Creating Mathematics Capacity
cognitive neuroscience and learning in mathematics

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)
“...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.”

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

Isaac Newton Institute, Cambridge University

Chemistry department, Oxford University

Importance of tea-room conversations in learning


O’Boyle et al 2005, Cognitive Brain Research 25 583
The best bits are non-linear and unexpected words take cognitive control.

Scrabble for meaning – fluid analogising and exploring connections.

Describe
- Describe with prohibited words
- Describe in pairs
- Describe in pairs with prohibited words

Not the same as harder sums.

Creating Capacity

(i) interconnectedness (relational thinking)

Knowing and doing

Which shows a reflex angle?

- \[ \text{knowledge} \]

- \[ \text{knowledge - procedure} \]

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

Summit

Base

What is the temperature at the summit? \[\text{°C}\]
Creating Capacity

(i) interconnectedness

(ii) taking control: executive functions

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
Activity everywhere and enhanced almost everywhere

Biggest difference in the frontal lobes

Frontal lobes mediate “high-order” maths?

Estimate: \( \frac{12}{13} + \frac{7}{8} \)

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\begin{array}{cccc}
2 & 7 & 19 & 21 \\
\hline
\end{array}
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“knowing but not doing” knowledge - procedure


Maths-anxiety eats up working memory

Particularly impacts tasks that require high WM

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

4. Look back

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

6. SENSE: Does your answer make sense?

George Pólya (1945)  John Pegg, UNE

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

“... those children who became more self-controlled from childhood to young adulthood had better outcomes by the age of 32 y, even after controlling for their initial levels of childhood self-control.”

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)

<table>
<thead>
<tr>
<th>Entity</th>
<th>Incremental</th>
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<tbody>
<tr>
<td>- measuring ability</td>
<td>- skill acquisition</td>
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<tr>
<td>- performance goals</td>
<td>- learning goals</td>
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<tr>
<td>- futility of effort</td>
<td>- utility of effort</td>
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<td>- setbacks:</td>
<td>- setbacks:</td>
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<tr>
<td>perservere/withdraw</td>
<td>change strategy</td>
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<tr>
<td>- “intellectual ability fixed”</td>
<td>“intellectual ability can be developed”</td>
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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

“Learning for understanding” versus “Learning for knowledge”

- Interconnection of brain cells
- Interconnection of ideas
- Relational thinking
Creating Capacity

(i) interconnectedness
(ii) executive functions
(iii) view of self as learner

… we do it to them!