

# STEM and Metacognition: What strategies complement our teaching?

# Contracting Session

- Ask questions at any time!
- Contact details provided at end for further follow-up

# Who Am I?

- Nathan Burns
- Former Head of Maths/Pastoral Lead/MAT Lead
- Metacognitive researcher, author, trainer and consultant
- Teacher educator delivering PD, including ITT and NPQs



# Session Aims

1. Determining the *why* of having a metacognitive focus
2. Understand the *what* of metacognition
3. Identify the *how* of metacognitive implementation

Write...

*Why does metacognition matter?*

# Why Metacognition? The Headlines...

- Greatest positive attainment impact of any intervention (EEF, 2019)
- OFSTED (2018) suggested area of focus for high-quality CPD
- Benefits ALL students (regardless of: socio-economic status; prior attainment; sex; behaviour; SEN status; age) (many, many papers...)

# Anything Else?

- Works across phases (i.e. can be a focus for all)
- Works across curriculum areas (i.e. can be a whole school focus)
- Compliments whole school work around feedback, modelling, questioning (and more...)

# There's More?

- Develops problem solving skills
- Improve skill transference across contexts
- Improves students self-regulatory abilities
- Increases revision effectiveness



Write...

*What is metacognition?*

# What Metacognition Isn't

- Metacognition is not the same as self-regulation
- Self-regulation is an umbrella that cover learning habits AND behaviours

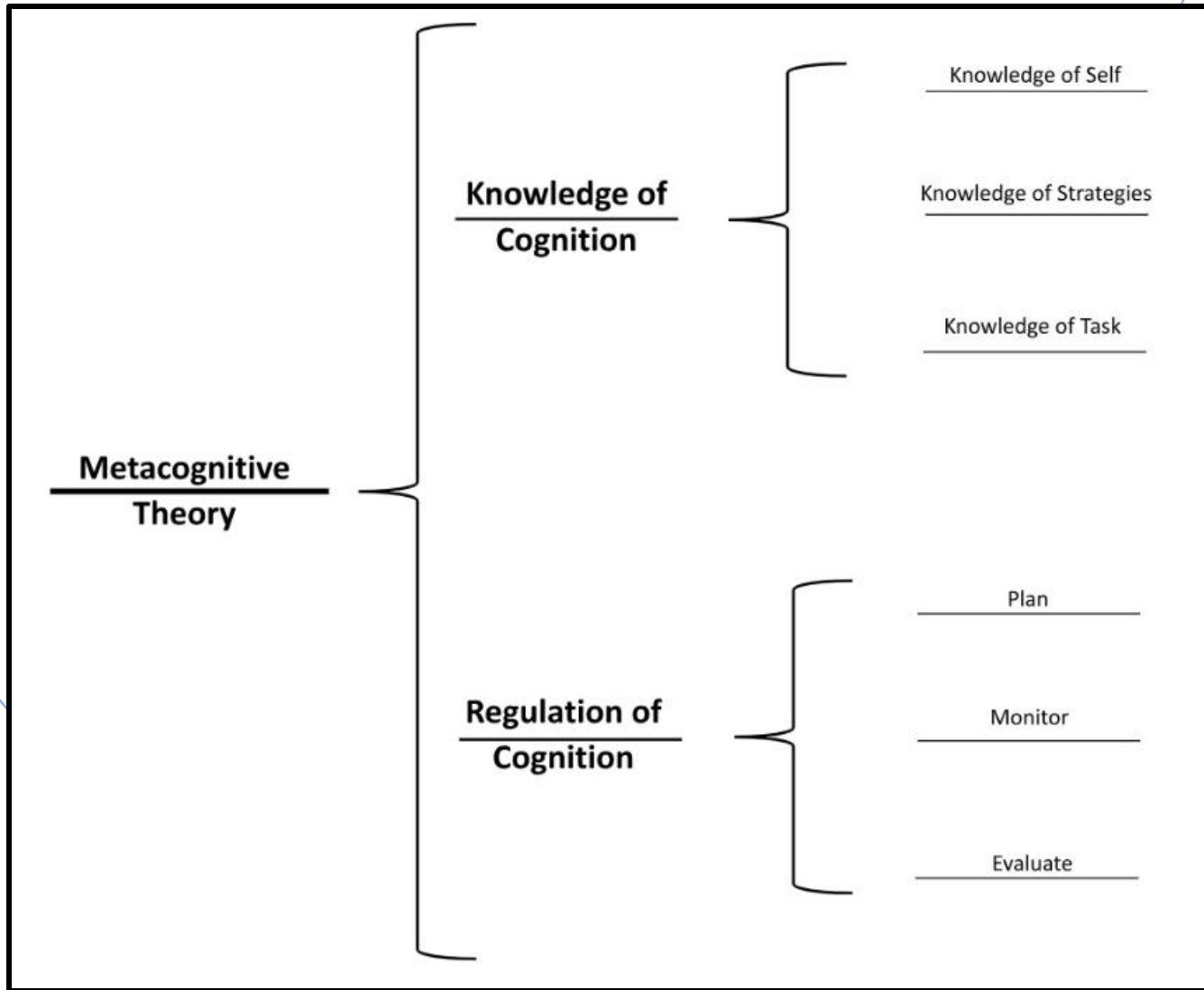


# What Metacognition Is

- Flavell (1972): 'I am being metacognitive if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as fact'
- Burns (2023): '[Metacognition is] the little voice inside your head that constantly evaluates and informs your decisions.'

# Why Is It So Difficult?

- It's invisible
- There are complexities to the theory
- It is reliant on cognition and motivation (i.e. it is not a standalone strategy or pedagogy)



Knowledge

Vs

Regulation

# Knowledge Of Cognition

- Knowledge of task – knowledge of requirements to meet to fulfill task criteria
- Knowledge of self – knowledge of... knowledge
- Knowledge of strategies – knowledge of methods available to attempt a cognitive task

# Regulation Of Cognition

- Planning – an approach for the task
- Monitoring – staying on track for successful task completion
- Evaluation – review of the efficiency and effectiveness of approach and outcomes

# Levels Of Metacognition

- Metacognition is not a dichotomy
- We have Perkins' (1992) 4 levels: tacit; aware; strategic; reflective

*Tacit* – not aware of control of cognitive processes

*Aware* – aware of cognitive processes but don't actively engage with them

*Strategic* – begin to plan and evaluate cognitive action

*Reflective* – plan, monitor and evaluate cognitive action





Write...

*What are the myths around metacognition?*

# Myths Of Metacognition

1. Metacognition is only for high-attaining students
2. Metacognition is not for students with SEN
3. Metacognition is only for older students
4. Metacognition is only for girls
5. Metacognition is just a fad and a repetition of 'Learning to Learn'

# Explicit Justifications

What?

- Justify the choices that you make during modelling
  - Explaining where (relevant) you take a different possible pathway (use of a key word; strategy; use of prior knowledge and so forth)

Why?

- Ensures students learn from our experiences rather than trial & improvement 100 times over.
- Aim to lead to a greater depth of understanding.
- Model to students how an expert goes about decoding and completing a task.

# Example

I would utilise a bar chart to graph this data. This is because the data is discrete, not continuous, so a line graph is not suitable. There is not a total amount so I cannot use a pie chart.

**Water Temperatures  
at Various Depths**

<b>Water Depth (meters)</b>	<b>Temperature (°C)</b>
50	18
75	15
100	12
150	5
200	4

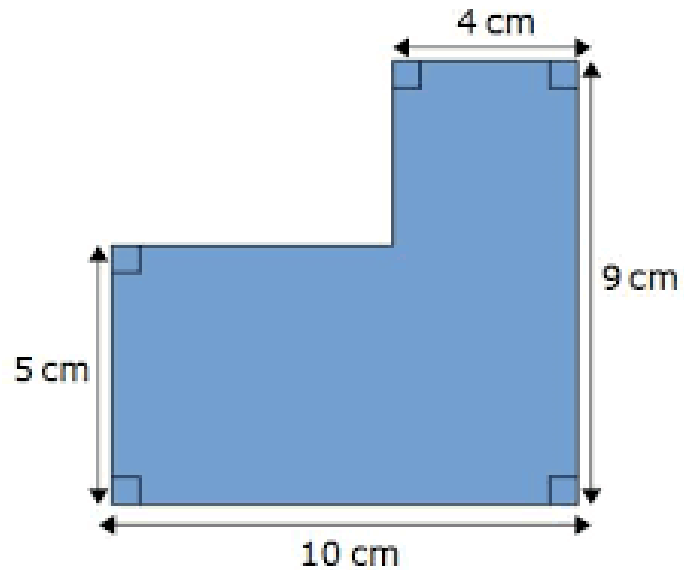
# Example

Animals are divided into two main groups. Animals that have a **backbone** (spine) are called **vertebrates**. Animals that don't have a **backbone** are called **invertebrates**.

Vertebrates and invertebrates are divided into smaller groups.

Ensuring that we define these key words, rather than just assuming that students will know them, because it is 'banked' knowledge for us.

# Example



There are two ways of calculating the area here, which are...

I am going to find the area using this method.... because...

# Knowledge of Grid

What?

- Knowledge of grid is a planning tool to get students to think about the fundamentals of *any* cognitive activity:
  - Knowledge of task
  - Knowledge of self
  - Knowledge of strategies

Why?

- Student forced to attend to these factors
- Places emphasis and priority on these areas (and moves it away from just doing the task)
- Scaffolds an approach to a (complex) task

# Example

Describe how the student could use the apparatus to estimate the **mean** length of onion cells on the slide.

[6 marks]

Figure 2 shows onion cells viewed using a light microscope.

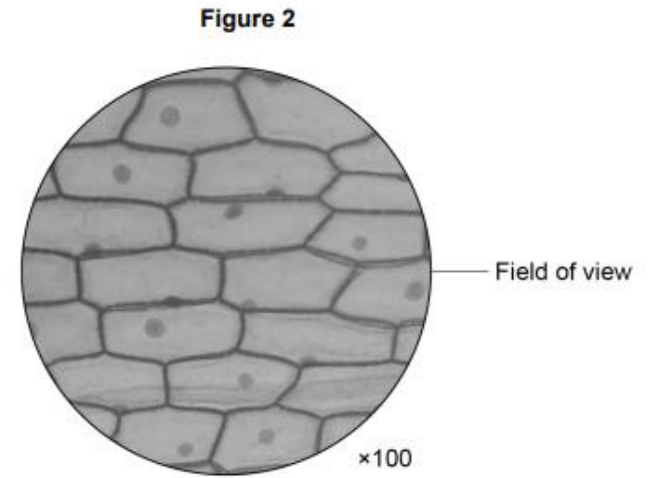
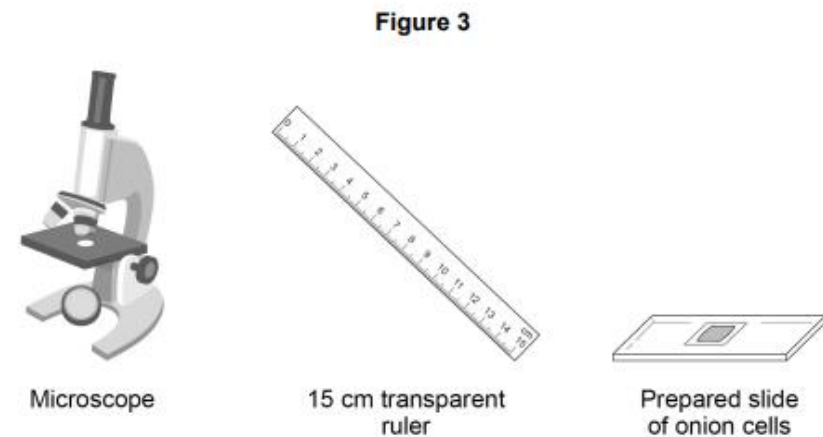


Figure 3 shows the apparatus given to a student.





# Example

Knowledge of Task	Knowledge of Self	Knowledge of Strategies
<p>Description task Need to accurately explain how the apparatus can be used Need to find a mean length for the onion cells So need to find multiple measurements and calculate</p>	<p>Know how to work out mean (add up measurements/how many there are) Use microscope with slide underneath How do I use the ruler to take the measurements?</p>	<p>Step-by-step. Will number bullet point a list of steps 6 marks so 6 points?</p>

# Example

Consider the benefits and drawbacks of using a 'dry run' for a newly develop computer program (5)

Knowledge of Task	Knowledge of Self	Knowledge of Strategies
Need to define Need to provide at least 2 benefits and 2 drawbacks (5 marks, 1 for define, 2 for +, 2 for -)	+ Identify issues + Reduce costly changes later  - Takes time - Financial cost	Start with define, then do the two + then two -  Or I could try to link them together, e.g. identify issues but this will cost more money to do

# Example

Choose two different types of animal, and describe their life cycle

Knowledge of Task	Knowledge of Self	Knowledge of Strategies
<p>Need two types.</p> <p>Need to be different.</p> <p>Need to explain stages.</p> <p>Need to have a good life cycle</p>	<p>Certain on butterflies</p> <p>Less sure on frogs</p> <p>Can do sheep etc. But that's easy</p>	<p>Describe one and then the other.</p> <p>Compare and contrast as I go along</p>

# Goal Free Problems

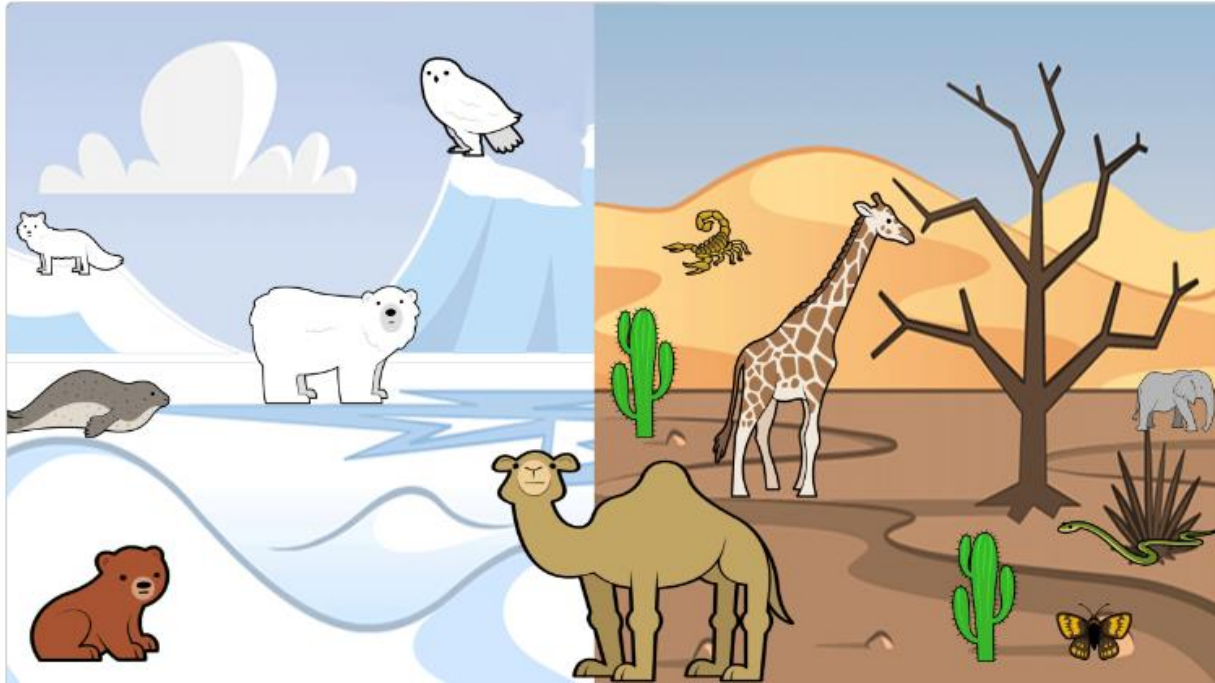
What?

- Provide students with a longer problem question, but remove the question/task element
- Allow students to recall as much information as they can.

Why?

- Superb retrieval task
- Removes the barrier of a 'question'
- Improves student confidence; show them what they can do

# Example



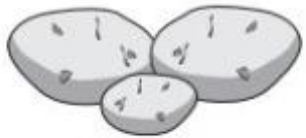
What could a question be?

What can you deduce from the image?

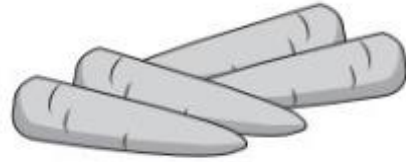
What do you agree on? What do you disagree on?

What topic(s) may this link in to?

# Your Turn



potatoes  
£1.50 per kg



carrots  
£1.80 per kg

Jack buys  $1\frac{1}{2}$  kg of potatoes and  $\frac{1}{2}$  kg of carrots.

- What can you calculate?
- How many marks can you achieve?
- List all potential questions
- What units does the question link to?

# Do It Again

What?

- Students given a task or problem and allowed to approach and complete it in any way they wish
- Students receive feedback as normal (and determine the 'correct answer')
- Students must repeat the task, utilising a different strategy

Why?

- Forces students to develop their use of a range strategies
- Allows for strategy comparison (strengths, weaknesses, efficiencies, effectiveness)
- Students become more 'flexible'

# Example

- Solving equations with brackets --> expanding; dividing by the denominator
- Solving quadratics --> factorise; formula; complete the square
- Re-run an experiment with different equipment or different quantities
- Programming --> Micropython; Python



# Content Checklists

What?

- Produce a list of the content that needs to be included in a successful task response.
- Teacher or TA led, or group/pair/individually produced.

Why?

- Reduce cognitive load during task completion
- Increase likelihood that all content is included within task response.

# Example

(BBC Bitesize): "State the law of conservation of mass, and explain why some reactions may appear to involve a change of mass (6)"

Checklist...

- In reaction, no atoms lost/made
- Mass products = mass reactants
- Mass looks like increase
- As solid reactant joins air (gas)
- Mass looks like decrease
- Products = gas = disappear

# Stay In Touch!

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