



Catholic
Education
Tasmania

Student Focused
Christ Centred
Learning for Life

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created for attendees of the
Teaching Matters Summit.

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Teaching For Productive Learning In Mathematics

Brendan Lee

TEACHING MATTERS

*SCIENCE OF LEARNING
NATIONAL SUMMIT*



Catholic
Education
Tasmania



CATHOLIC EDUCATION
Archdiocese of Canberra & Goulburn

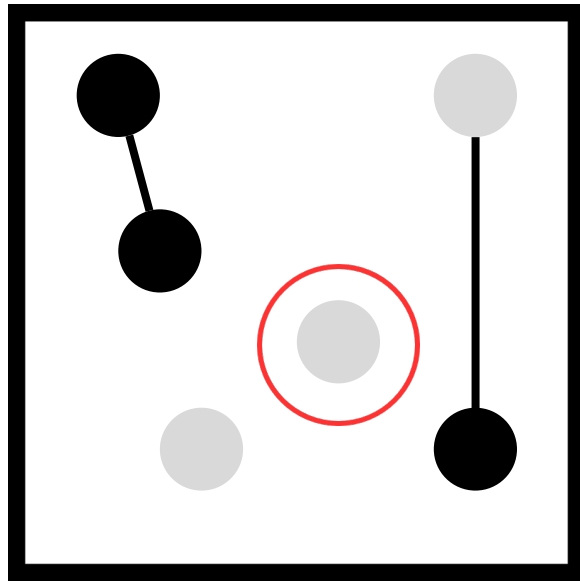
When was the last time that you tried to learn something complex and gave up?



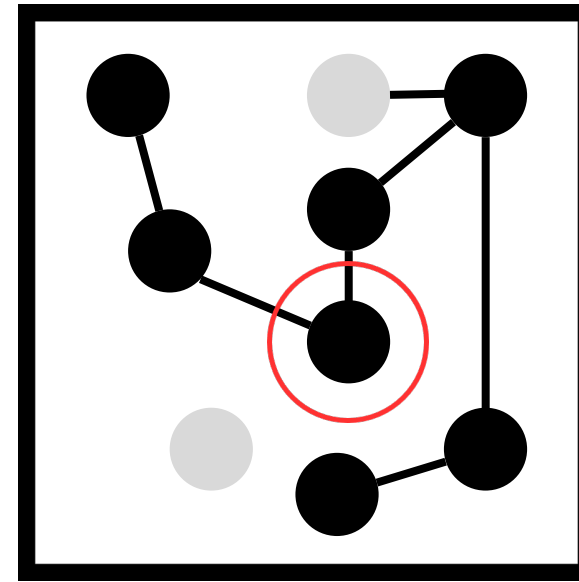
Professional Learning Norms

1. Be open to fresh thinking
2. Be aware of your cognitive biases
3. Stay focused on the topic & remove distractions
4. Take notes as you go
5. Know that learning is hard!

How learning happens



Novice



Expert

Learning maths is like learning another language

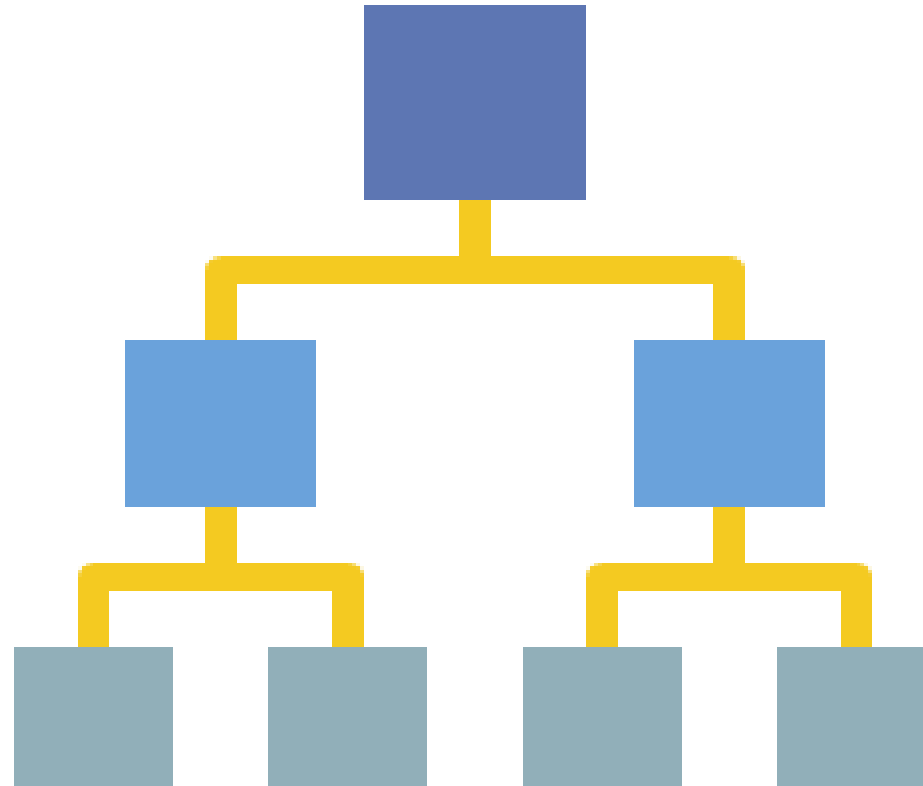


Start with simple language



Say this	Not this
Three twos is six	Three times two is six
One ten and three ones	Thirteen
Same as	Equals
Three equal parts out of a whole of five equal parts	Three fifths

Mathematics is highly hierarchical



Developmental model of cognitive number representation

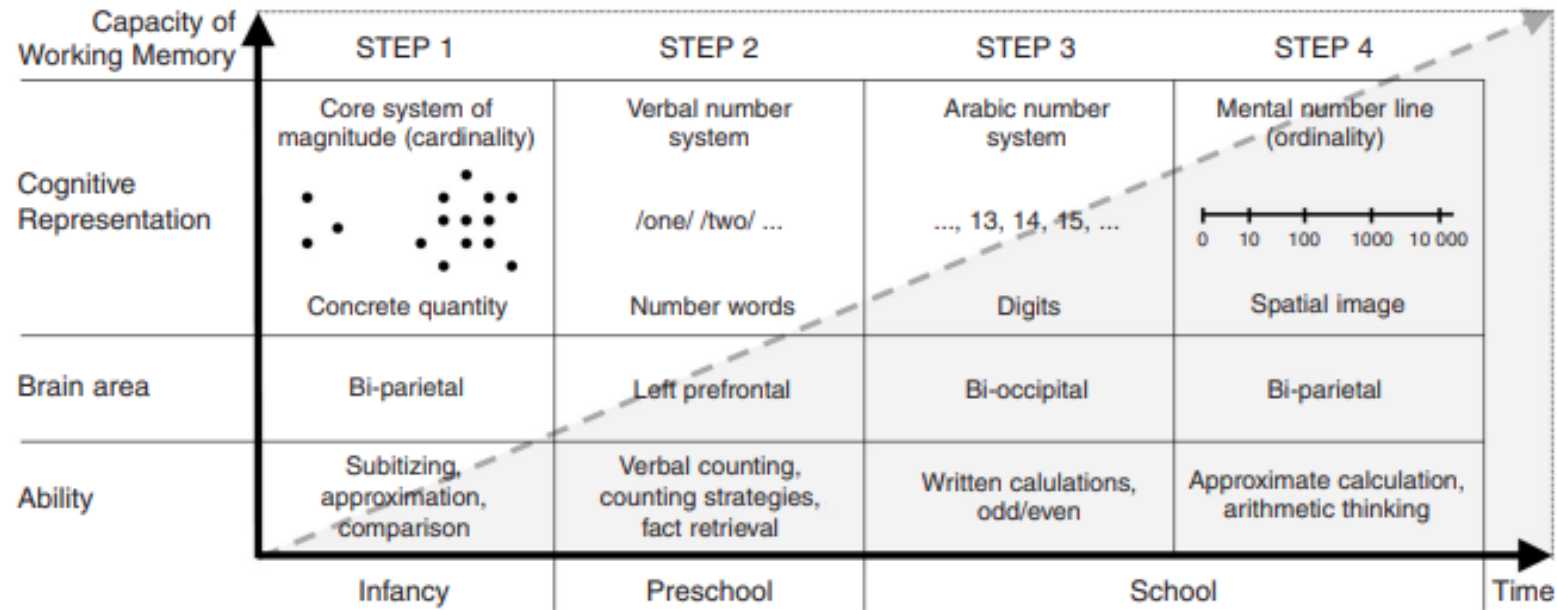
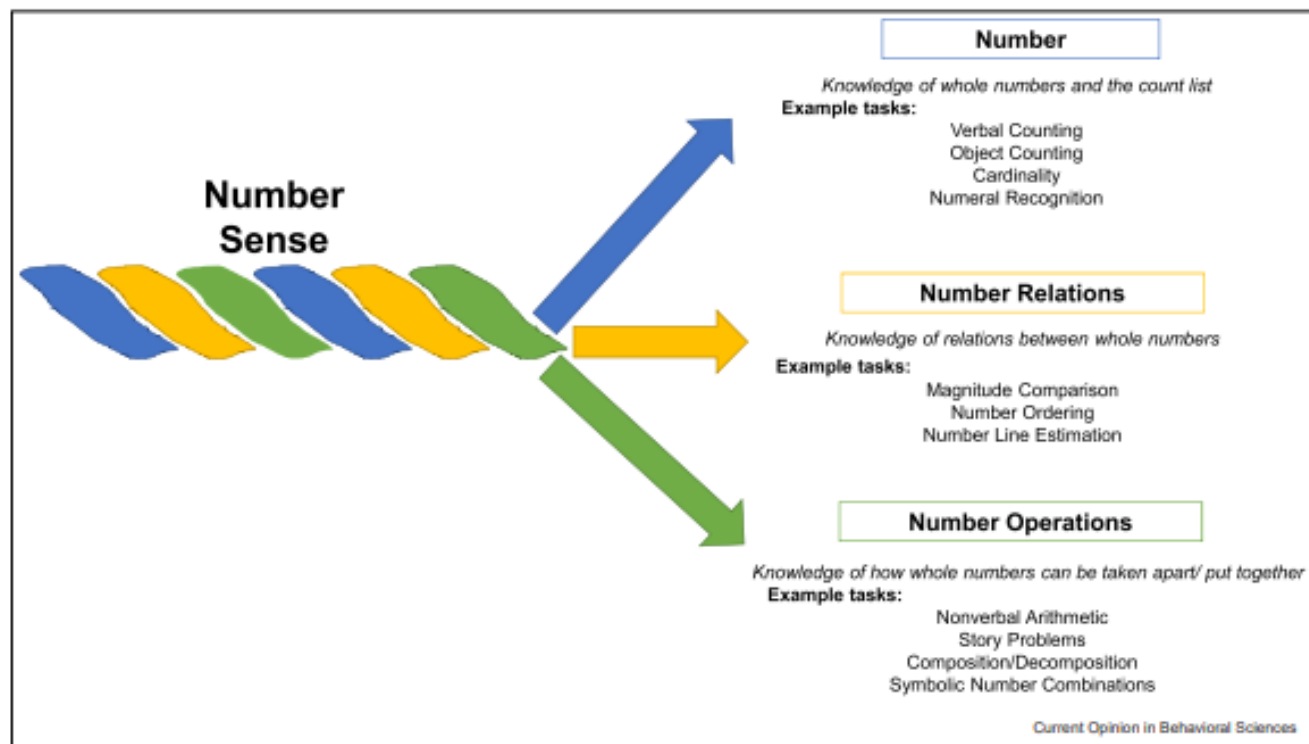


Figure 1: Four-step-developmental model of numerical cognition. Shaded area below broken line: 'increasing working memory.'

(von Aster & Shalev, 2007)

The number sense framework

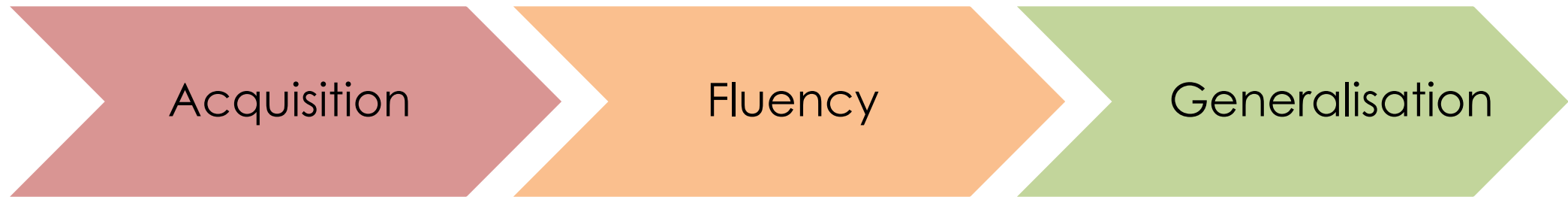


(Jordan et al., 2022)

Instructional Hierarchy: Stages of Learning

Instructional Tactics

- Worked examples



Goal

Learn how to complete the skill accurately and repeatedly without assistance.

(Haring et al, 1978; VanDerHeyden & Peltier, 2024)

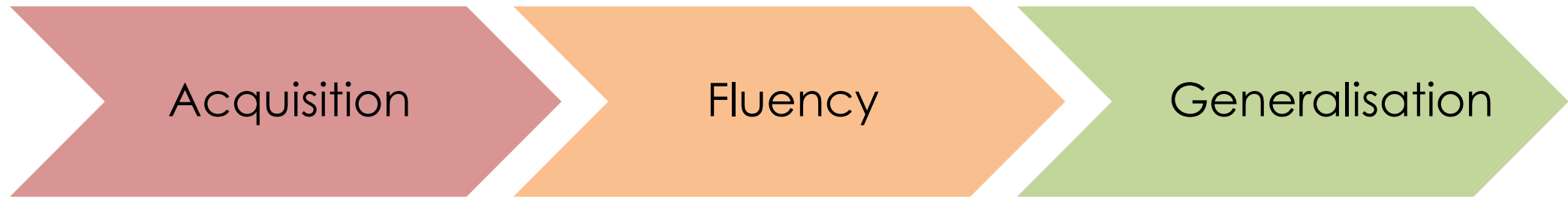
Worked Examples

- Worked examples are completed solutions that we ask students to study and learn from (Pershan, 2021)
- Cognitive load is reduced if we learn the overall method separately from trying to apply it.

Instructional Hierarchy: Stages of Learning

Instructional Tactics

- Worked examples
- Think alouds
- Examples and non-examples

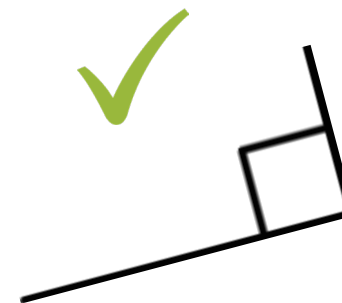
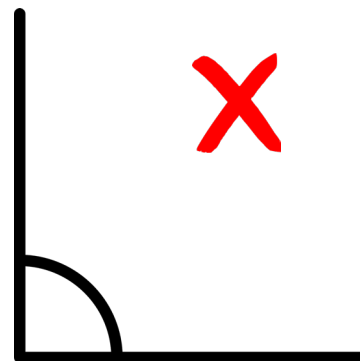
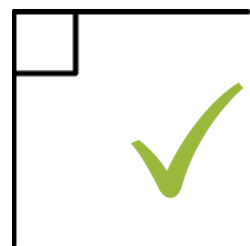
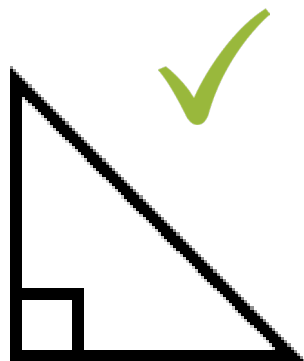
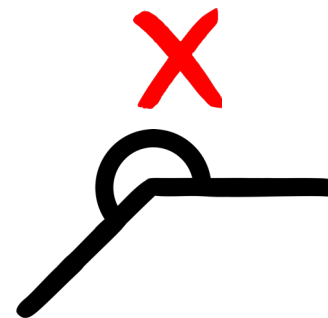
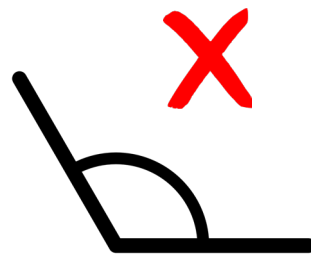
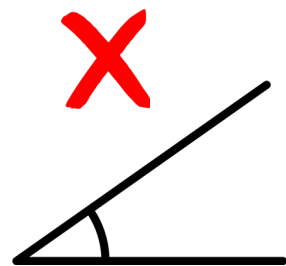


Goal

Learn how to complete the skill accurately and repeatedly without assistance.

(Haring et al, 1978; VanDerHeyden & Peltier, 2024)

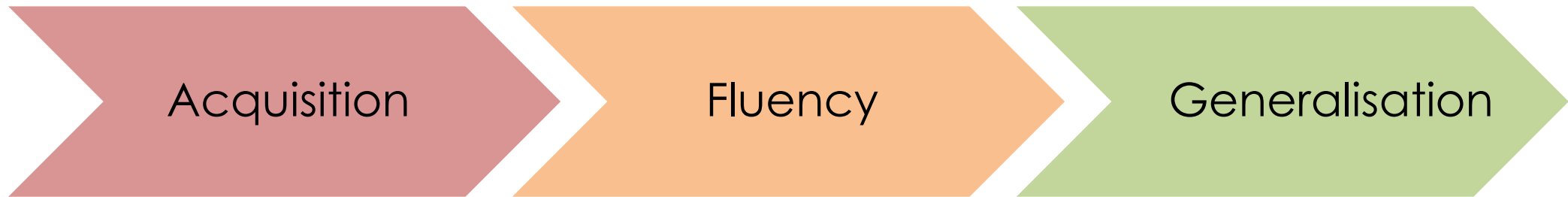
Examples & Non-Examples



Instructional Hierarchy: Stages of Learning

Instructional Tactics

- Worked examples
- Think alouds
- Examples and non-examples
- Immediate corrective feedback
- Prompts and scaffolds



Goal

Learn how to complete the skill accurately and repeatedly without assistance.

(Haring et al, 1978; VanDerHeyden & Peltier, 2024)

Self-Explanation Prompts

Questions:

- "What are the first steps?"
- "Why were they important?"
- "Would it have been ok to..."
- "Why did I..."

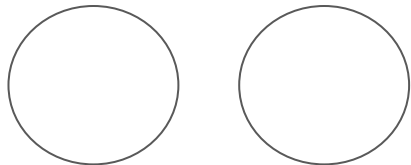

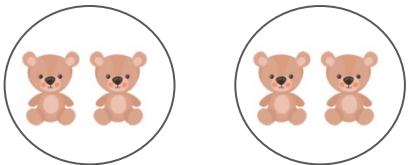
Can also use:

- Fill in the blanks
- Choose from a menu of explanations

(McGinn, Lange & Booth, 2015; Berthold, Eysink & Renkl, 2009)

Concrete-Pictorial-Abstract Framework

- Strengthens conceptual and procedural understanding and enables students to think more flexibly
- Use multiple representations
- Aim to fade
- Keep it relevant

2	x	2	=	4
	x		=	
2 groups	of	2	is	4

(Peltier et al., 2020;

Guided practice

- Example-problem-pair
- Bit-by-bit
- Backwards fading
- Make or break practice

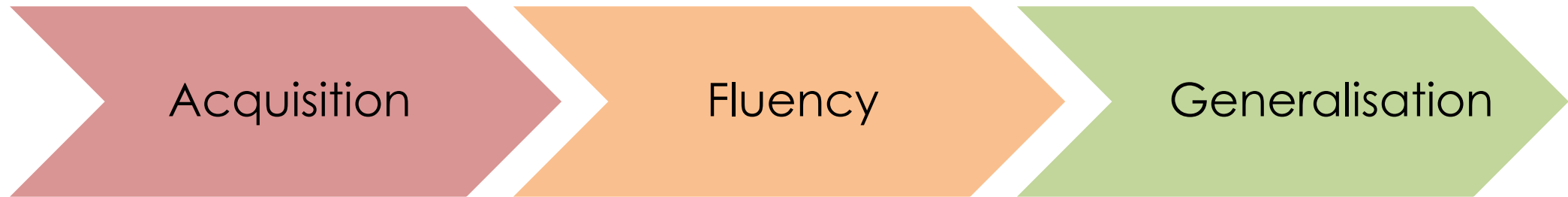
Instructional Hierarchy: Stages of Learning

Instructional Tactics

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Instructional Tactics

- High dosage of opportunities to respond
- Discontinue modelling and prompting
- Set goals for improved performance
- Delayed feedback



Goal

Learn how to complete the skill accurately and repeatedly without assistance.

Goal

Maintain accuracy while increasing speed.

(Haring et al, 1978; VanDerHeyden & Peltier, 2024)

Fluency in basic maths facts opens doors



Instructional Hierarchy: Stages of Learning

Instructional Tactics

- Worked examples
- Think alouds
- Examples and non-examples
- Prompts and scaffolds
- Immediate corrective feedback

Instructional Tactics

- High dosage of opportunities to respond
- Discontinue modelling and prompting
- Set goals for improved performance
- Delayed feedback

Instructional Tactics

- Novel problem types
- Spaced and Interleaved practice
- Use reinforcers when skill is used in a new setting



Goal

Learn how to complete the skill accurately and repeatedly without assistance.

Goal

Maintain accuracy while increasing speed.

Goal

Able to use the skill across settings and without confusing it with similar skills.

(Haring et al, 1978; VanDerHeyden & Peltier, 2024)

Learning to ride a bike



We need to plan for good instruction

- What are the learning intentions?
- What is the prerequisite knowledge?
- What are the common misconceptions?
- What are their strengths/weaknesses?
- What is the key vocabulary?
- What are the hinge questions?
- How can you sequence the concept in small steps?

Anxiety in maths

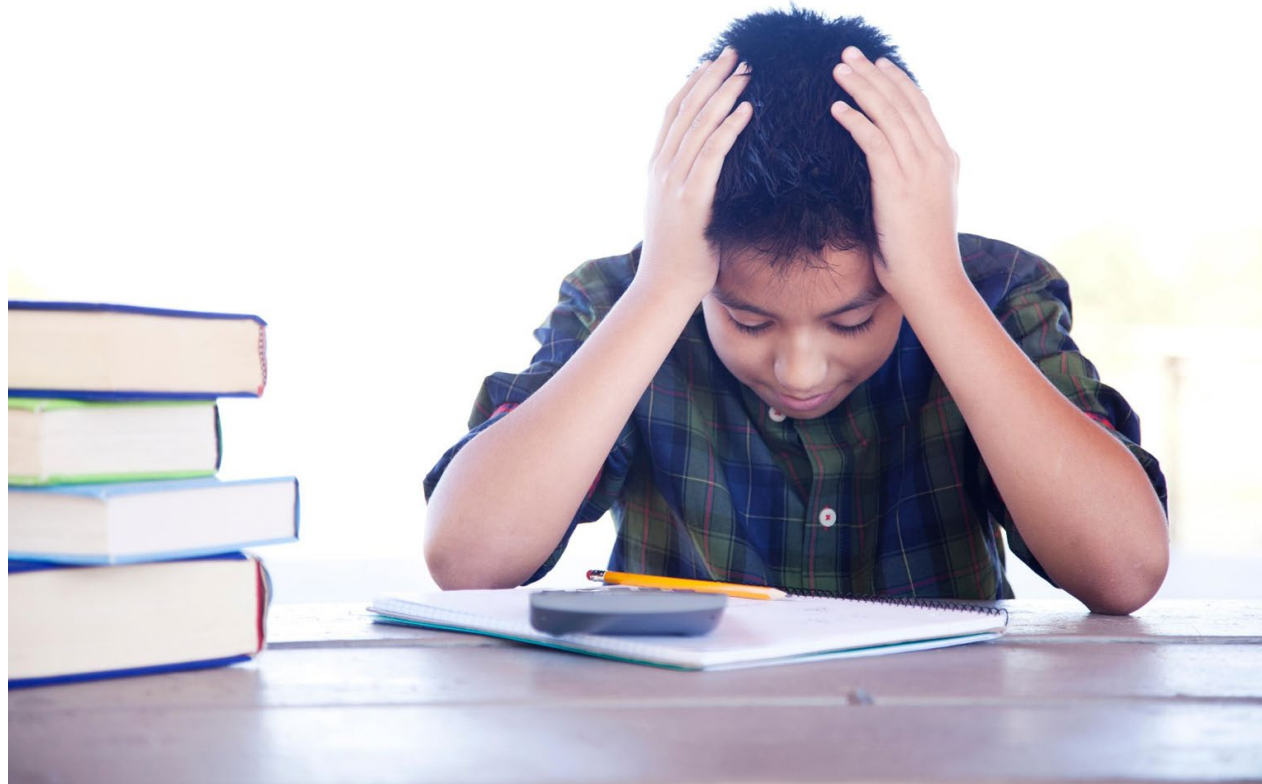
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Having to understand mathematical concepts intuitively and the difficulty in conjuring up the spatial imagery is actually what causes the feelings of anxiety.

”

Krasa et al, 2022

Productive struggle vs destructive struggle



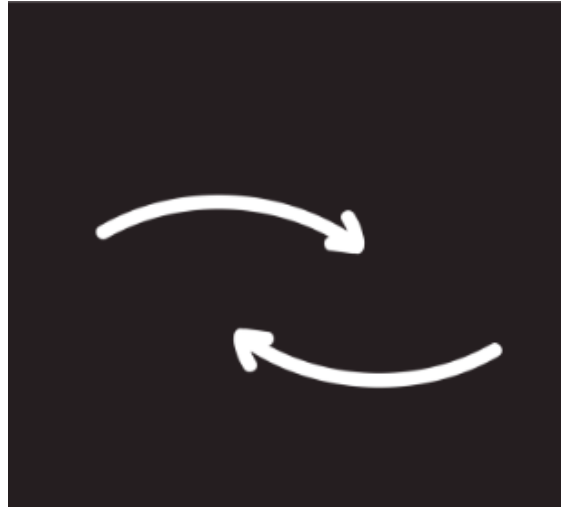
Success breeds success



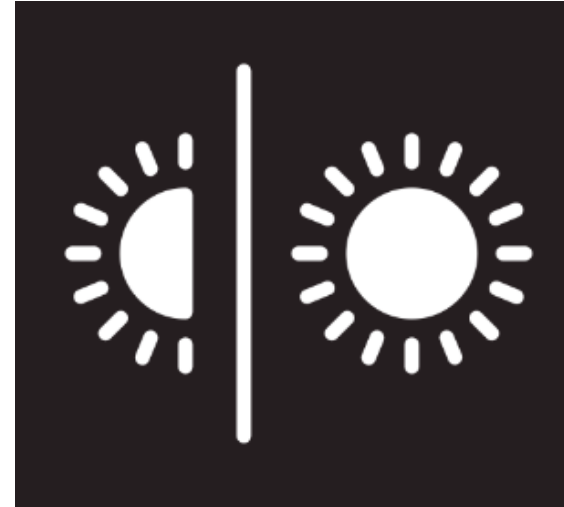
Desirable Difficulties



Spaced practice



Interleaved practice



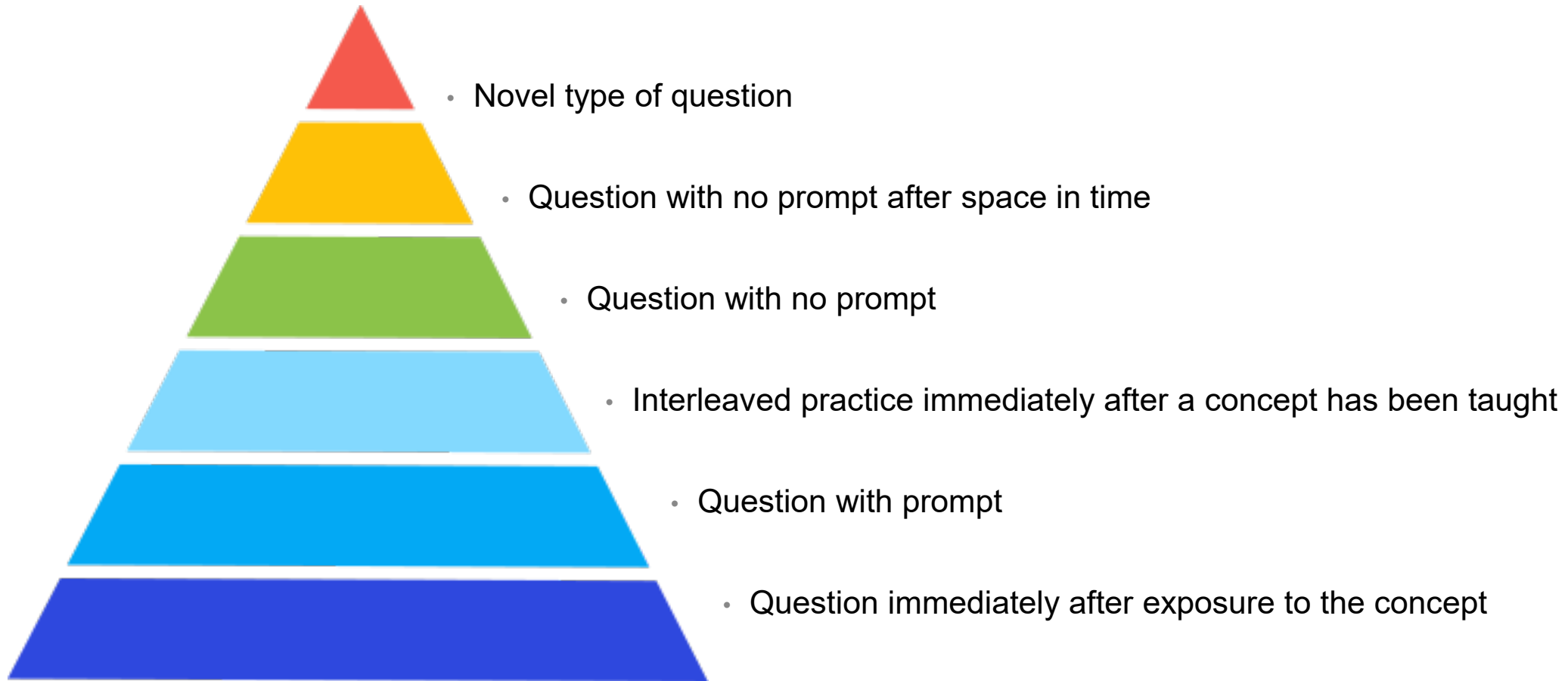
Varied conditions



Generation effects

(Bjork & Bjork, 2011)

Desirable Difficulties



Decrease the stakes



Speak positively about mathematics



Let the maths be the fun part



It's time!



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Knowledge for Teachers