




TEACHING MATTERS
SCIENCE OF LEARNING
NATIONAL SUMMIT

Science of Learning in Mathematics
Jordan O'Sullivan

 **Shaping Minds**
The science of learning meets the art of teaching


 Catholic Education Tasmania

 CATHOLIC EDUCATION AUSTRALIA

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In this session...


- Cognitive Science
 - Information Processing Model
 - Cognitive Load Theory
- Four Instructional implications flowing from the above

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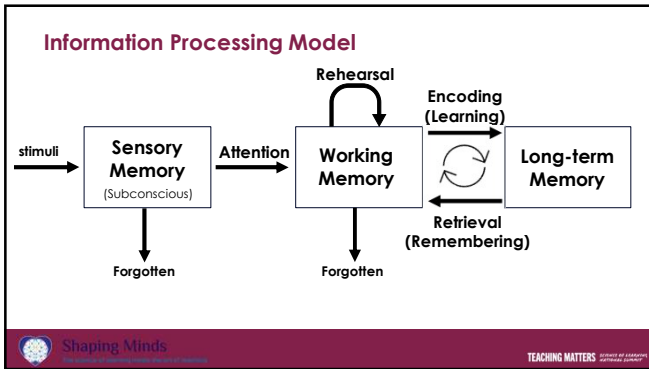
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Information Processing Model

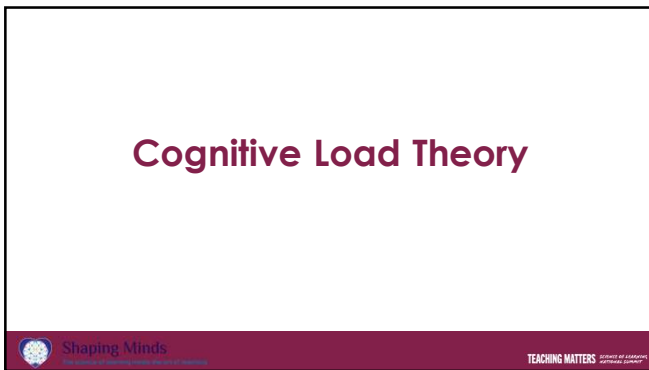
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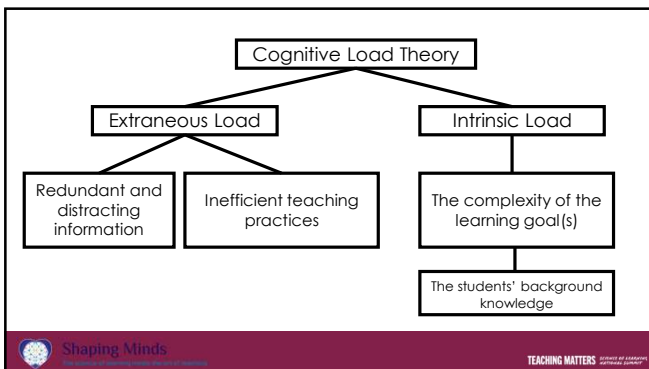
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Cognitive Overload

When the sum of extraneous and intrinsic load exceeds working memory capacity

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High Extraneous Load: Inefficient Teaching

The extra mental work that the student needs to do to understand the information, as a result of inefficient or ineffective instruction, is extraneous load

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Inquiry & Cognitive Load

“Any instructional theory that ignores the limits of working memory when dealing with novel information is unlikely to be effective... **inquiry-based instruction places a huge burden on working memory.**”

Kirschner, Sweller & Clark, 2010

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Low Extraneous Load: Efficient Teaching

When teaching is efficient and aligns with the science of how humans learn, students don't need to do as much unnecessary mental work to understand the information.

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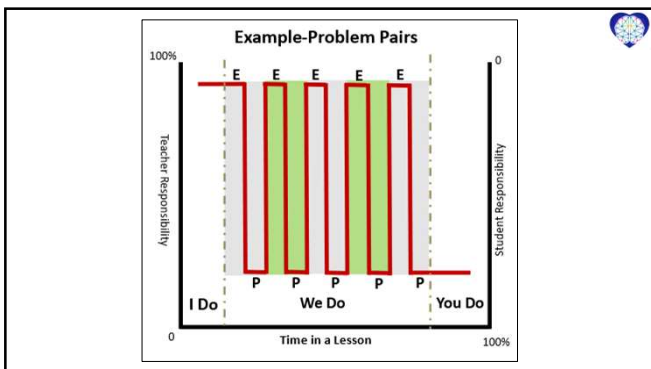
Important Term: 'Variation'

For a skill that you teach, there are sometimes different 'ways' that the skill needs to be applied, or slight increases in difficulty for the same skill. These are '**variations**' of the skill.

Calculating Supplementary Angles

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Teacher	Students
Draw a rectangle and shade $\frac{2}{5}$ two fifths	Draw a rectangle and shade $\frac{4}{5}$ four fifths
<p>Step 1: Draw the shape. Step 2: Check the denominator and divide the shape into that many equal parts. Step 3: Check the numerator and shade that many equal parts.</p>	

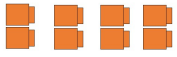
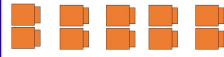
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Teacher	Students
Draw a rectangle and shade $\frac{3}{8}$ three eighths	Draw a rectangle and shade $\frac{7}{8}$ seven eighths
<p>Step 1: Draw the shape. Step 2: Check the denominator and divide the shape into that many equal parts. Step 3: Check the numerator and shade that many equal parts.</p>	

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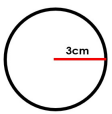
<p>We Do <small>(I do / You do)</small></p> <p>$4 \times 2 = \underline{\quad}$</p> <p>$\underline{\quad}$ groups of $\underline{\quad} = \underline{\quad}$</p> <p>$\underline{\quad} + \underline{\quad} + \underline{\quad} + \underline{\quad} = \underline{\quad}$</p> 	<p>We Do <small>(You do / I do)</small></p> <p>$5 \times 2 = \underline{\quad}$</p> <p>$\underline{\quad}$ groups of $\underline{\quad} = \underline{\quad}$</p> <p>$\underline{\quad} + \underline{\quad} + \underline{\quad} + \underline{\quad} + \underline{\quad} = \underline{\quad}$</p> 
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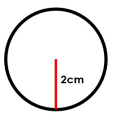
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We Do

What is the circumference of this circle?

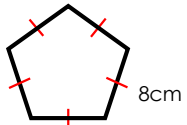
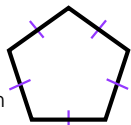


What is the circumference of this circle?



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<p>We Do</p> <p>Steps</p> <ol style="list-style-type: none"> Check that it is a regular polygon. • Hint: are all the sides the same length? Determine how many sides there are. Multiply the side length by the number of sides. Write your answer with the unit of measurement. 	<p>Teacher: Calculate the perimeter</p>  <p>Students: Calculate the perimeter</p> 
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Classroom Arrangement Matters

The diagram shows a classroom layout with desks arranged in a grid. A purple circle highlights a group of desks in the center. A whiteboard is located at the bottom. On the left, there is a book cover for 'Tools for Teaching' by Fred Jones, 2nd Edition, with the subtitle 'Discipline • Instruction • Motivation'.

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Daily Review

A fast-paced session in which the teacher leads spaced practice and retrieval practice of a range of facts and skills.

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What goes in a Daily Review?

1. Facts and skills to-be-automatised.
2. Facts and skills relevant to the lesson that follows (if applicable).*

*Because Activating Prior Knowledge is part of an explicit lesson design, point 2 is less of a focus for Daily Review than point 1

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Shaping Minds Maths Curriculum

A scope & sequence of the Australian Curriculum that maps out and tracks lesson and daily review content.

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Year 3 Mathematics Curriculum

Topic 4: Fractions & Decimals	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
...

Week 5

Core Daily Review Content

Order of the Day

- I can write the number names and other the related 10, the number 10, the number 100, the word form and whether it's odd or even for a 4-digit number of the day.

Reading & Writing

- I can write 4-digit numbers when shown the number represented by concrete materials (e.g. base ten blocks or place value discs).

Addition & Subtraction

- I can solve one addition and subtraction equations one two or three steps: $14 + 5 = 19$ or $19 - 5 = 14$ or $14 + 5 = 19$ or $19 - 5 = 14$.
- I can add and subtract 2- and 3-digit numbers using a written algorithm without regrouping.

Multiplication & Division

- I can write 2-, 3- and 10-times tables equations for given arrays.

Problem Solving

- I can write addition and subtraction equations for unknowns in all positions.

Reasoning

- I can draw and shade collections to represent unit fractions including $\frac{1}{10}$, $\frac{1}{100}$, $\frac{1}{10}$ and $\frac{1}{100}$.

Cyclical Daily Review Content

- I can tell o'clock, half past, quarter past and quarter to times.
- I can identify and describe 2D shapes including polygons and different quadrilaterals.

Lesson 1 **Lesson 2** **Lesson 3**

I can pose questions and solve problems involving multiplication and division in a table.

I can make a line graph with 1 to 2 comparisons from data displayed in a table.

I can divide and make shapes to represent $\frac{1}{10}$, $\frac{1}{100}$, $\frac{1}{10}$ and $\frac{1}{100}$.

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Practical Implications

1. Make your instruction efficient by using worked examples.
2. Present information and arrange your classroom in a way to minimise distractions for students.
3. Break complex learning goals into 'instructional units' so that they can be committed to long-term memory.
4. Dedicate time to leading spaced practice and retrieval practice of a range of Maths facts and skills (Daily Review).

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