Mathematics and Learning

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Research, learning and maths

- What does research tell us about learning?
- What are the essential ingredients for learning maths?
- How can this inform the way we teach students with learning difficulties?

- The pieces of the jigsaw are there!

The main issues for students with maths LD

- Working Memory
- Basic facts/rote learning
- The first learning experience
- Consistency
- Language and communication
- The inter-dependence of these

- And …. 'it's little more complicated than that' Ben Goldacre

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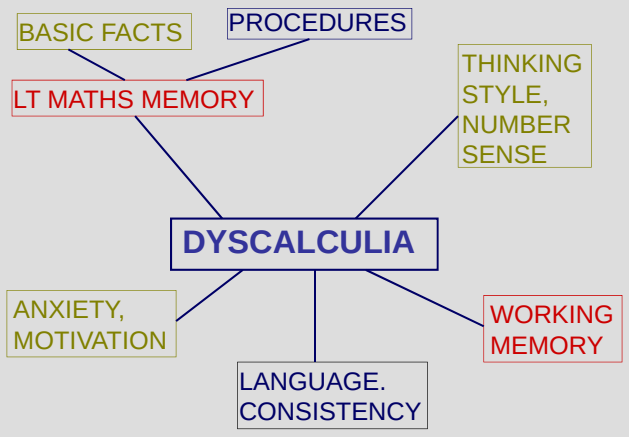

What makes a child have 'special needs' in maths?

- The subject matter?
- All the subject matter?
- The pace of the curriculum?
- The pedagogy?
- The teachers?
- The culture of maths?
- The beliefs: explicit or ingrained?
- Is it the learner, or the way she is taught?

Multiple Intelligences and Specific Learning Difficulties/Differences

- Gardner's theory of multiple intelligences suggests that there are 8 intelligences (for example, linguistic, logical, musical). We do not necessarily have equal abilities in all 8 intelligences, If you are especially weak in linguistic and logico-mathematical intelligences you could be labelled as having a SpLD. Not so for musical intelligence.

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'Must trig harder: how we can make maths count in primaries' (TES.26/03/10)

- Rob Eastaway: 'Mismatch between methods that parents know and those taught in primary schools.'

New maths

Tom L ..\..\My Documents\Tom Lehrer - New Math2.wmv

'Must trig harder: how we can make maths count in primaries' (TES.26/03/10)

- Richard Dunne: 'I want to see maths teaching not based on real life but on a carefully designed learning system that mimics the essence of mathematics.'

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Side track 1: The Elephant in the Classroom

Jo Boaler. Souvenir Press. 2009

- 'Students come to know that they are entering a realm in which common-sense and real world knowledge are not needed.'
- 'Students learn to ignore contexts and work only with the numbers.'

Side track 2: Unlocking progress. The National Strategies. 2009

- AfL: Assessment for learning.
- 'the process of identifying aspects of learning as it is developing, using whatever informal and formal processes best help that identification, primarily so that learning itself can be enhanced.'

What else are you teaching?

Teaching and diagnosis are irrevocably linked

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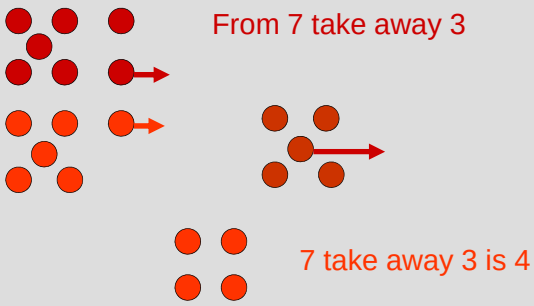
'Must trig harder: how we can make maths count in primaries' (TES.26/03/10)

- Jo Boaler: 'It's about having methods demonstrated and reproducing them – giving children a very narrow view of maths.
- The curriculum has a lot of methods and teachers respond with having to teach method after method.'

Materials

- Materials are not the answer on their own
- Materials do not teach
- Teachers teach

Language and materials



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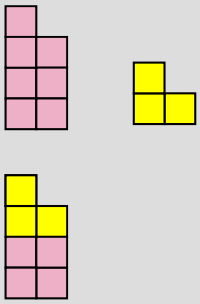
Language and materials



What is the difference between 7 and 3?

7 – 3 = 4

'Must trig harder: how we can make maths count in primaries' (TES.26/03/10)

- Ann Dowker: 'Interventions should take into account that mathematical ability is not a single entity.'
- 'But there is one very important point, which is that there is still a rather significant tail of under achievement in maths.'
- 'Is underachievement restricted to low achievers?'

The levels of attainment in literacy and numeracy of 13- to 19-year olds in England, 1948-2009

- Prof Greg Brooks, Sheffield Univ
- 22% of 16- to 19-year olds are functionally innumerate
- This has remained at the same level for at least 20 years.

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Functional skills vs Skills for life

- One system of numeracy education for children in schools, teenagers in apprenticeships and adults.
- Apprentices are rejecting classroom-based approaches… key skills integrated into their practical work was more effective

Review of maths in post-primary education. Ireland. 2006

- "Teachers need to be encouraged to adopt more imaginative approaches in their teaching and to encourage their students to 'make sense' of the mathematics they learn."
- 'The emphasis on procedural skills rather than understanding.'

Key understanding in mathematics learning. Nuffield Foundation. 2009

- Aims:
- What insights must students have in order to understand basic maths concepts?
- What are the sources of these insights and how does informal maths knowledge relate to school learning of maths?
- What understanding must students have in order to build new maths ideas using basic concepts?

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'How People Learn' (2000)

National Research Council, USA

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

Key research: First experience

(Buswell and Judd, 1925)

- There is the problem that the first time you learn a new idea or procedure it often creates a dominant learning experience.
- This means that the consequences of that experience being incorrect are highly detrimental.
- Susan Greenfield: neurological evidence

NRC: Key finding 2

- To develop confidence in an area of inquiry, students must:
- have a deep foundation of factual knowledge
- understand facts and ideas in the context of a conceptual framework
- organise knowledge in ways that facilitate retrieval and application.

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Implications for the classroom.
(Nuffield, 2009)

- Teaching should make it possible for children to:
- Connect their knowledge of counting with their knowledge of quantities
- Understand additive composition and one-to-many correspondence

- Understand the inverse relation between addition and subtraction
- Solve problems that involve these understandings
- Develop their multiplicative understanding alongside additive reasoning.

Maths beliefs and culture

- Speed
- Long term mathematical memory
- Rote learning: practice makes perfect
- Why do we need this stuff?

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Everyone loves fractions

At what age are you noticing poor motivation and anxiety in pupils doing maths lessons?

- 109 responses

- Age 5 11
- Age 6 42
- Age 7 45
- Age 8 11

Reasons: (130+ responses)

- Rate as: 1 minor
- 2 significant
- 3 major
- Answering quickly: (145) 2.8
- Memorising facts: (146) 2.5
- Mental arith: (145) 2.2
- Writing up sums: (121) 2.0

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High Anxiety Items (SC. 2009)

- Taking an end of term maths exam
- Doing long division questions without a calculator
- Waiting to hear your score on a maths test
- Having to work out answers to maths questions quickly
- Learning the hard times table facts

Carol Vorderman

- "They have to practise. Sometimes they have to do 50 sums a week, sometimes more."
- The programme is based on techniques she had used on her own children.
- "I remember her (daughter) learning her times tables in a week when she was six."

More CV

- She's a stickler for the basics, drilling kids on their times tables, and for practising sums again and again.
- 'How dare you enforce rote learning?' said some, but without your tables you don't stand a hope in hell of moving on in maths.

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Teaching division

Division.cv...\shortdivision.mpg

Rose dyslexia definition 06/09

- Dyslexia is a learning difficulty that primarily affects the skills involved in accurate and fluent word reading and spelling.
- Characteristic features of dyslexia are difficulties in phonological awareness, verbal memory and verbal processing speed.

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- Dyslexia can occur across a range of intellectual abilities.
- **It is best thought of as a continuum, not a distinct category, therefore there are no cut-off points.**
- Co-occurring difficulties may be seen in aspects of language, motor co-ordination, mental calculation, concentration and personal organisation, but these are not by themselves the markers of dyslexia.

Obesity or measles? Ellis 1985

- Ellis suggested that dyslexia is a condition more like obesity then measles.
- Is the same true of dyscalculia, that is it exists on a continuum rather than as an entity.
- So are there any implications?

Short term memory and working memory

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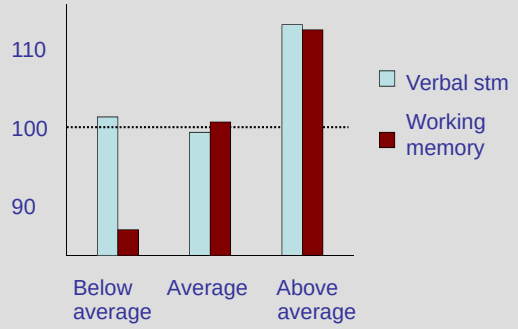
STM, working memory and maths in 6 and 7 year olds



QT Standards mental maths

- One hundred and thirty pupils paid £1.50 each to attend their school disco. The refreshments cost £65 and the DJ charged £110. How much profit did the disco make?
- A school day finished at fifteen thirty. The afternoon lessons were fifty-five minutes each with a fifteen minute break between lessons. What time did the first afternoon lesson begin?

Doubles

..\NNS98Y2doubles.mpg

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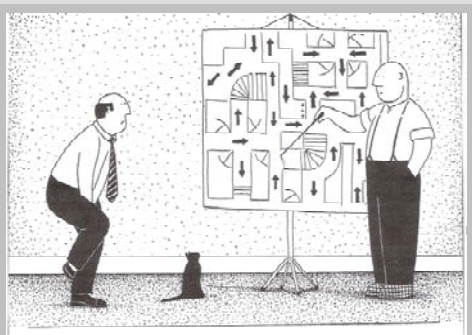
Liverpool Rhymes

- Twice one are two
- Twice two are four
- Twice three are six
- And there's kids on the floor



FRED GAVE PIP DIRECTIONS TO THE BATHROOM

Long term mathematical memory

One of the main issues:

Retrieval of basic facts

What do we mean by 'retrieval'?

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Derived Facts

Gray and Tall. 1994. Univ Warwick

- 72 students aged 7 – 13 years… addition
- Above av: 9% counted on
- 30% known facts
- 61% derived facts
- Below av: 72% counted on
- 22% counted all
- 6% known facts
- 0% derived facts

'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

'Getting back on track – pupils who make slow progress in Key Stage 3'

2007

- 'I don't get stuck in other subjects – only maths. When I'm doing English, I can always get on with my work. If I'm not sure about a spelling, I can just have a go and still get my work done. But I can't do that in maths. If I'm stuck I can't do anything but wait for help.'
- Helplessness …… resilience

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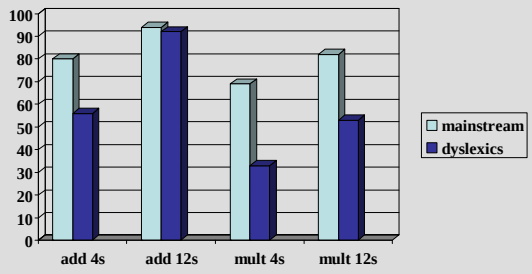
Retrieval of + and x facts



Error Patterns for x (2002)

- A multiple choice test
- 26% made no errors. 12.5% made one error
- 10% made two errors. 75% of these were 'mismatch' or 'close'
- 26% made 3-5 errors. 62% made 'digit' errors
- 25% made >5 errors. High occurrence of 'digit' and 'addition' errors
- Students making the most errors made a range of different errors

Visible Learning

Hattie, 2009

- 'The highest effects accrued when teachers provided feedback data or recommendations to students.'
- **'The programmes with greatest effect were strategy based methods'**
- Least effective were using technology for independent practice, and the strategy of working within a peer group *(but I think it's more complicated than that!)*

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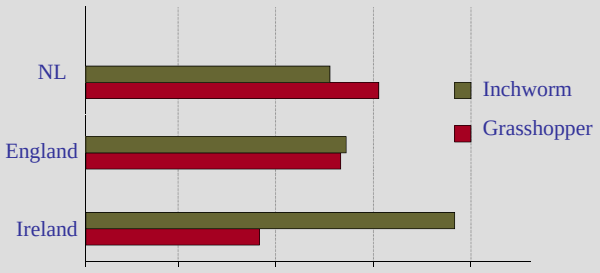
Key understandings in mathematics learning. Nuffield Foundation. 2009

- 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.

NRC. Key Finding 3

- 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.

Cognitive Style – Non-Dyslexics



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

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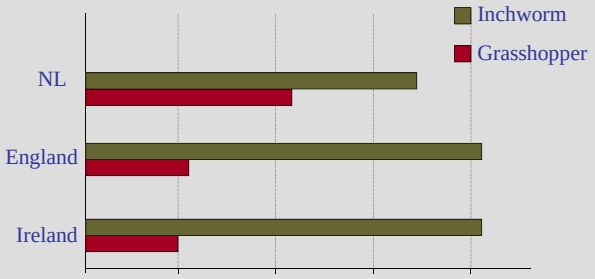
Cognitive Style – Dyslexics



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Six signposts to excellence in education. Hattie 2009

- 'Teachers need to move from the single idea to multiple ideas, and to relate and the expand these ideas such that learners construct and reconstruct knowledge and ideas.
- **It is not the knowledge or ideas, but the learner's construction of this knowledge and these ideas that is critical.'**

Flexibility, consistency and security

- The desire for consistency is a central motivator of our behaviour.

* 'Consistency allows us a convenient, relatively effortless and efficient method for dealing with complex daily environments that make severe demands on our mental energies and capacities.'

- Caldini 'Influence' 2007

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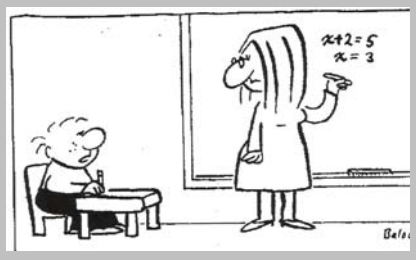
Consistency brings security



"Just a darn minute! Yesterday you said that x equals two!"

Learning from special needs

- Special needs / learning difficulties
- 'Expertise in a particular domain does not guarantee that one is good at helping others learn it. In fact expertise can sometimes hurt teaching because many experts forget what is easy and what is difficult for students..' (How People Learn. NRC)

NRC. Key Finding 2 (again)

- To develop confidence in an area of inquiry, students must,
- have a deep foundation of factual knowledge
- understand facts and ideas in the context of a conceptual framework
- organise knowledge in ways that facilitate retrieval and application.

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Implications for teaching (NRC)

- Teachers must draw out and work with pre-existing understandings that their students bring with them.
- Superficial coverage of all topics in a subject area must be replaced with in-depth coverage of fewer topics that allows key concepts in that discipline to be understood.

Implications for teaching

- Because metacognition often takes the form of an internal dialogue, many students may be unaware of its importance unless the processes are explicitly emphasised by teachers.
- Self-voice learning. Colin Lane

NCTM 'Principles for school mathematics' (2004-2009)

- "Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge."

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DCSF Select Committee Inquiry into Assessment and Testing (2008)

- "Too often pupils are expected to remember methods, rules and facts without grasping the underpinning concepts, making connections with earlier learning and other topics."

Professor Tim Miles

- 'To put the matter another way, if there is bad practice it seems likely that intelligent non-dyslexics may in many cases survive it without any major disaster, whereas its effect, even on the most intelligent dyslexics is likely to be catastrophic.'

'Dyslexia and Mathematics' Miles T and Miles E (1992)

Times table facts: an example

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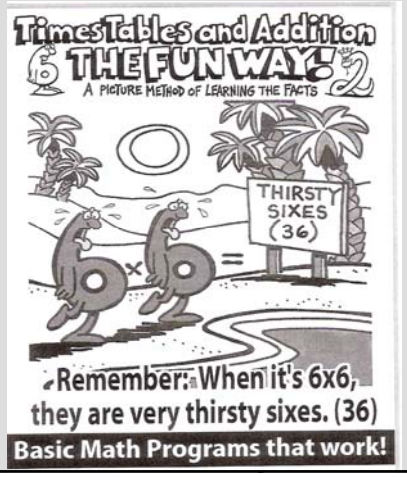
What else are you teaching?

Teaching and diagnosis are irrevocably linked

Expectations

- From a maths book….'Further Activities: Things to do at Home'
- TABLES: Choose a multiplication table that is problematic …..
- and learn it!
- Learn to say it backwards too.

- From the TES, Feb 2006….Year 3 pupils will be expected to learn the 3x and 4x tables *(it was Year 4)* 'It is not about drilling children in their tables, but at some stage children do need to know them.'



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Multiplication Facts/Combinations are Pervasive: 3 x 7 = 21

3 x 17 38 x 47 30 x 70

51 ÷ 3 651 ÷ 21

$\frac{2}{3} + \frac{1}{7} = \frac{14}{21} + \frac{3}{21}$

0.3 x 0.7 30% of 70 -3 x -7

3 x 7p 30 x 7g 3 x 70cm 3 x 75cl

Area: 3m x 7m 7a x 3b $x^2 + 4x - 21$

How many days in 3 weeks?

Einstein

- 'Everything should be made as simple as possible, but not simpler.'

Place value and Counting

- Counting on …. in ones
- Counting back … in ones
- Crossing the 10s 100s 1000s
- Counting in more than ones … chunks

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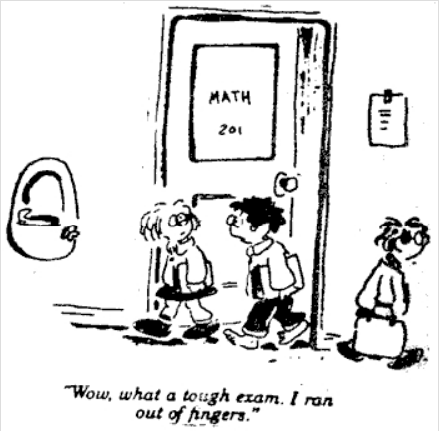
Counting and multiplication

- Counting in ones. Crossing the tens
- Counting in twos, fives, tens
- Number bonds for 10
- Addition of two numbers
- Addition of three and more than three numbers…. Chunking
- Addition of same numbers….. Chunking
- Multiplication



Counting

- There are three kinds of people in the world
- those who can count
- and those who can't

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Developing concepts

- Are the numbers a barrier?
- As concepts develop can number sense develop?
- Structure …. diagnosis

Do you know the pre-requisites?

- Facts
- Concepts… you need to know where it is going and where it came from.
- Assume nothing!
- Beware the illusion of learning

Relating key numbers: 1,2,5,10 Reducing the number barrier

- **3** 2 + 1
- 4 2 x 2
- 5 10 ÷ 2
- 6 5 + 1 (not 3 x 2)
- 7 5 + 2
- 8 2 x 2 x 2 10 – 2
- 9 10 – 1
- What else are you teaching?

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Multiplication by repeated addition

The 'Key Facts' are: 1x 2x 5x 10x

3 x 8 8 + 8 + 8

6 x 8 8 + 8 + 8 + 8 + 8 + 8

7 x 8 8 + 8 + 8 + 8 + 8 + 8 + 8

12 x 8 8+8+8+8+8+8+8+8+8+8+8+8

9 x 8 8+8+8+8+8+8+8+8+8 (8)

Using the key facts to chunk

Using the 'Key Facts': 1x 2x 5x 10x

3 x 8 8 + 8 + 8 — **2 x 8 + 1 x 8**

6 x 8 8 + 8 + 8 + 8 + 8 + 8 — **5 x 8 + 1 x 8**

7 x 8 8 + 8 + 8 + 8 + 8 + 8 + 8 — **5 x 8 + 2 x 8**

12 x 8 8+8+8+8+8+8+8+8+8+8+8+8 — **10 x 8 + 2 x 8**

9 x 8 8+8+8+8+8+8+8+8+8 (8) — **10 x 8 – 1 x 8**

The Foundations of Algebra

3 x 8 8 + 8 + 8 — 2 x 8 + 1 x 8
3a a + a + a — 2a + a = 3a

6 x 8 8 + 8 + 8 + 8 + 8 + 8 — 5 x 8 + 1 x 8
6b b + b +b + b + b + b — 5b + b = 6b

12 x 8 8+8+8+8+8+8+8+8+8+8+8+8 — 10 x 8 + 2 x 8
12c c + c + c + c + c + c + c + c + c + c + c + c — 10c + 2c = 12c

9 x 8 8+8+8+8+8+8+8+8+8 (8) — 9 x 8 = 10 x 8 – 8
9d d + d + d + d + d + d + d + d + d — 9d = 10d - d

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'Long' Multiplication *from place value*

62 x 37 with 37 as 30 + 7

```
   62
  x37
 1860   62 + 62 + …62  (30 x 62)
  434   62 + 62 + …62  (30 x  7)
 2294
```

'Long' Multiplication *using key facts*

62 x 37 What else are you teaching?

30 + 7 or 20 + 10 + 5 + 2

1 x 62	=	62
2 x 62	=	124
5 x 62	=	310
10 x 62	=	620
20 x 62	=	1240
40 x 62	=	2480

62 x 20 = 1240
62 x 10 = 620
62 x 5 = 310
62 x 2 = 124
62 x 37 = 2294

Efficacious learning and maths LD

- The research on what makes learning effective can be and should be applied to specific learning difficulties.
- This population needs a reliable and coordinated pedagogy, not just 'tradition and practice'.

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