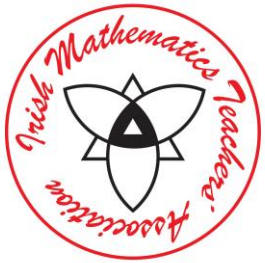
maths explained




# Meta-cognition and Cognitive Style

Steve Chinn

2024

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# ‘How People Learn’

## Key Finding 3 (NRC, 2000)

A ‘metacognitive’ approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.

*Metacognition has been in the Singapore national maths curriculum framework since the 1990s.*

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# Cognitive (Thinking) Style

Riding and Rayner (1998) define cognitive (thinking) style as:

"A person's preferred and *habitual* approach to organising and representing information."

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# Learning Style

A broader construct that includes other factors such as:

Working environment, for example, vanilla

Medium, for example auditory or visual

Attention span

Time of day

Holistic or a series of logical steps

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# The Concept of Thinking Styles

Descartes (1638)…. ‘A succession of logical deductions’ compared to ‘Intuition and immediate perceptions of connections and relationships.’

Polya (1962)…. Algebra, generalisations, groping, bright idea.

Skemp (1971)…. Instrumental and relational.

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# The Concept of Thinking Styles

Sharma (1986) Mathematics Learning Personalities:

Quantitative and Qualitative

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# ‘Thinking, Fast and Slow’
(2012) Kahneman, D., Penguin

System 1 operates automatically and quickly, with little or no effort and no sense of voluntary control.

**System 2** allocates attention to the effortful mental activities that demand it, including complex calculations. The operations of System 2 are often associated with the subjective experience of agency, choice and concentration.

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Time to check you out

(Take some notes??)

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# Mental Arithmetic

**223 + 98**

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# Mental Arithmetic

**223 – 98**

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# Mental Arithmetic

**2 x 4 x 3 x 5**

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# Mental Arithmetic

**25 x 96**

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# Word Problem

Red pens cost 17p. Blue pens cost 13p.

If I buy two red pens and two blue pens, how much do I pay?

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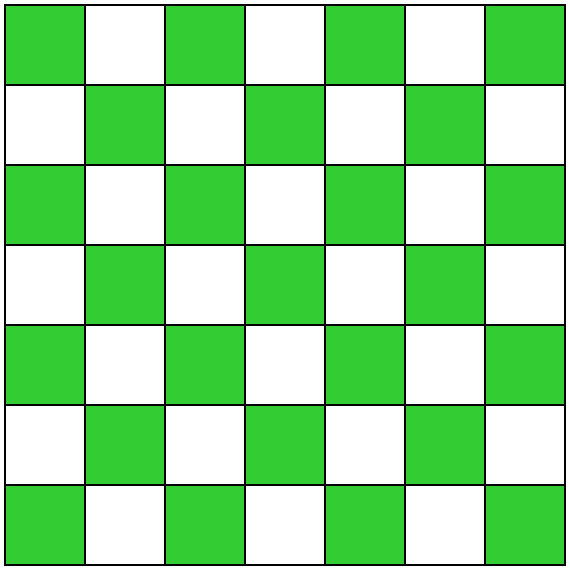
There are 49 squares in this figure.

How many are green?



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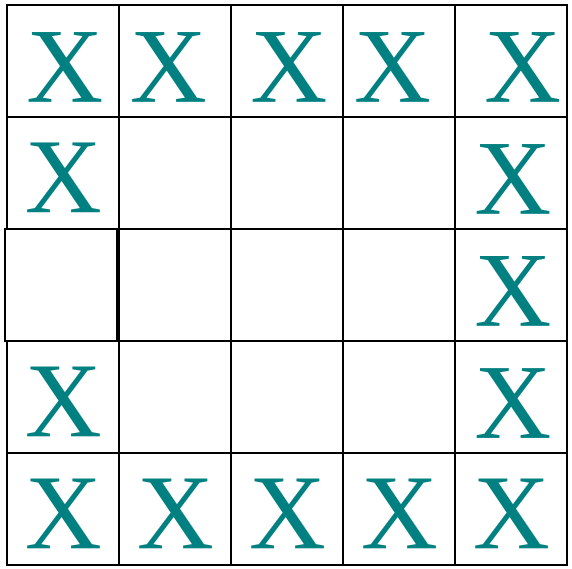
# There are 25 squares in this figure.

- How many have an X ?

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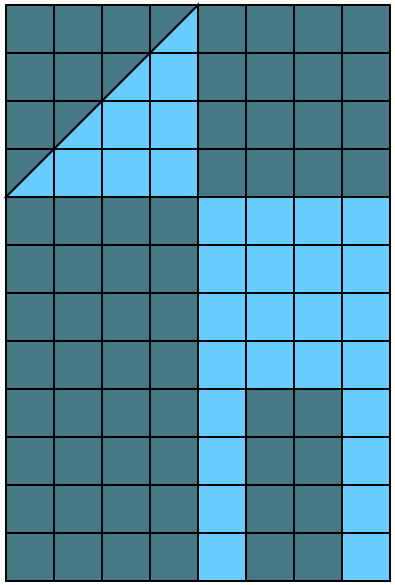
# The ‘Horse’

- How many **blue** squares in the ‘horse’?



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# You are driving a bus from London to Pe:

At London 17 people get on

At Reading 6 people get off and 9 get on

At Swindon 2 people get off and 4 get on

At Cardiff 11 people get off and 16 get on

At Swansea 5 people get off and 3 get on

What is the name of the driver?

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‘How did you do that?’

What else can you learn as the assessor?

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# The Inchworm

- Focuses on the parts and details… separates
- Looks for a relevant formula or procedure

- Constrained focus. Wants one method
- Works in serially ordered steps… forward
- Uses numbers exactly as given
- More comfortable with paper and pen… documents

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# The benefits of algorithms (Usiskin, 1998)

*Power:* An algorithm applies to a class of problems.

*Reliability and accuracy:* Done correctly, an algorithm always provides the correct answer.

*Speed:* An algorithm proceeds directly to the answer.

*AI?*

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# The benefits of algorithms. #2

*A record:* A paper and pencil algorithm provides a record of how the answer was determined.

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# The Inchworm

Unlikely to check or evaluate answers.

If a check is done, it will be done using the same method.

May not understand the method or procedure used. Works mechanically.

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# Teacher-identified math weaknesses.

Bryant, Bryant and Hammill, JLD, 2000

- Ranked 4th….
- Fails to verify answers and settles for first answer

- Ranked 9th ….
- Reaches ‘unreasonable’ answers

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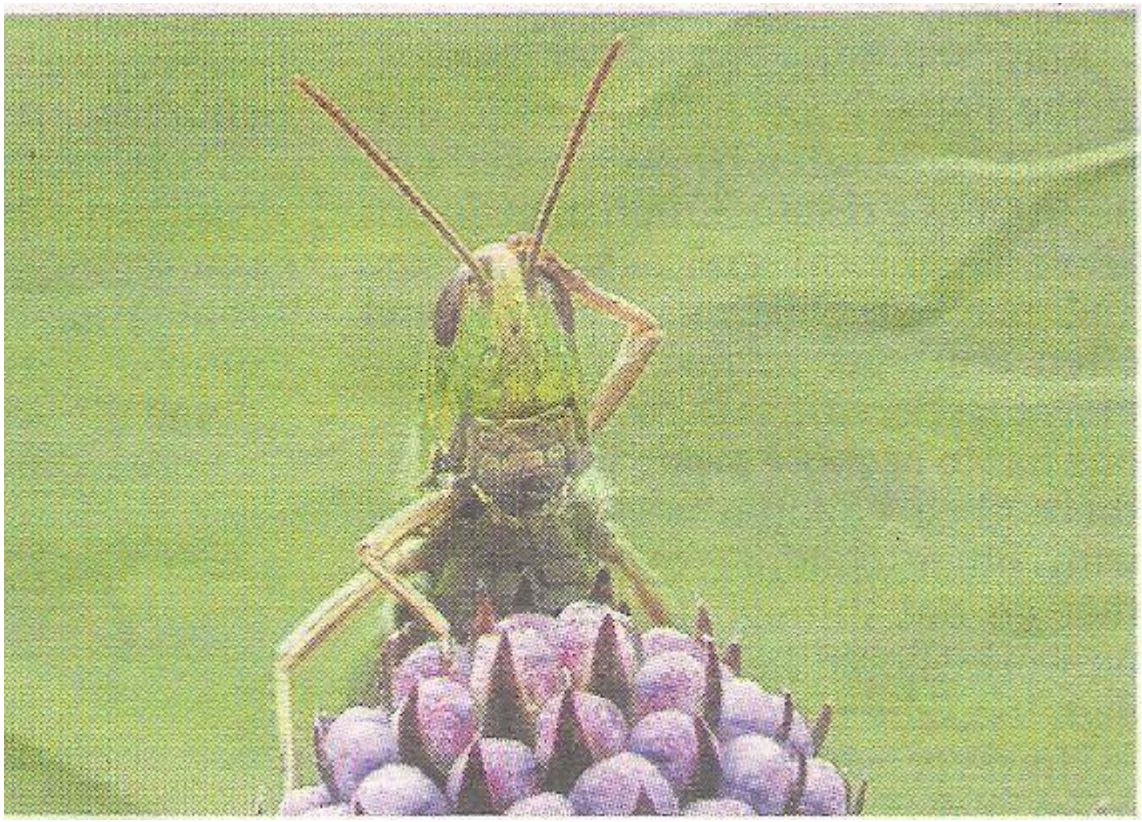
# The Grasshopper



Better prepared for life?

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# The Grasshopper

- Overviews, puts together, holistic
- Looks at the numbers and the facts to restrict down or estimate an answer. ‘This is not guesswork, it is controlled exploration.’

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# The Grasshopper

- The methods used are flexible
- Often works back from a trial answer
- Adjusts, breaks down/builds up numbers, finding the easy numbers
- Performs the calculation mentally. Rarely documents.

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# 6 year old pupil

- 32 - 19 = 27

- ‘Show how you worked out your answer’

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# The Grasshopper

- Is likely to appraise and evaluate the answer
- Checks by a different method
- Has a good understanding of numbers, their inter-relationships and the operations and their inter-relationships.

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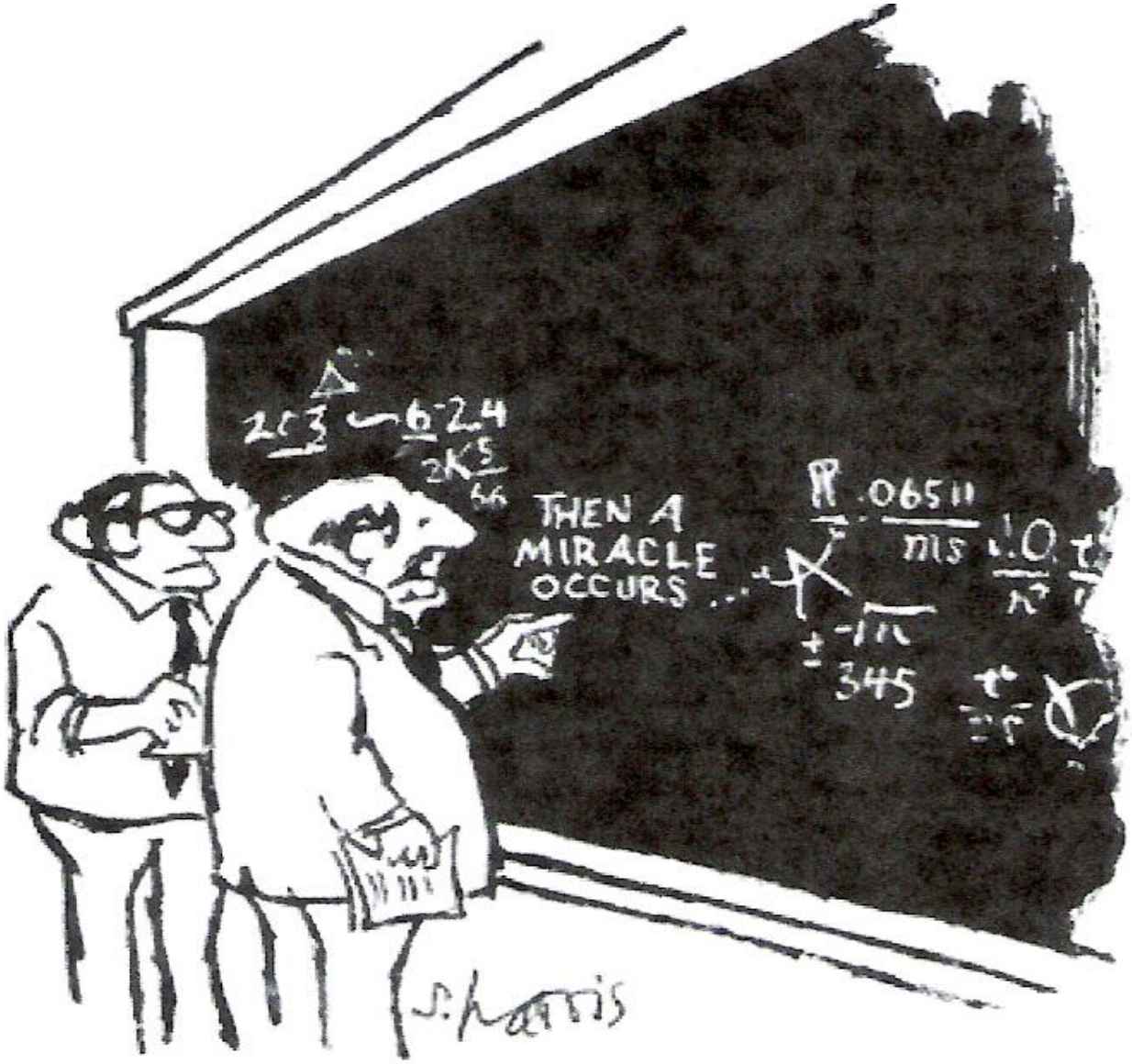
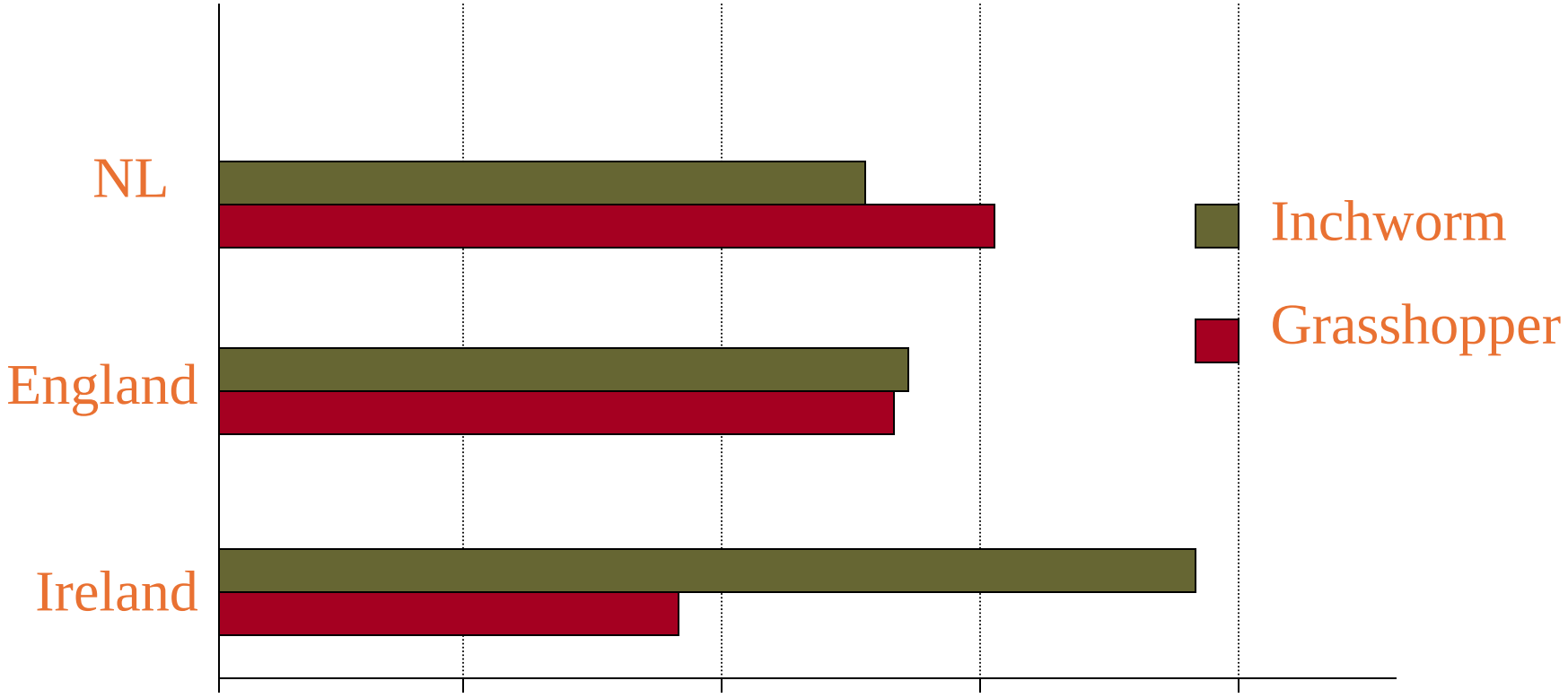



"I think you should be more explicit here in step two."

# Cognitive Style – Non-Dyslexics




Chinn et al (2001) Brit J of Special Ed, v28, #2

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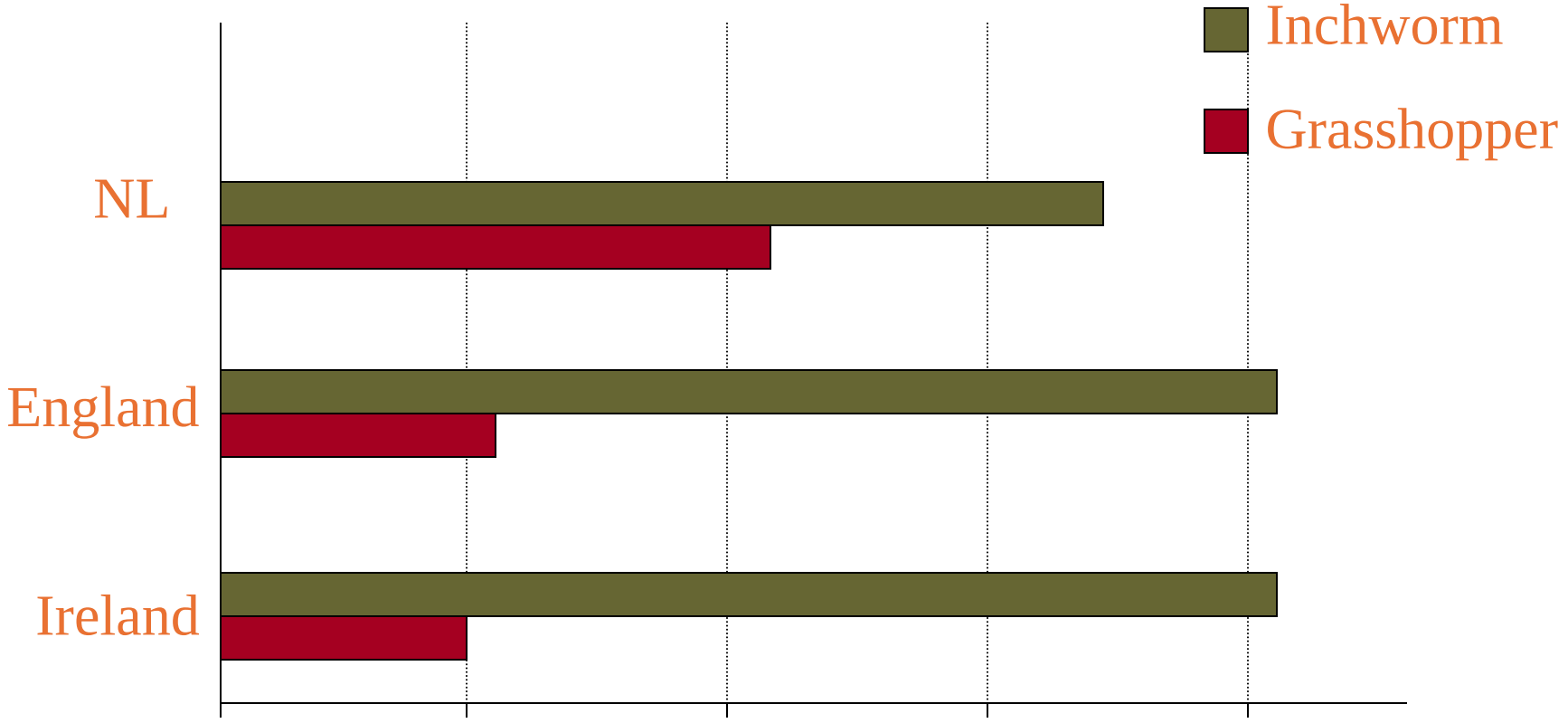
# Cognitive Style – Dyslexics




Chinn et al (2001) Brit J of Special Ed, v28, #2

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# Thinking Style and Dyscalculia

- Inchworm
- Memories:  Ltm, WM
- Speed of working
- Sequential skills
- Anxiety **BUT they do document**

- Grasshopper
- Careless/inaccurate
- No documentation

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# Evaluation and Feedback

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# Four farmers let their 32 sheep graze together on the hills for the summer. In the Autumn they sent their children to bring them down….

Sandra was to bring 5 more than Alan.

Alan was to bring 2 less than Robert.

- Jackie was to bring twice as many as Alan.

How many sheep did each of the children bring home?

How many gave birth before they got down?

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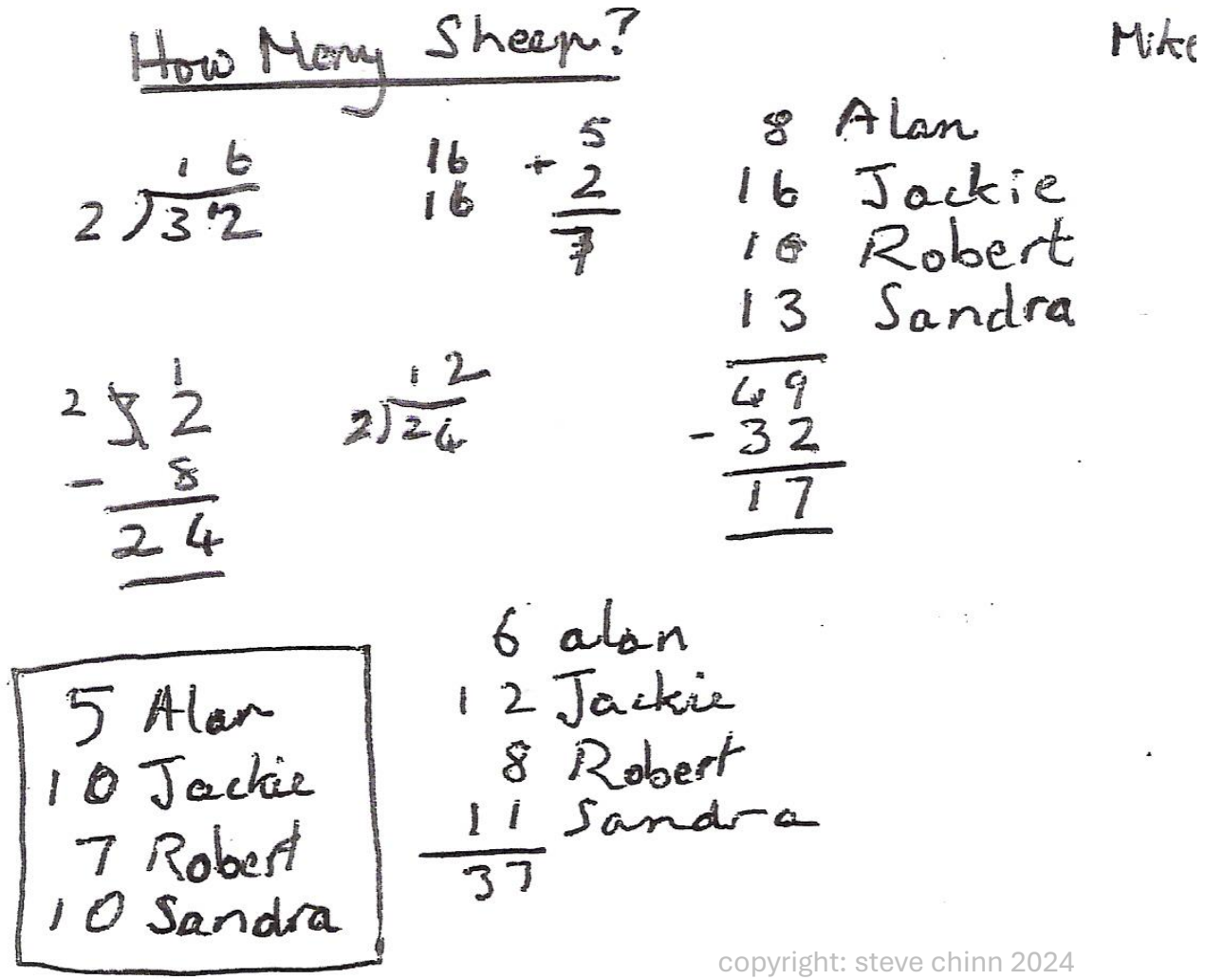
# Pupil 1 (Mike)

Trial and adjust

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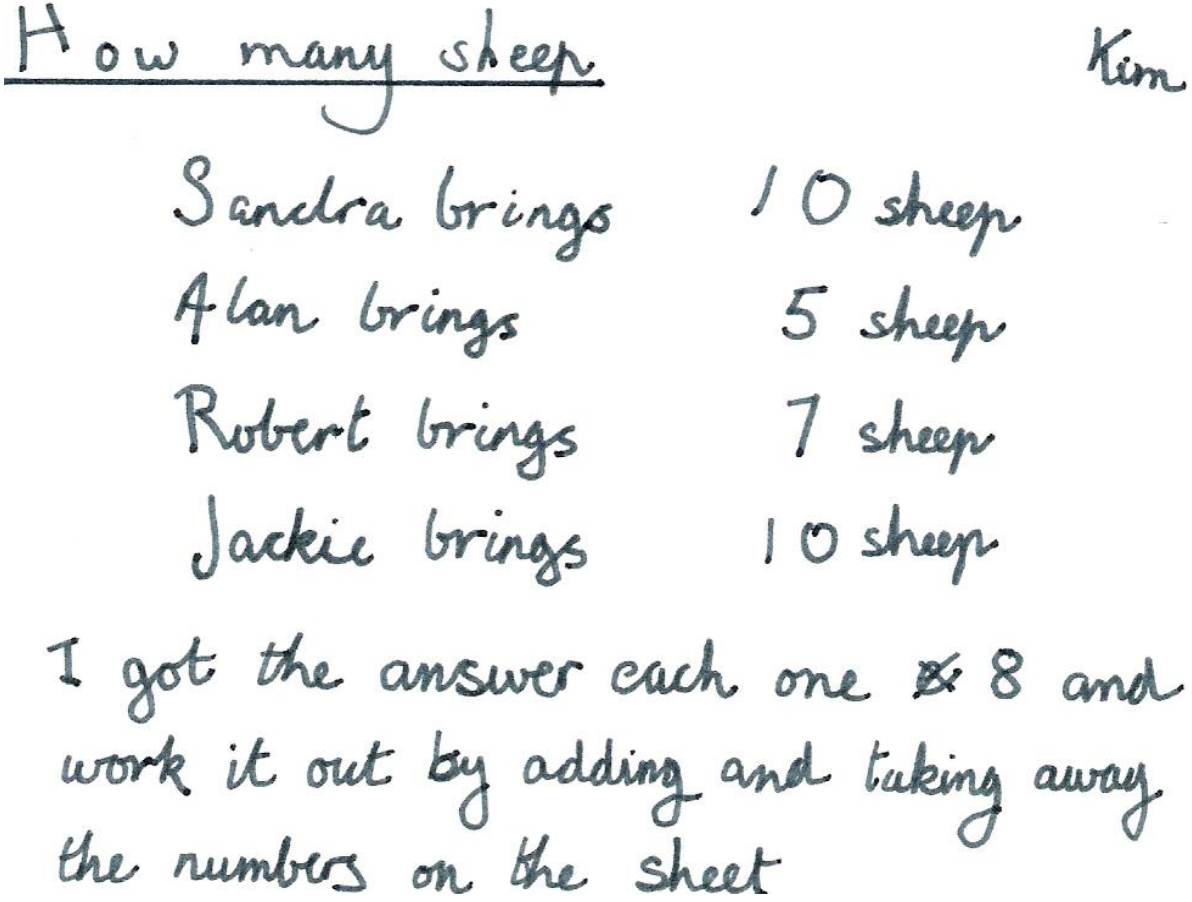
# Pupil 2 (Kim)

I just did some ‘working’

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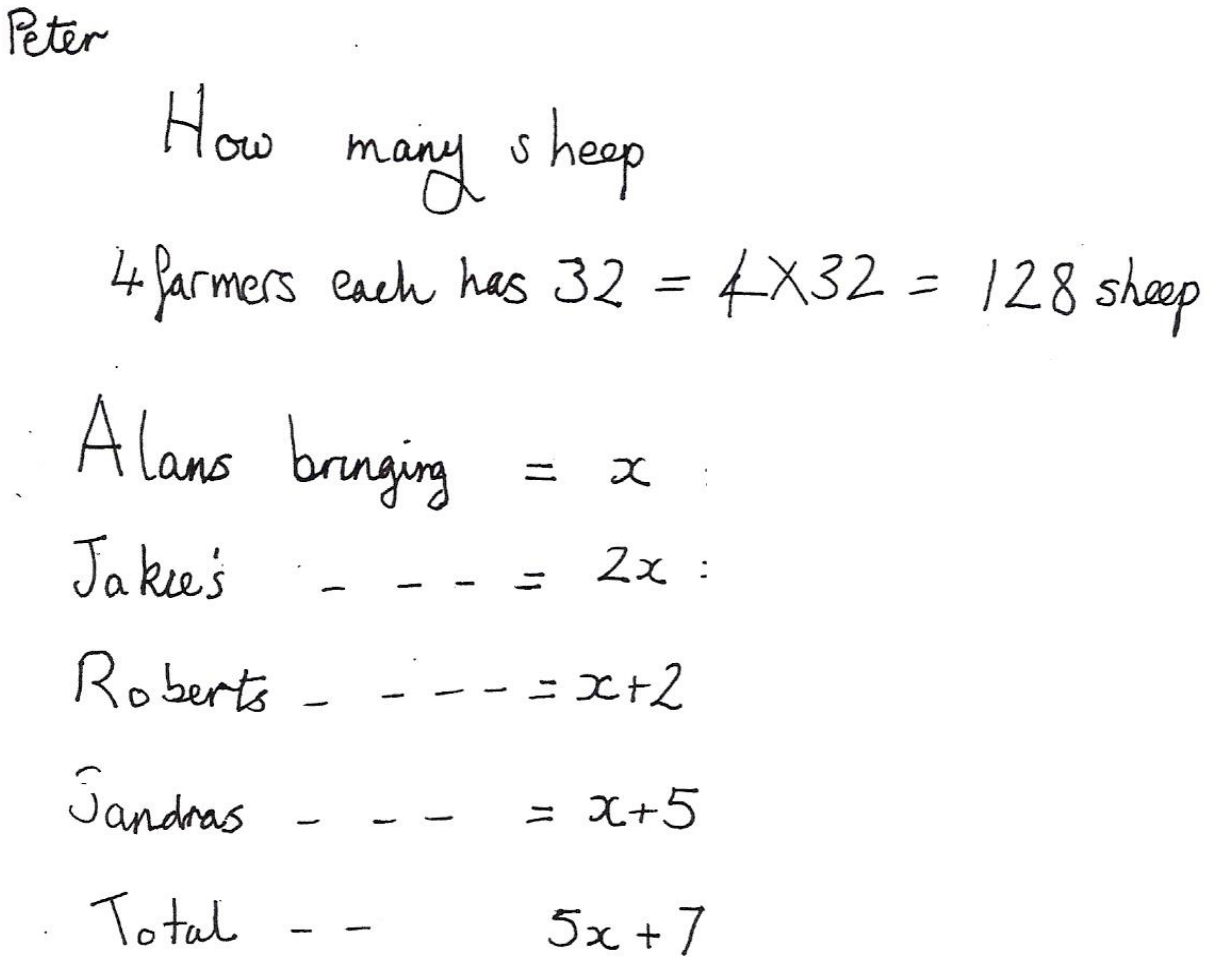
# Pupil 3 (Peter)

Algebra

….. but

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# Marking

| Trial and adjust | ‘working out’ | algebra |
| --- | --- | --- |
| 7 | 6 | 8 |
| 5 | 7 | 9 |
| 6 | 8 | 4 |
| 7 | 5 | 3 |
| 2 | 2 | 10 |
| 6 | 3 | 0 |
| 5 | 6 | 9 |

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# Evaluation and Feedback

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# Maths NQT's

- BEd students at MMU
- Of whom 80% found maths intimidating at school
- Likely to follow the patterns of teaching that they so loathed when they were pupils
- Widespread anxieties about learning maths and about teaching the subject.

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# ‘How People Learn’ (2000) National Research Council, USA

## Key Finding 1

Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged they may fail to grasp the new concepts and information that they are taught, or they may learn them for the purposes of a test,

*but revert to their preconceptions outside the classroom*.

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# Preparing teachers to teach maths to students with learning difficulties

Parmar and Cawley, JLD 1997, v30, #2

Behaviouristic

(Guided meaning)

Constructivist

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# Behaviouristic

- A focus on developing skills
- Identification of a single algorithm
- Teacher provides sequence of steps
- Students memorise and follow set procedure
- Mastery of skills prior to their application
- Individualised drill and rehearsal activities for mastery

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# Constructivist

- Focus on deeper level of understanding
- Evolvement of a variety of materials and activities
- Teacher encourages discussions
- Students interact with materials to develop conceptual learning
- Students assimilate new concepts into prior knowledge

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# Key understandings in mathematics learning. Nuffield Foundation. 2009

- Emphasis on procedures and manipulation with numbers, rather than on understanding the underlying relations and mathematical meanings, can lead to over-reliance and misapplication of methods in arithmetic, algebra and problem solving.

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# Then …… Skemp (1971)

- '…. The increasing efforts the student makes will inevitably use the only approach which he knows …….. memorising. This produces a short-term effect, but no long-term retention. So further progress comes to a standstill, with anxiety and loss of self-esteem.'

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# Mastery and cognitive style

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# Key features of the mastery approach

## Curriculum design

Effective mastery curricula in mathematics are designed in **relatively small carefully sequenced steps**, which must each be mastered before pupils move to the next stage.

*(Basic fact experiment)*

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# Teaching resources

**Concrete and pictorial representations** of mathematics are chosen carefully to help build procedural and conceptual knowledge together.

Making connections in mathematics deepens knowledge of concepts and procedures, **ensures what is learnt is sustained over time,** and cuts down the time required to assimilate and master later concepts and techniques.

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# Lesson design

Lessons are crafted with similar care and are often perfected over time with input from other teachers, drawing on evidence from observations of pupils in class.

Lesson designs set out in detail well-tested methods to teach a given mathematical topic.

They include a variety of representations needed to introduce and explore a concept effectively

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# Teaching methods

In highly successful systems, teachers are clear that their role is to teach in a **precise** way which makes it possible for all pupils to engage successfully with tasks at the expected level of challenge.

Pupils work on the same tasks and engage in common discussions.

Your thoughts on this?

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# Pupil support and differentiation

Differentiation occurs in the support and intervention provided to different pupils, **not in the topics taught, particularly at earlier stages.**

There is no differentiation in content taught, but the questioning and scaffolding individual pupils receive in class as they work through problems will differ.

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# Pupil support and differentiation

Pupils' difficulties and misconceptions are identified through immediate formative assessment and **addressed with rapid intervention** – commonly through individual or small group support later the same day:

There are very few "closing the gap" strategies, because there are very few gaps to close.

The role of diagnosis in teaching

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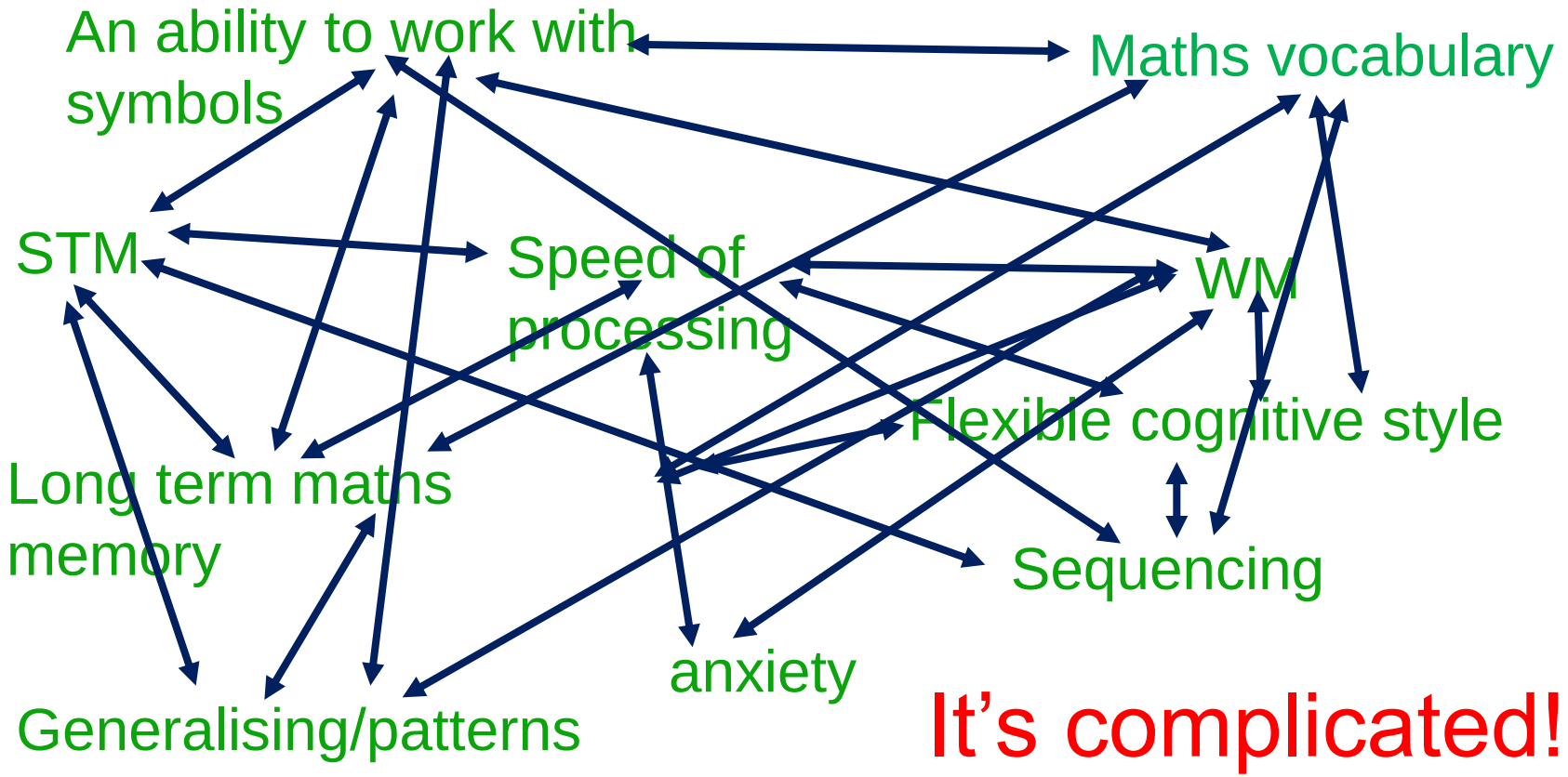
# Learner factors

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# Mind maps and lists

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maths explained

# Meta-cognition and Cognitive Style

Steve Chinn

**End of session.**

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# www.mathsexplained.co.uk

Guide for LSAs (and some teachers)

Use with individual pupils

Repetition

Developmental …. Scaffolding and visual support

Consistency

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