statistics and probability
Measurement and geometry
Number and algebra

“Accelerating students by using content beyond their year level may not be the best way to extend proficient mathematicians.”

best bits are non-linear

unexpected word – take cognitive control



scrabble for meaning – fluid analogising

exploring connections

Describe

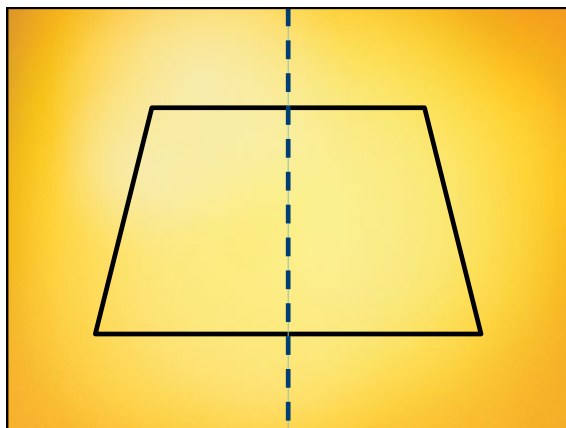
Describe with prohibited words

Describe in pairs

Describe in pairs with prohibited words

Square
[e.g.1; four]
[e.g.2; four, side]

not the same as harder sums

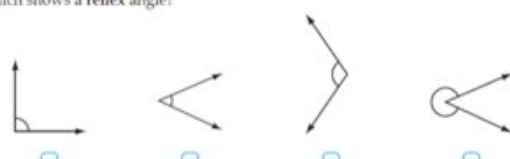


Creating Capacity

(i) interconnectedness (relational thinking)


knowing *and* doing

Which shows a reflex angle?



knowledge

The temperature at the base of a mountain is 8°C.
The temperature at the summit is 26°C colder than at the base.



What is the temperature at the summit? °C

knowledge - procedure

estimate $\frac{12}{13} + \frac{7}{8}$


2 7 19 21

○ ○ ○ ○

**“knowing but not doing”
knowledge - procedure**

Blair et al 2008 Mind, Brain and Education 2:80

Two squares are drawn on the sides of an equilateral triangle as shown. A straight line is then drawn through the point where the 3 shapes touch.



What is the size of the shaded angle? °

**“knowing but not doing”
knowledge - procedure**


Creating Capacity

(i) interconnectedness

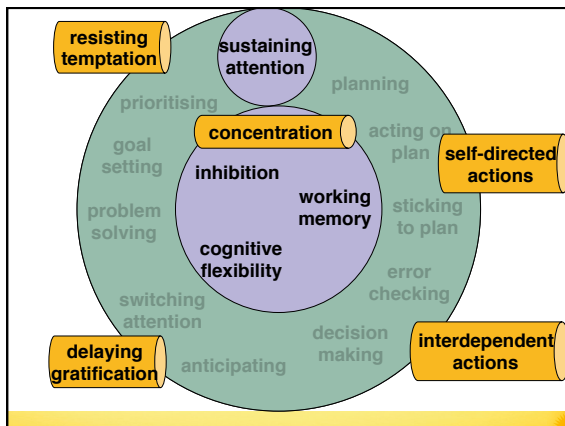
(ii) taking control:
executive functions

Changing minds

- Hybrid laparoscopy training system (video & real)
21 residents, 12 attending, 15 men, 18 women
- Past game play (>3hr/week)
37% fewer errors (P<0.02)
27% faster (P<0.03)
- High scoring gamers (top tertile)
47% fewer error (P<0.001) 39% faster (P<0.001)
- Relative weight analysis
0.3% years of training, 2% sex, 2% cases performed
10% video game experience 31% video game skill

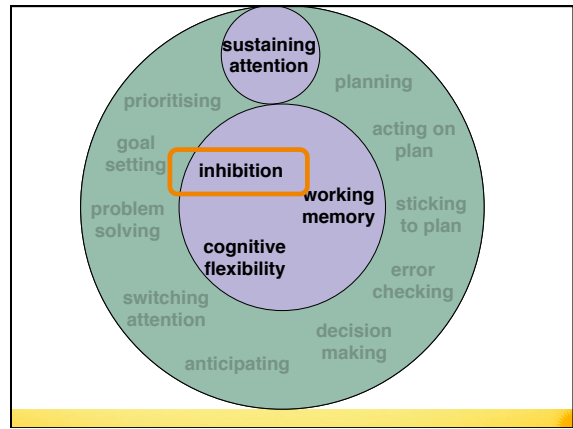
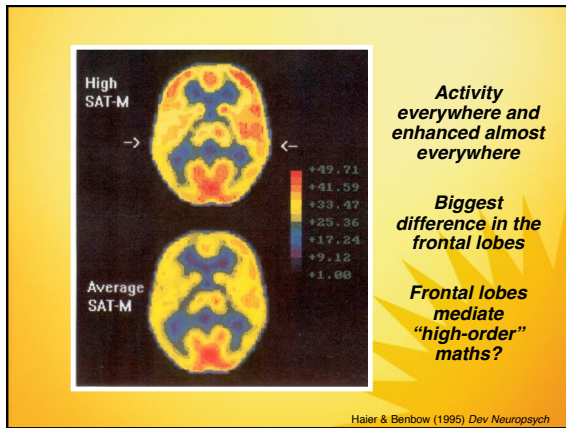


Rosse et al 2007, Archives of Surgery



Executive Functions (EF)

- Aspects of our thinking that relates to how we **control** our thoughts and actions
- Used in new environments or when you have to do something different to normal - **organise** our thinking and behaviour



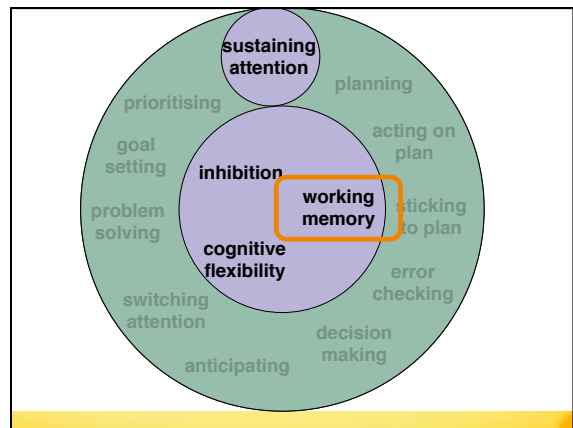
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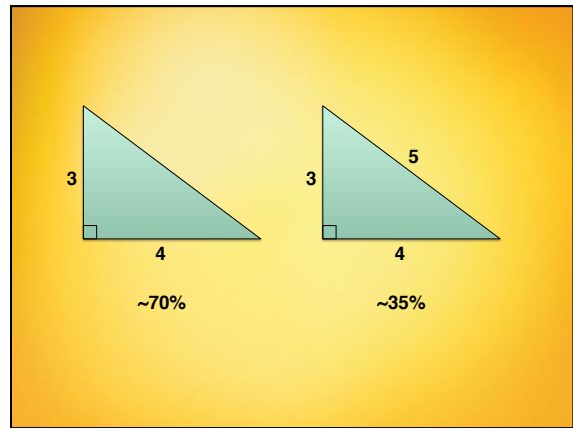
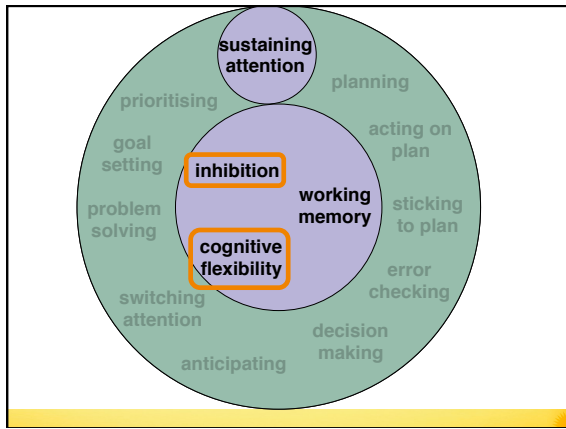
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**“knowing but not doing”
knowledge - procedure**

Maths-anxiety eats up working memory

Particularly impacts tasks that require high WM


Ashcraft & Krause (2007) *Psychonomic Bulletin & Review*



1. Understand the problem

1. **SEARCH:** Underline the question
2. **SORT:** Identify relevant information

2. Devise a plan



3. **SEE:** Visualise the problem: in your head, on paper, in a diagram, etc
4. **SELECT:** Select the operation(s) you will use to solve the problem

3. Carry out the plan

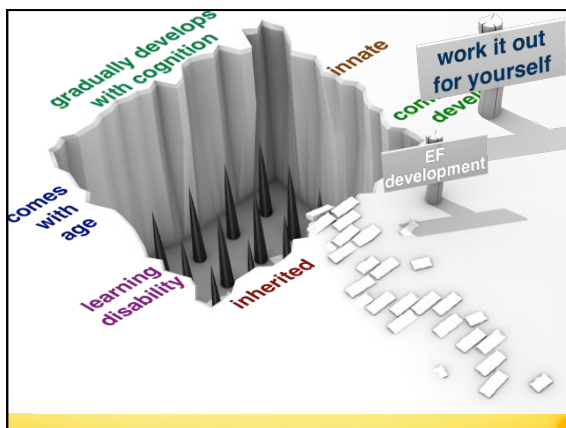
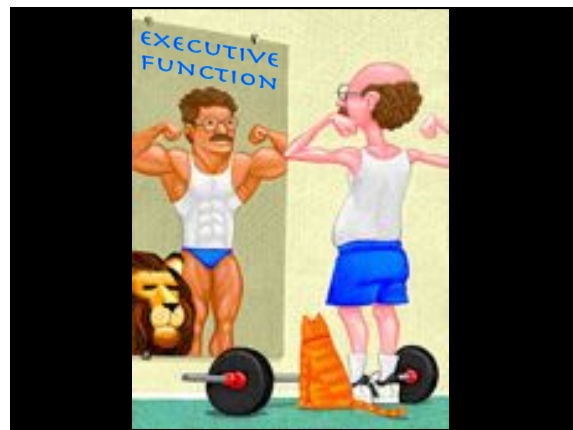

5. **SOLVE:** Use your mathematical knowledge to work out the answer

4. Look back

6. **SENSE:** Does your answer make sense?

quicksmart

George Pólya (1945) John Pegg, UNE

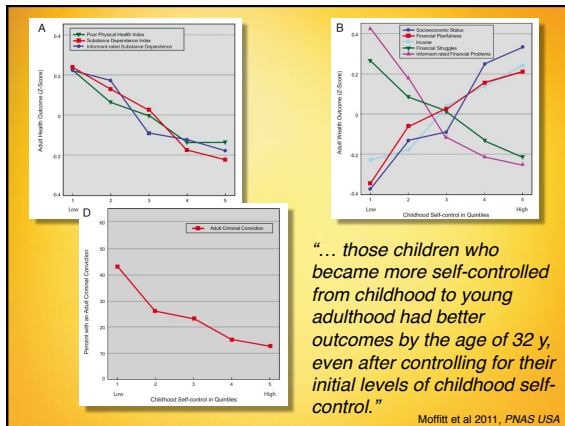



Walter Mischel - Classic 'Marshmallow Experiment' Importance of self-control

4-year old "resisting" marshmallows

- frustration
- self-esteem
- sociability
- SAT scores (uni entry)

Mischel, W. et al (1989). Science, 244, 933-938; Casey et al., (2011) PNAS USA, 108, 14998-15003



Creating Capacity

(i) interconnectedness

(ii) executive functions

(iii) view of self as learner

Limitation through categorisation

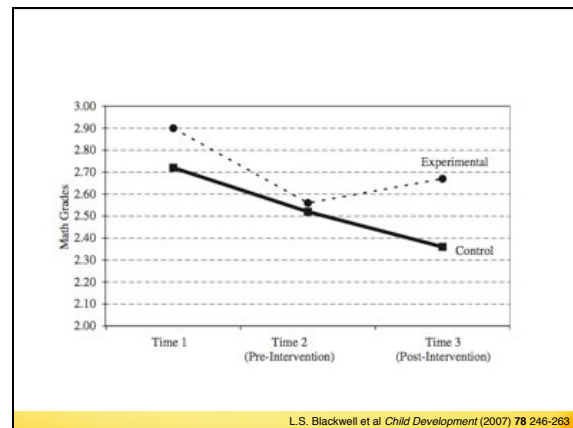
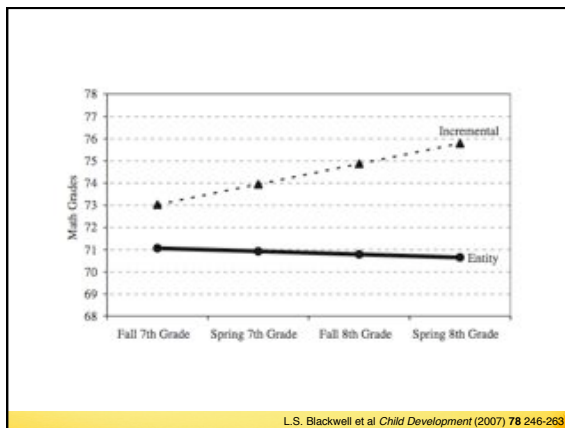
- “It’s in your genes”
- Purposeless streaming
- Specialist schools/courses
- Boys vs girls
- “Dad couldn’t do that either”
- Value of education, literacy, etc
- Visual learners, left-brain thinkers: neuromyths
- Theory of intelligence

Students’ mindset

- Theories of intelligence (early adolescents)

<p>Entity</p> <ul style="list-style-type: none"> - measuring ability - performance goals - futility of effort - setbacks: persevere/withdraw - “intellectual ability fixed” 	<p>Incremental</p> <ul style="list-style-type: none"> - skill acquisition - learning goals - utility of effort - setbacks: change strategy - “intellectual ability can be developed”
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L.S. Blackwell et al *Child Development* (2007) 78 246-263



Students' learning choices

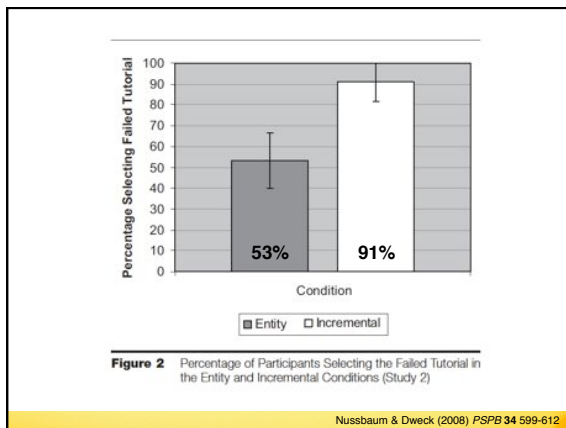
Nussbaum & Dweck (2008) PSPB 34 599-612

Students' learning choices

5/5 5/5 2/5 5/5

All students chose to do a tutorial

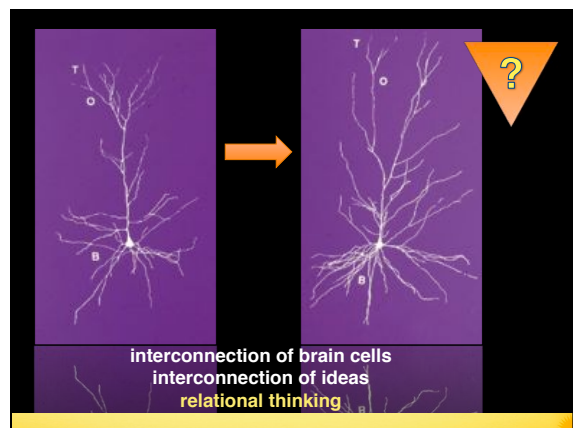
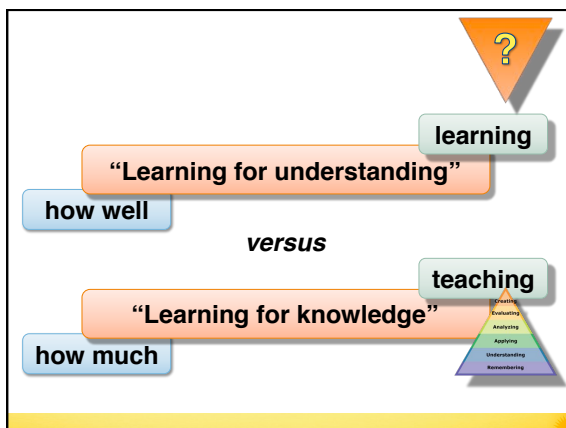
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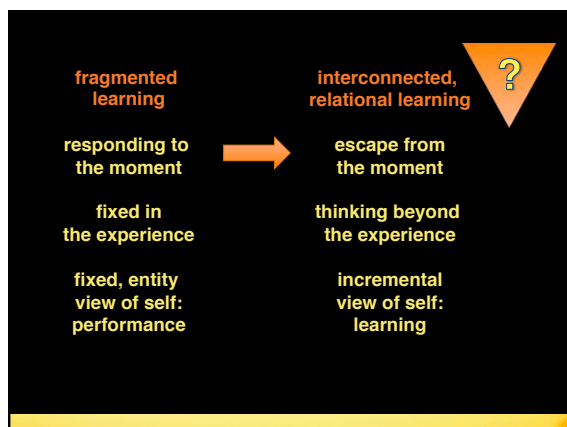


“A culture of genius: How an organization’s lay theory shapes people’s cognition, affect, and behaviour”

- Organisation’s “theory of intelligence” affects inferences about what is valued and behavioural decisions
- Present “smarts” to entity environment
- Present “motivation” to incremental environment

Murphy & Dweck (2010) PSPB 36 283-296







Creating Capacity

- (i) interconnectedness
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- (iii) view of self as learner

... we do it to them!

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 cognitive neuroscience and learning in mathematics

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