Long-term, working and short-term memories. Critical skills for learning maths.

Steve Chinn
www.stevechinn.co.uk

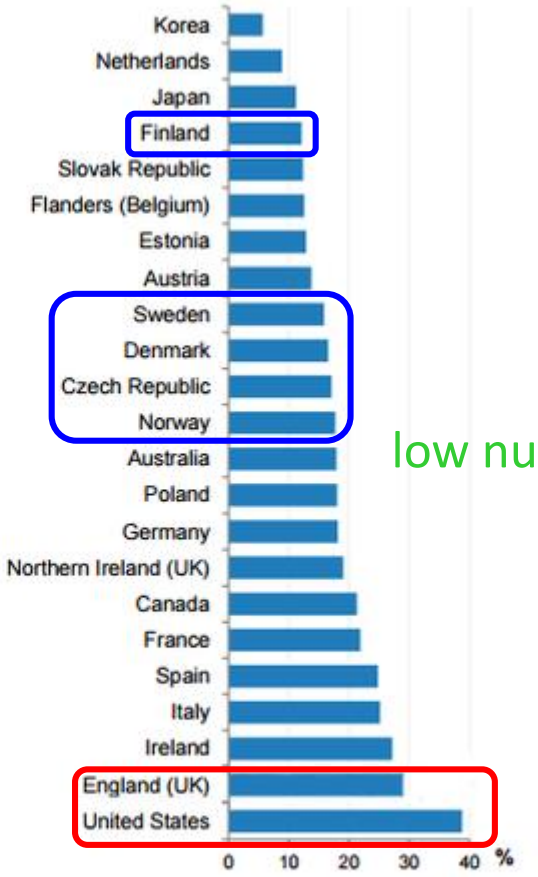
Dansk SpecialMatematik

21/09/2019

OECD data (2012) 16-19 year-olds

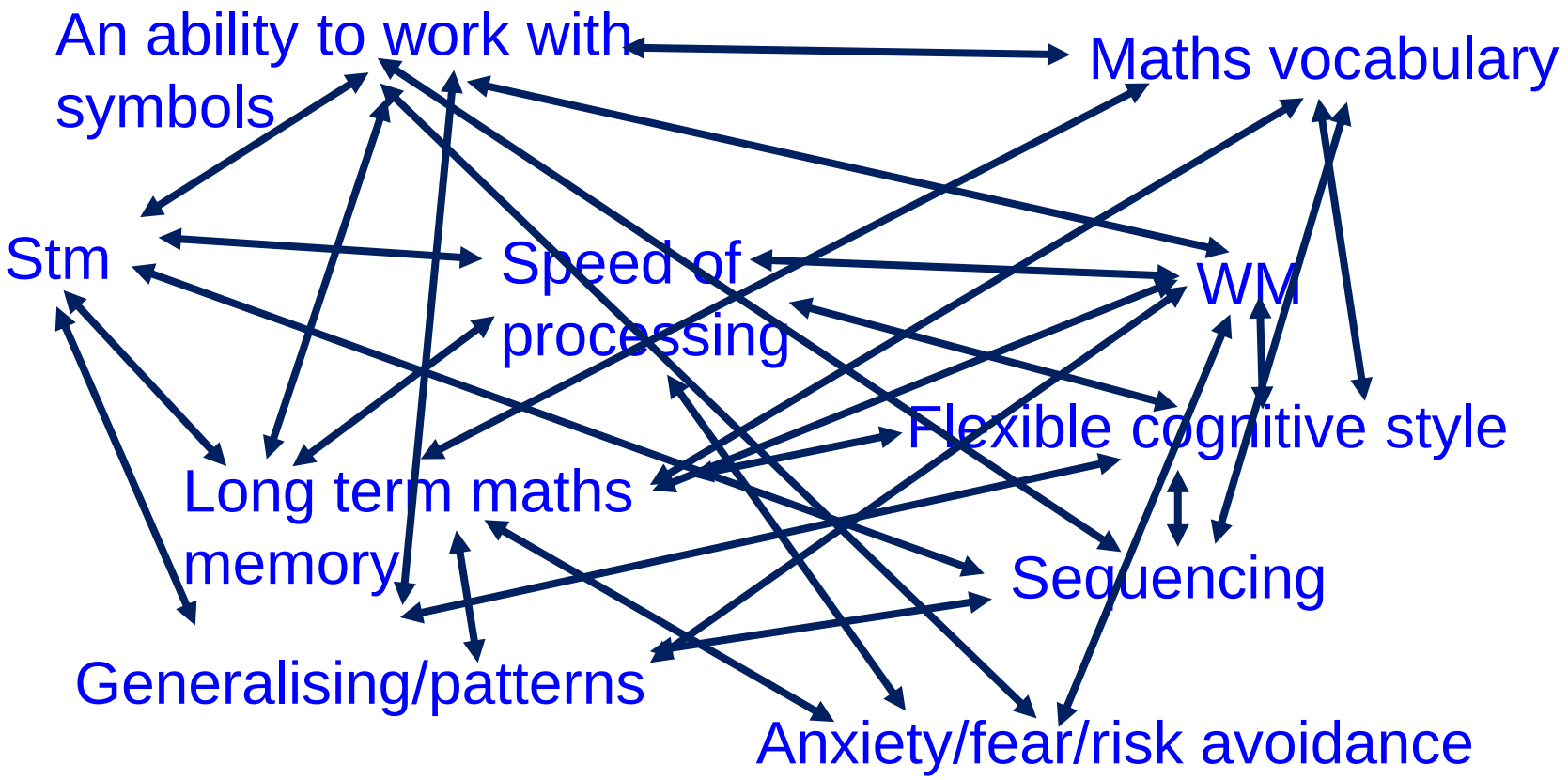
Percentage of 16-19 yr olds with low levels of literacy and numeracy (below Level 2)

low literacy



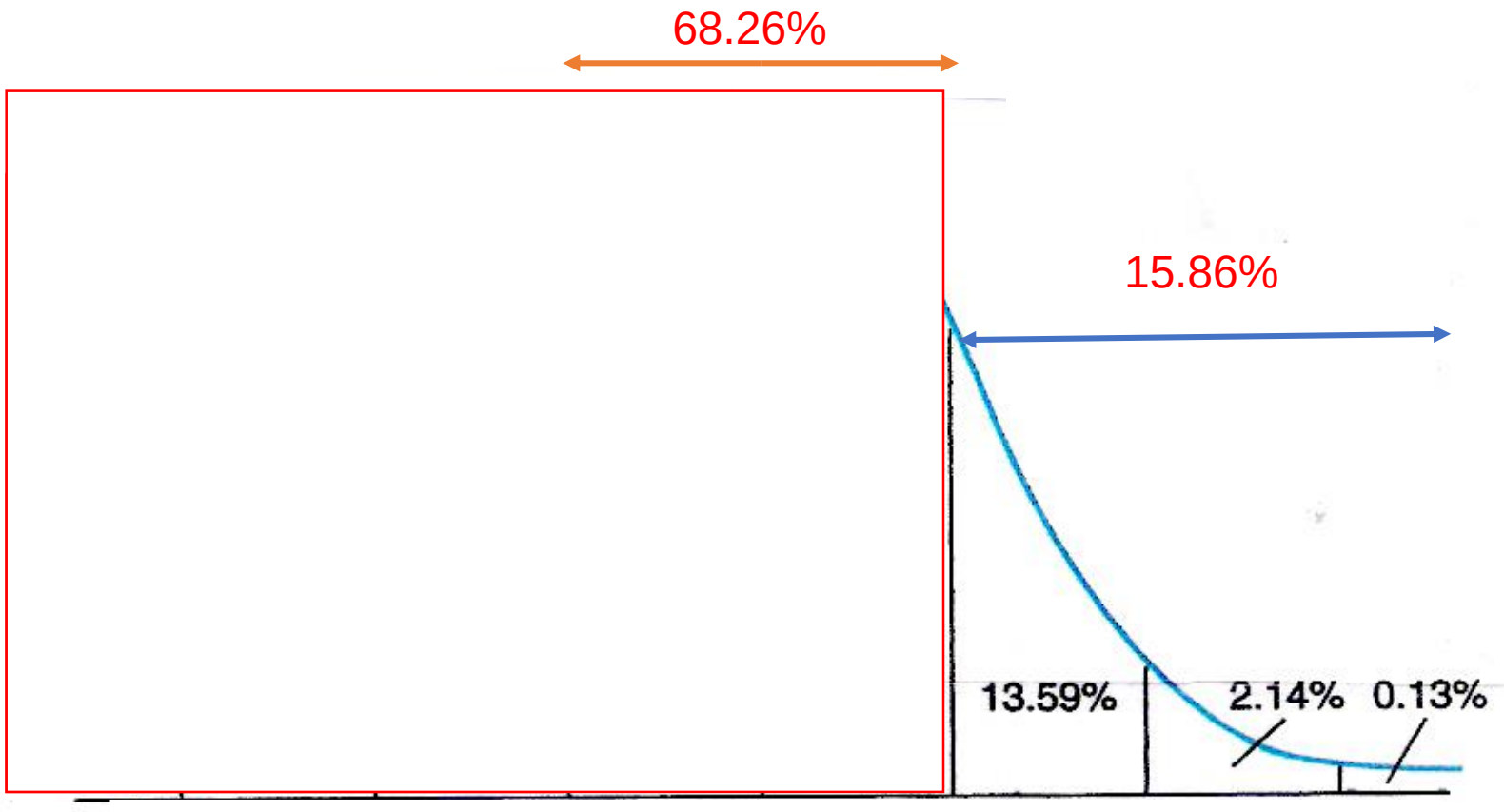
low numeracy

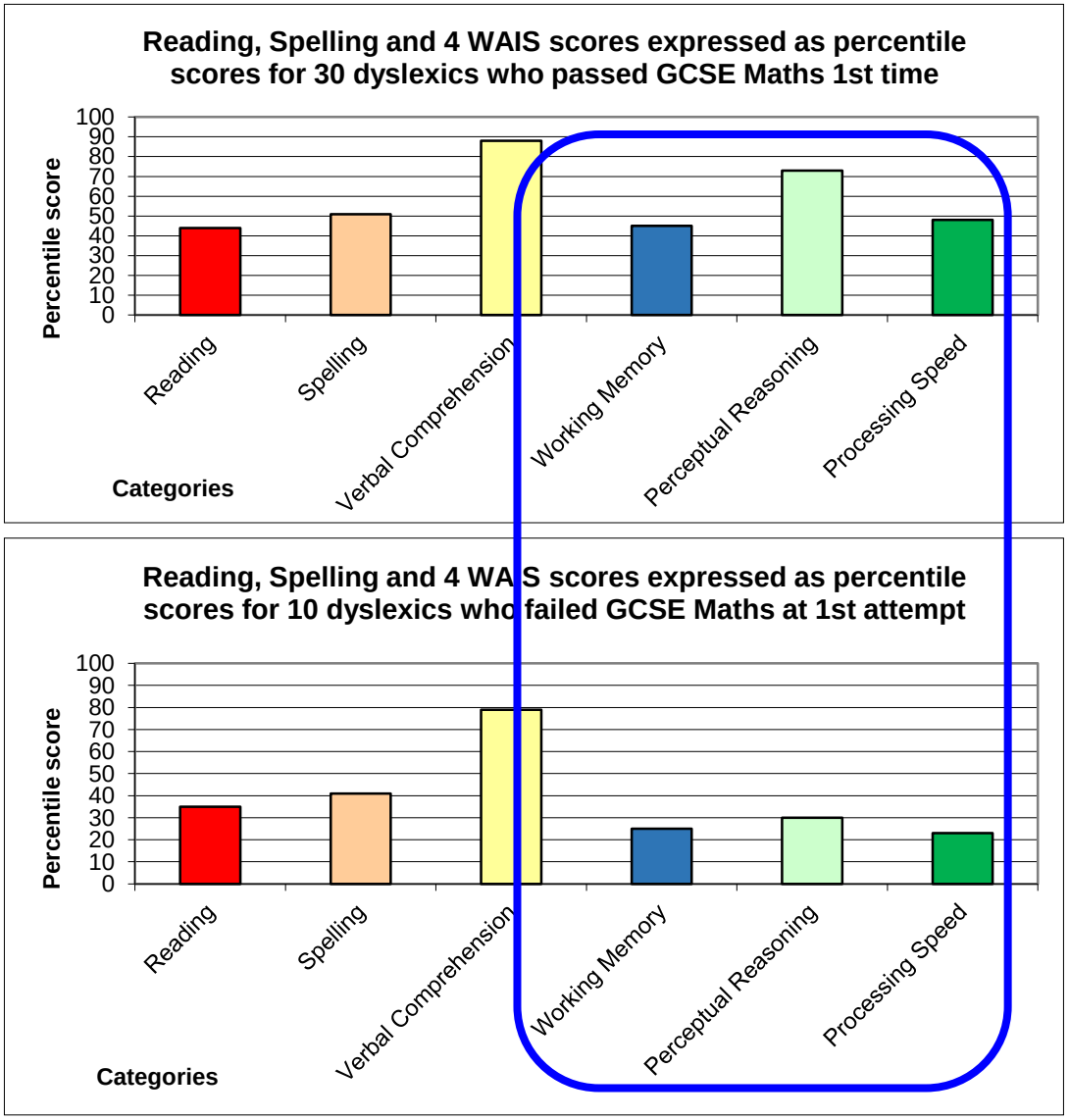
Learner skills



It’s complicated.

The normal distribution





David Grant
2019

How soon do pupils start to withdraw from maths?

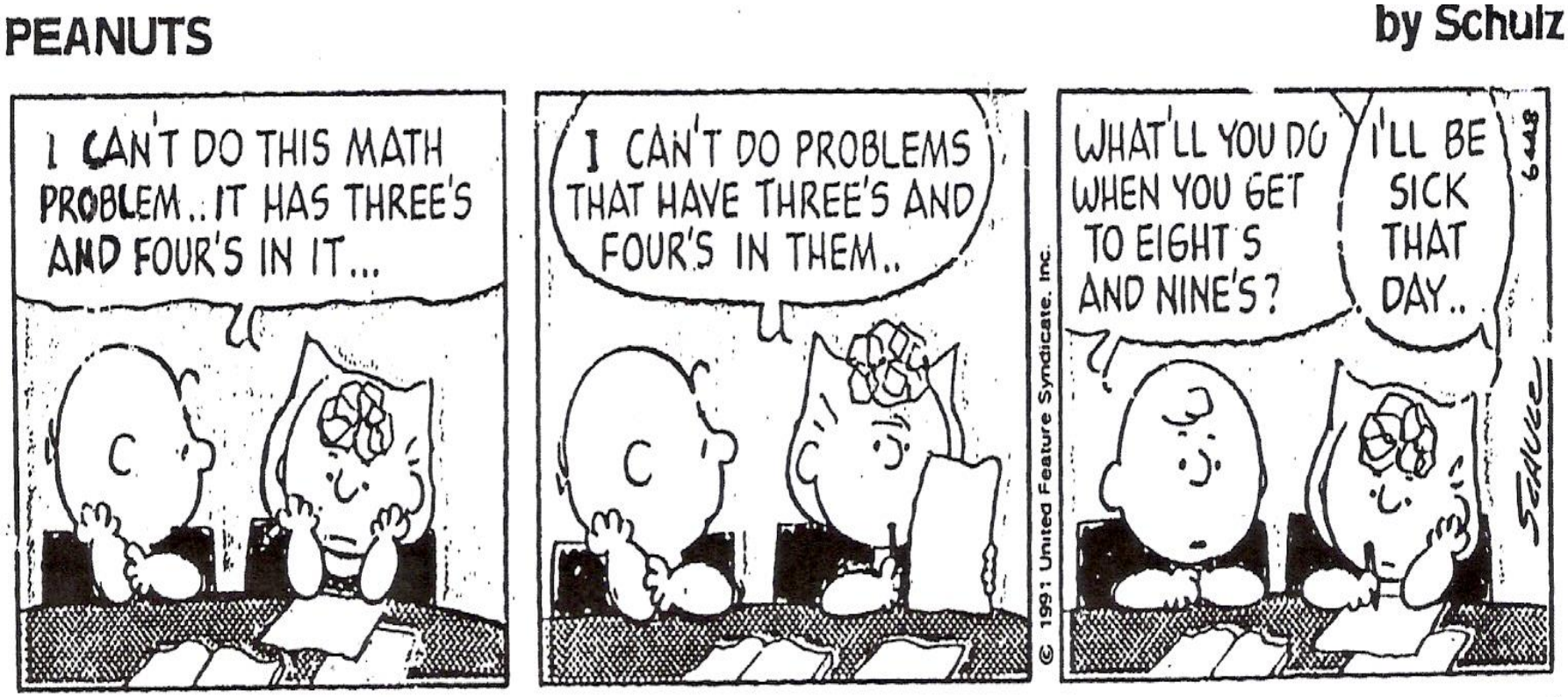
Giving up at 7 years old

Have they already learned that maths is not easy?

It's a problem at 7 and a problem at 17

and probably at 77 years old

Poor recall of basic facts and risk-avoidance strategy



School Report. Basic intervention.

- I also feel that Ellie has become rather lazy from the point of view of always saying she doesn't remember how to do any maths processes. She will seem to have grasped a concept yet the following lesson she will have forgotten it.

- I am beginning to insist that she tries to remember how to do the work.

Short term memory

An essential for communication

Short-term memory is the capacity for holding, but not manipulating, a small amount of information in mind in an active, readily available state for a short period of time. For example, short-term memory can be used to remember a mental arithmetic question that has just been asked.

Copying from text books, worksheets, board, etc

Working Memory

Working memory is a cognitive system with a limited capacity that is responsible for temporarily holding information available for processing. Working memory is important for reasoning and the guidance of decision-making and behaviour.

Short term memory. Working memory

Why test these skills?

How to test?

Cautions about dual tasking and distractions

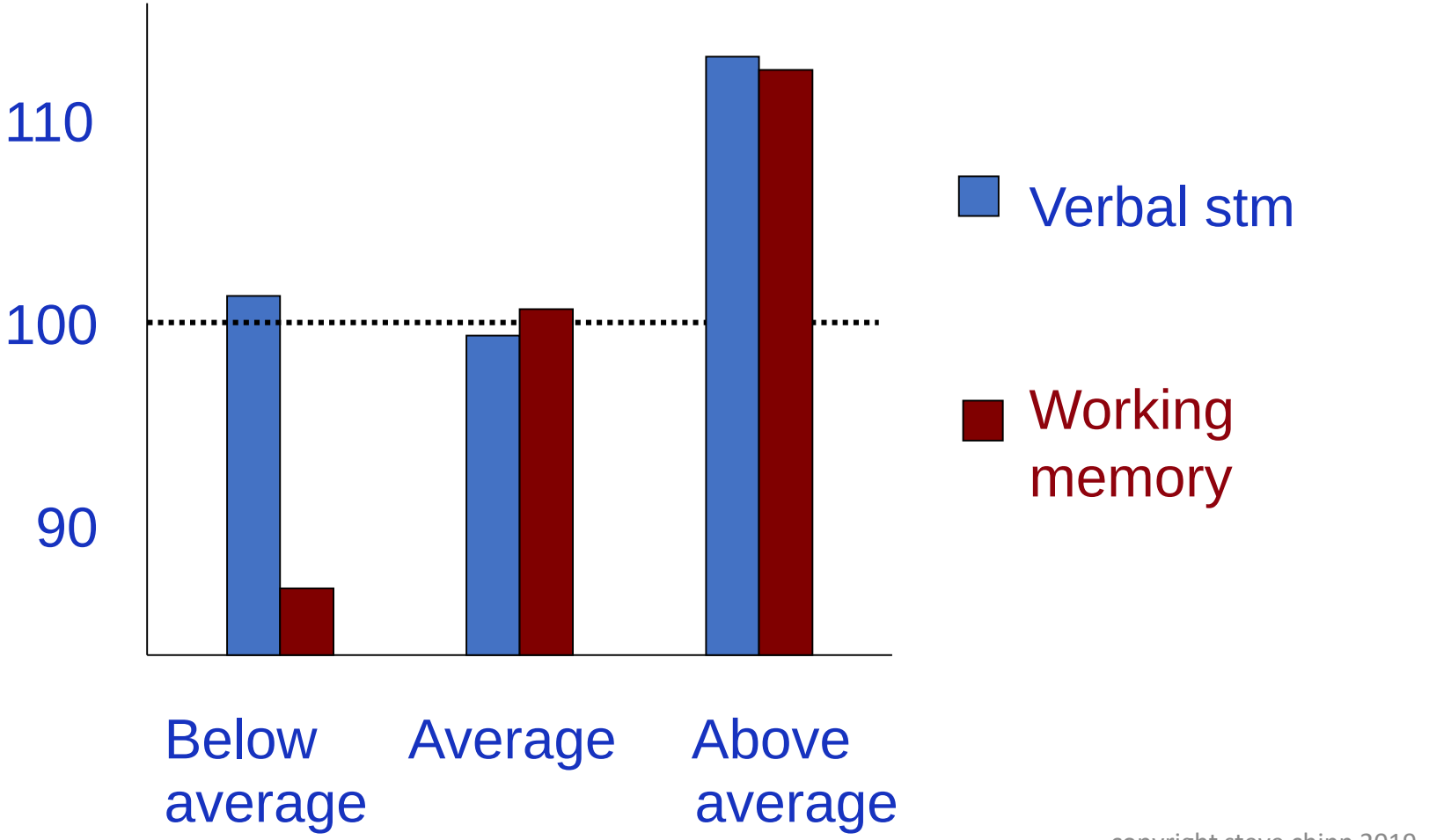
Vital information for teachers/tutors. Why?

Standardised test? Or capacity?

The role of a buddy.

Stm, working memory and maths in 6 and 7 year olds

Gathercole and Pickering (2008)



What do we remember most in any period of learning?

Ltm or stm or both?

Information at the beginning and at the end.

Information associated with other information.

Extraordinary things.

Repeated information.

Information that links to us personally.

What we remember least

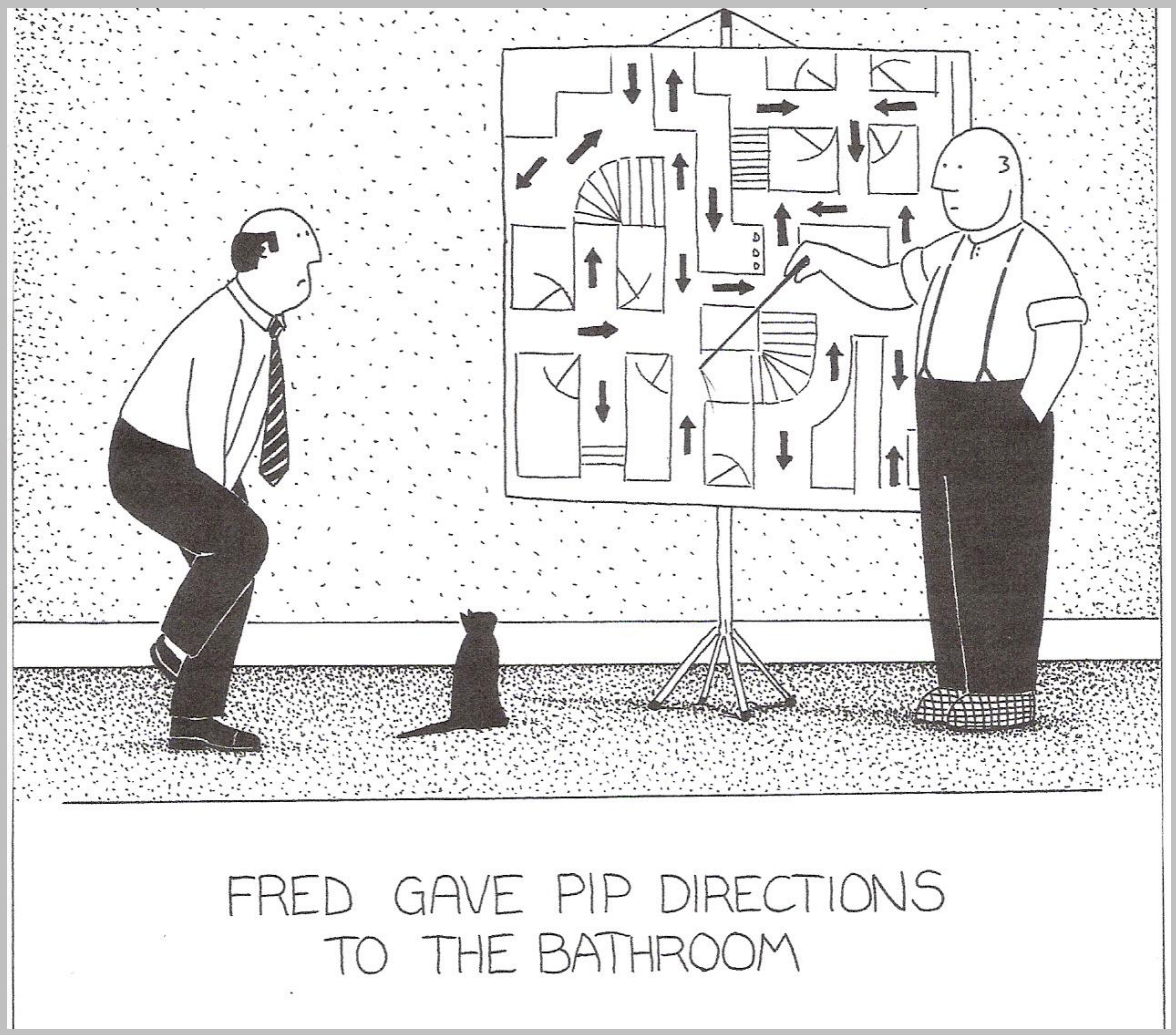
Information presented in the middle.

Anything that is not outstanding in any way.

Anything that is not associated or linked.

PS. Do you stick to the point?

With acknowledgements to Rupert Fawcett



Anxiety impacts on short-term memory

Working memory and anxiety

- Ashcraft et al (1998) found that in maths tasks that rely on the working memory system, high maths anxious subjects show degraded performance either in speed or accuracy.

- Skemp (1986) suggested that reflective activity (introspective analysis) is the most easily inhibited by anxiety.

Fear of maths

Lyons and Beilock (2012): There is a compelling neurological reason for the high anxious to avoid maths:

The prospect of completing a mathematical task is equivalent to anticipating bodily harm.

The ‘no answer’

Fear of negative evaluation.

The UK National Numeracy Strategy (1999)

‘An ability to calculate mentally is at the heart of numeracy.’

‘I’m dead!’ Is this a fact or a belief? Discuss!!

‘They will develop some methods intuitively and some you will teach explicitly.’

‘At this stage, it can be hard for them to hold all the steps in a calculation in their heads and so informal paper and pencil notes become a part of mental strategy.’

Maths beliefs and culture

The sample of 1 …. ‘It worked for me.’

‘But even compelling causal statistics will not change long-held beliefs or beliefs rooted in personal experience.’ Kahneman (2011)

Telegraph.co.uk. 18/02/2014

A former Schools Minister said:
"Children are falling behind in maths because of 'strong resistance' to traditional teaching methods in the classroom."

A former Schools Minister said:
"Pupils struggle to understand basic mathematical concepts following a decline in the use of mental arithmetic and rote learning at a young age."

Mental arithmetic: 240 + 99

‘I know I can’t do it.’ 14y old

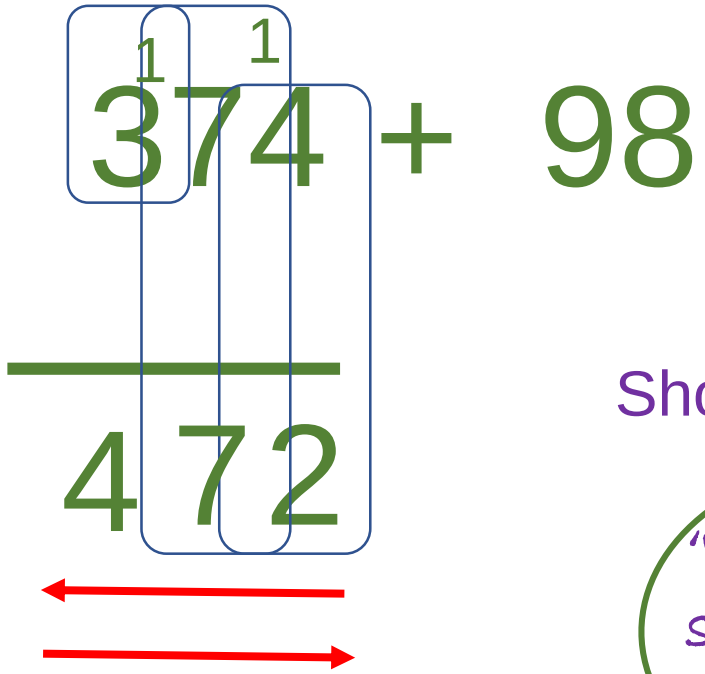
Fear of negative evaluation

Avoidance and withdrawal

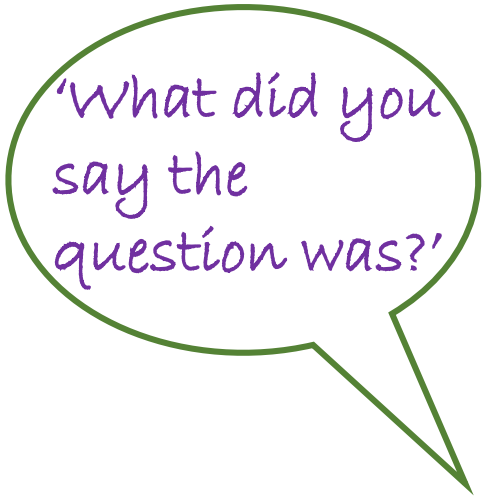
And their impact on testing

Working memory and mental arithmetic

Cognitive style.
'Inchworm'
or
'Grasshopper'



Short-term memory



Mental arithmetic

375 + 1980

'Is the (final) answer bigger or smaller?'

'Smaller ..... by 2'

'What are you testing?'

Caviola and Lucangeli (2015)

- Computations that are more complex, particularly in the number of steps required to achieve a solution will be more affected by working memory capacity. **This is especially relevant for mental arithmetic**.

- Metacognition and the development in children of strategies that can compensate for poor abilities to retrieve facts from memory.

Rapid mental arithmetic

Lee and Johnston-Wilder (2015) suggest that asking learners to perform tasks that require **rapid** feats of memory is cognitive abuse.

They note that making children perform tasks **rapidly** causes (additional levels of) anxiety.

Chinn (2009) ‘Having to work out answers **quickly**’

E-mail. Psychologist

10 yr old: His parents are very concerned with his performance in mental maths activities. He finds these so stressful and has become quite distressed at home about these tests.

I have suggested that he makes little jottings on his paper so that he is not entirely reliant on memory and that the school might consider allowing extra time.

Not a positive response from the school… **‘He must try his best!’**

WM in use in ‘simple’ division

72 ÷ 3

$$\begin{array}{r} 24 \\ 3\overline{)72} \end{array}$$

2 x 3 = 6
7 - 6 = 1

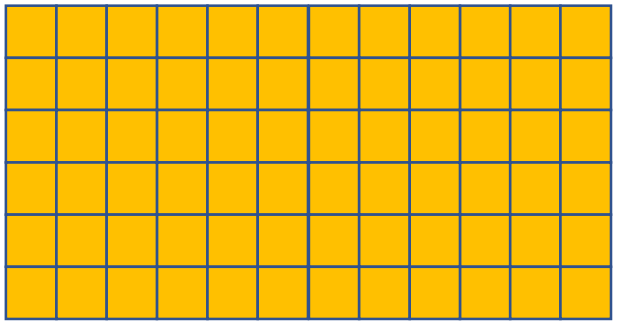
~~10~~

1

How many 3s in 12?

12 ÷ 3

72 ÷ 3 by chunking



10 x 3 = 30

10 x 3 = 30

2 x 3 = 6

2 x 3 = 6

72 – 30 = 42

42 – 30 = 12

12 – 6 = 6

6 – 6 = 0

Linking operations.
Repeated subtraction

Can you train WM?

It seems not

(Melvy-Lervag and Hulme, 2013)

But ……..

‘Simple stuff to improve your working memory.’ Tracy Packham Alloway

‘She presents key tips and strategies, such as the benefits of eating chocolate or of barefoot running.’

Scientists now believe **eating chocolate** could be beneficial for cognitive ability. A review from the University of L'Aquila in Italy found that tucking in to a small bit of **dark chocolate** each day improved attention, processing speed, **working memory** and verbal fluency. 29 Apr 2019

Alloway, 2016

The aim of the present study was to compare the potential cognitive benefits of running barefoot compared to shod. Young adults ($N = 72$, M age = 24.4 years) ran both barefoot and shod on a running track while stepping on targets (poker chips) and when not stepping on targets. The main finding was that participants performed better on a working memory test when running barefoot compared to shod, but only when they had to step on targets. These results supported the idea that additional attention is needed when running barefoot to avoid stepping on objects that could potentially injure the foot. These findings suggested that working memory may be enhanced after at least 16 minutes of barefoot running if the individual has to focus attention on the ground.

Long term mathematical memory

Gardner's 'multiple intelligences'

Bruner

A recent UK Education Minister:

"Children may be falling behind their Chinese counterparts in maths because of a failure to learn times tables by heart."

"This includes the times tables up to 12 x 12 by the age of nine."

It may be a tad more complicated than that.

'Mathematical competence is a constellation of abilities' Xinlin Zhou (2015)

The ‘staying behind’ conundrum

The Catch-22 of catch-up

‘Children who start behind generally stay behind.’
Geary, 2013

Does dyscalculia get more severe as the child moves through school?

Bart Simpson on the USA’s Leg-Up programme:
“Let me get this straight. We are behind the rest of the class and we’re going to catch up to them by going slower?”

Rote learning

”Rote learning is learning something by repeating it, over and over and over again; saying the same thing and trying to remember how to say it; trying to say it fluently and fast.

Now, it doesn't help us to understand - it helps us to remember - and often we learn a poem, or a song, or something like that by rote learning.”

It has a place in learning, but that depends very much on the learner.

‘How People Learn.’ NRC Key Finding 2

- **To develop competence in an area of enquiry, students must:**
- (a) have a deep foundation of factual knowledge,
- (b) understand facts and ideas in the context of a conceptual framework, and
- (c) organise knowledge in ways that facilitate retrieval and application.

- (Use patterns and generalisations)

0 1 2 5 10 20 50 ……

Why is maths a great subject?

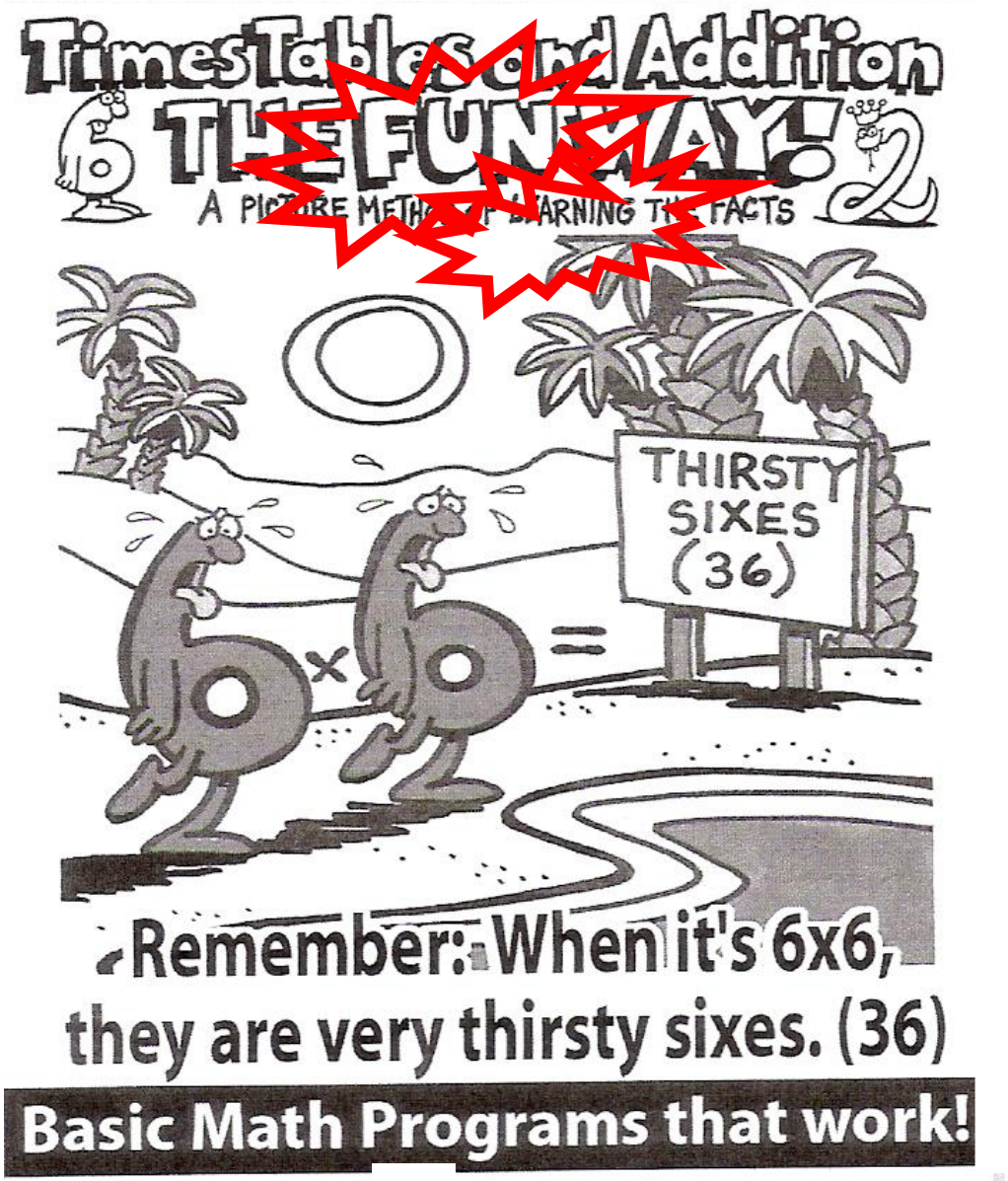
Because of (b) and (c)

Why can it be a bad subject?

Because we don’t make enough use of (b) and (c)

‘Maths made fun/easy/simple

……not conceptual’



KS 3 Mathematics.
Complete Revision & Practice. CGP

*Learn the **Three Rules:***

1) The front number must always be between 1 and 10.
2) The power of 10, n, is just how far the decimal point moves.
3) n is positive for big numbers and negative for small numbers.
(This is easier to remember than rules based on which way the point moves.)

Example 1

"Express 79 800 in standard form."

METHOD:

1) Move the decimal point until 79 800 becomes 7.98 ($1 \leq a < 10$):

2) The point has moved 4 places so n = 4, giving 10^4.
3) 79 800 is a big number, so n is +4, not –4.

ANSWER:

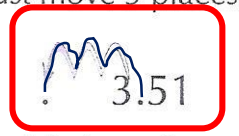
79 800 = 7.98×10^4

Example 2

"Express 3.51×10^{-3} as an ordinary number."

METHOD:

1) 10^{-3} tells us that the decimal point must move 3 places:



2) The "–" sign tells us to move the point to make the number small (i.e. 0.003 51 rather than 3510).

ANSWER:

3.51×10^{-3} = 0.003 51

Quick fixes

5.67 km = 5067 m

x 1000

13 yrs 36.6%

15 yrs 51.0%

16-19 yrs 49.1%

5.67

0

It's about UNDERSTANDING **place value** ….. The number system

International experiences

Children in Hong Kong receive early formal education from the age of three at kindergarten and as many as 81% of the kindergartens teach two-digit addition. (Ho et al, 2015)

In contrast, in India, children who are from environmentally derived populations and are often first generation learners are at significant risk of under achievement in mathematics. (Ramaa and Gowramma, 2015)

For Chinese children in Hong Kong, Ho et al (2015) found that a persistently low level of early **place-value** understanding appeared to be associated with later low mathematical outcomes.

They also noted that children appear to go through universal developmental changes in their place value understanding irrespective of the language of their number system.

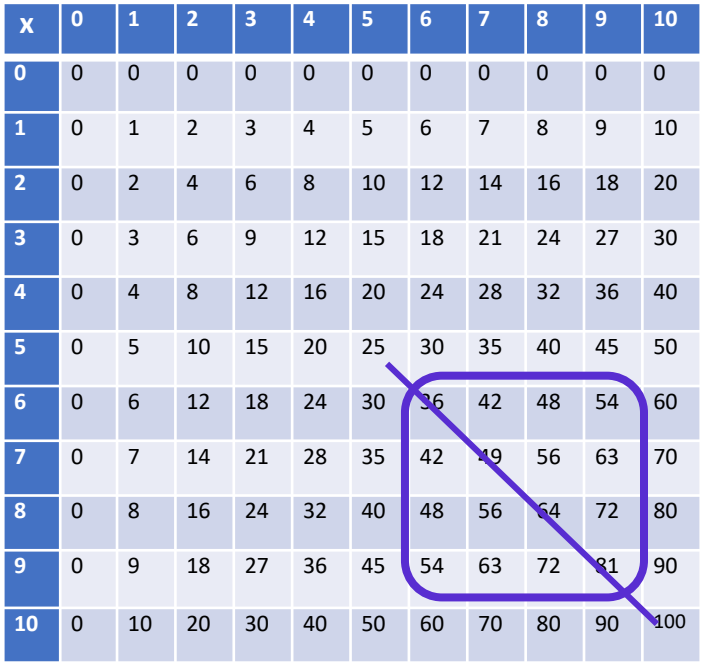
Difficulties in mathematics are international.

Early identification.

Ho et al, 2015 : a simple **place value** test given half way through 1st grade identified 95% of the children who were low achievers in 2nd Grade.

Which multiplication facts?

16 facts



X	0	1	2	3	4	5	6	7	8	9	10
0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	2	3	4	5	6	7	8	9	10
2	0	2	4	6	8	10	12	14	16	18	20
3	0	3	6	9	12	15	18	21	24	27	30
4	0	4	8	12	16	20	24	28	32	36	40
5	0	5	10	15	20	25	30	35	40	45	50
6	0	6	12	18	24	30	36	42	48	54	60
7	0	7	14	21	28	35	42	49	56	63	70
8	0	8	16	24	32	40	48	56	64	72	80
9	0	9	18	27	36	45	54	63	72	81	90
10	0	10	20	30	40	50	60	70	80	90	100

10 facts

Rote learning

ARROW (Colin Lane)

Self-voice echo

Sub-vocalising

Nothing works for everyone

‘Number combinations’

Increasingly the term *arithmetic (or number) combinations* is used, because basic problems involving addition and subtraction can be solved in a variety of ways and are not always retrieved as “facts.”

Gersten, Jordan and Flojo. 2005. JLD v 38 #4

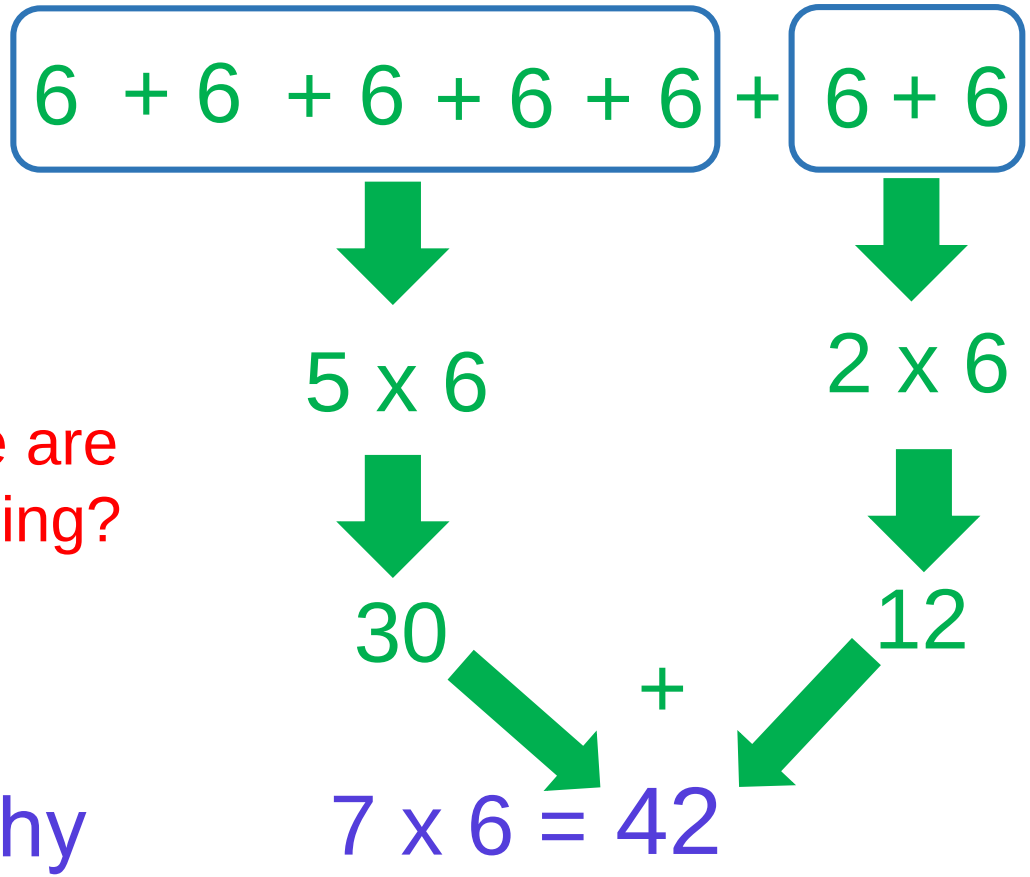
Use what you know to work out what you don't know

7 x 6

Easy fact 1: 5 x 6 = 30

Easy fact 2: 2 x 6 = 12

Chunk 7 x 6 *partial products*



What else are you teaching?

That's why

Some data from NZ (Sharpe and Hughson, 2019)

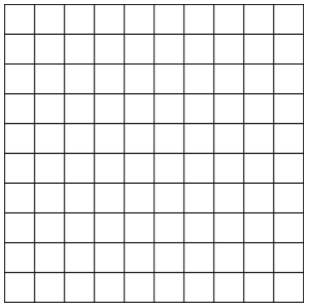
- How much money will you save?

• $20	30%
• $32	21%
• $60	23%
• $64	6%
• No answer	20%

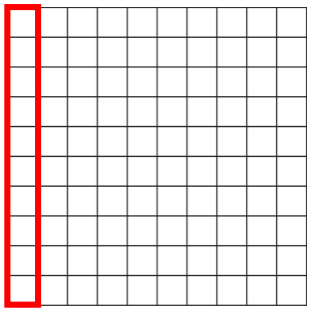
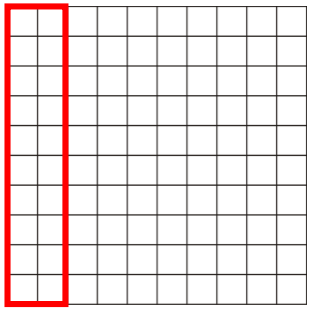
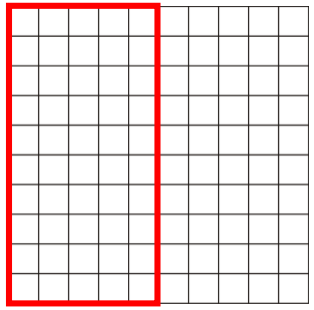
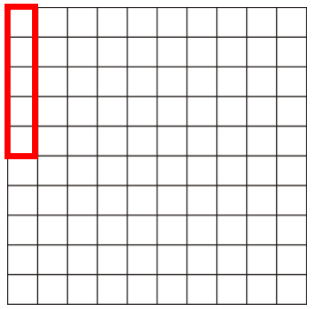
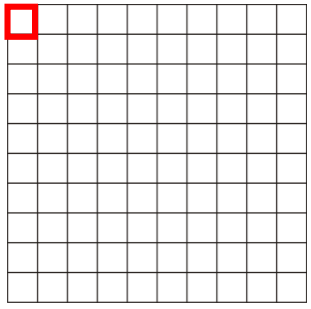
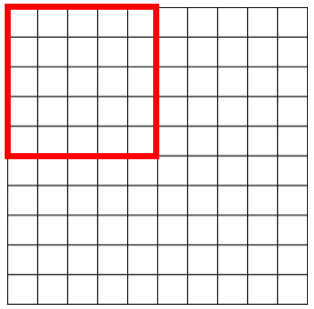
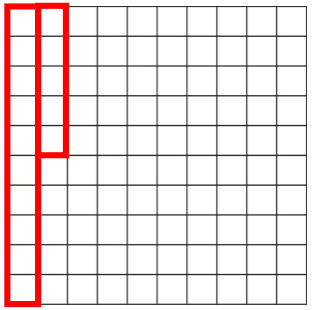
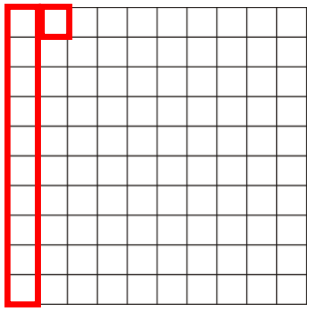
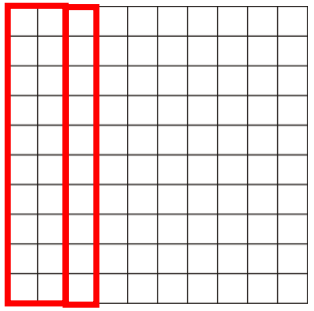
Percentages

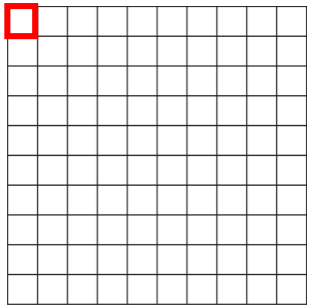
Percentages and hundredths 1/100

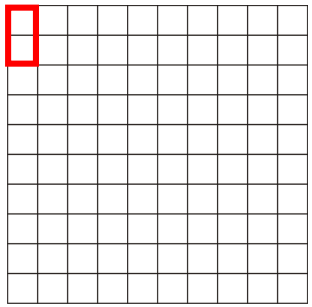
1 whole 100%

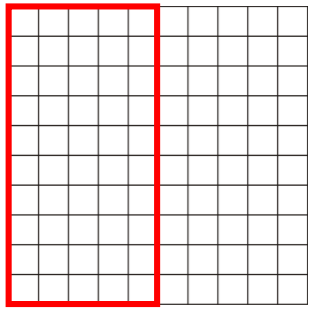


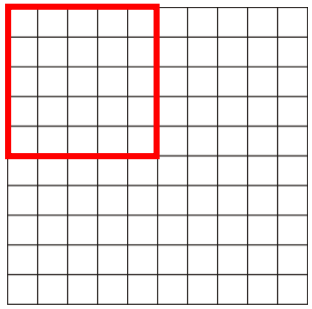
100% is $\frac{100}{100}$

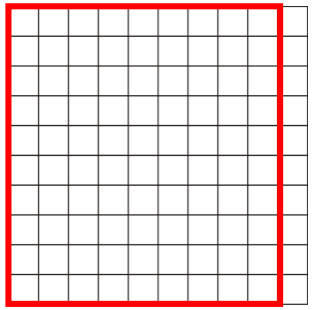




















Last thoughts

Practice makes perfect

John Holt How Children Fail Revised edition. 1982 (1965)

‘When we give children long lists of arithmetic problems to do, hoping to create confidence, security, certainty, we usually do quite the opposite, create boredom, anxiety, less and less sharpness of attention and so, more and more mistakes and so, more and more fear of making mistakes.’

+ Buswell and Judd. + Inhibition.

Maths ability adds up to long-lasting sex life

John Reynolds

Mathematicians are known for their prowess at multiplication and now in one sense, we can perhaps say why.

Research has revealed that people who have a natural ability to solve mathematical tasks are more likely to be sexually active, even into their old age.

Data from researchers at the International Longevity Centre-UK think tank found that pensioners who can give correct answers to a handful of moderately easy sums are twice as likely overall to be sexually active as those who struggle with the task.

The unexpected findings were documented in a paper on the importance of financial literacy in old age.

Cesira Urzi Brancati, a research fellow at ILC-UK, used data from the English Longitudinal Study of Ageing, which has been charting the lives of thousands of over-50s for the past 14 years to test links between cognitive ability and financial nous.

The data assessed participants' day-to-day lives and health as well as testing mental ability, including a sample of maths questions involving fractions, percentages and compound interest.

Dr Brancati found that 79 per cent of those who answered four or five of the questions correctly had had sexual activity in the previous year compared with 41 per cent of those who got one or none of the questions right.

'Higher cognitive ability means that they are able to enjoy life'

Almost half (49 per cent) of those in their 70s who got the questions right had been sexually active recently compared with only 28 per cent of those who struggled with the questions.

Among those in their 80s, one in five of those who scored highly in the maths test was still sexually active compared with just under 10 per cent of those who struggled. Dr Brancati said: "There are two possibilities: one is that the higher cognitive ability means that they are active and able to enjoy life or ... maybe it is some innate characteristic, it could be a personality trait — curiosity, openness to experience."

Saturday June 11 2016 | THE TIMES

The End

4 principles for learning

Empathetic classroom management which implies an active awareness and consequent adjustment to the learning strengths and difficulties of pupils, such as working memory;

Responsive flexibility which allows the teacher to have a repertoire of resources and strategies which respond to the individual (and often changing) needs of the pupil;

Developmental methods which are methods that address the remedial need while developing mathematical skills and concepts;

Effective communication which infers an awareness of thinking and learning style and an awareness of limitations such as language skills, poor short term memory or slower speeds of working. The layout and presentation of work on paper or on a board must have clarity.

The teaching context

Do we teach maths on the assumption that children can learn it as we tell it

or maybe as we are told to tell it

or maybe as we were told it when we were children

But did we know as much about how children learn back then? John Holt

‘No attempt’ (Chinn. 1995. Dyslexia Review)

	Dys	Mainstream
12.3 + 5	2.5%	0%
37.6 – 4	14.0%	2.2%
33 x 20	15.7%	3.6%
6040 ÷ 10	39.7%	5.8%
2)39	21.5%	2.9%