

**Math Learning Disabilities,  
Dyslexia and ADHD:  
Understanding and Remediating MLD**  
Diana Kennedy, MA, BCET

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**Proud member of  
The Association of Educational Therapists**  
The Association of Educational Therapists is the national professional association for educational therapists. AET defines and sets standards for the professional practice of educational therapy. Educational therapists provide a broad range of individualized educational interventions for children and adults with learning disabilities and other learning challenges.  
<https://www.aetonline.org/>

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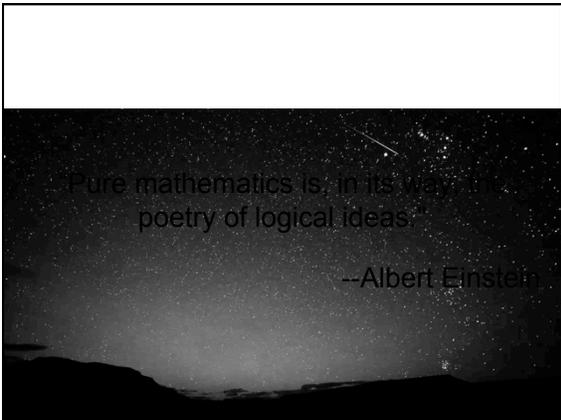
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Everytime I see a math word problem it looks like this:  
 If I have 10 ice cubes and you have 11 apples.  
 How many pancakes will fit on the roof?  
 Answer:  
 Purple because aliens  
 don't wear hats.



arrg! cards

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### Prevalence

- Math difficulties ~ 35%
- Math disability ~ 6.4%
- As common as Dyslexia and ADHD
- Familial prevalence 10X general population



1.  $483 + 562 =$   
 2.  $758 - 235 =$   
 3.  $852 \times 826 =$   
 4.  $893 \div 12 =$   
 5.  $3524/18 =$

(Shalev, 52; Gersten, Clarke, and Mazzocco, 13 in Berch & Mazzocco (Eds), 2009.)

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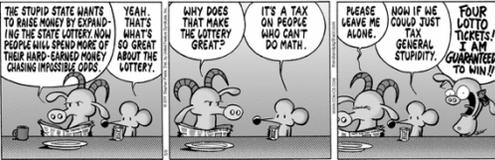
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### The "So What?"



THE STUPID STATE WANTS TO RAISE MONEY BY EXPANDING THE STATE LOTTERY. NOW PEOPLE WILL SPEND MORE OF THEIR HARD-EARNED MONEY CHASING IMPOSSIBLE DREAMS.

YEAH. THAT'S WHAT'S SO GREAT ABOUT THE LOTTERY.

WHY DOES THAT MAKE THE LOTTERY GREAT?

IT'S A TAX ON PEOPLE WHO CAN'T DO MATH.

PLEASE LEAVE ME ALONE.

NOW IF WE COULD JUST TAX GENERAL STUPIDITY.

FOUR LOTTO TICKETS! I AM GUARANTEED TO WIN!

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### The "So What?"

The image contains three overlapping promotional graphics. On the left is a sign for 'CASINO ROYALE VIDEO POKER' with a '99% PAYOUT' claim. In the center is a sign for 'Save even more 4 for \$12' featuring Coca-Cola cans. On the right is a 'RASMUSSEN REPORTS POLL' graphic with the text: 'Did scientists falsify research to support their own theories on Global Warming?' and a bar chart showing 59% 'SOMEWHAT LIKELY', 35% 'VERY LIKELY', and 26% 'NOT VERY LIKELY'.

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### Agenda

- What is a math learning disability (MLD)?
  - Connections to Dyslexia & ADHD.
- What to do about it?

The image features a red silhouette of a human head in profile, facing right. Above the head is a cluster of colorful mathematical symbols including numbers (1-9, 10), letters (a, b, c, x, y, z), and mathematical operators (+, -, %,  $\frac{1}{2}$ ,  $\frac{3}{4}$ ).

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### Agenda

- What is a math learning disability (MLD)?
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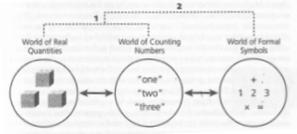
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## Math Competence



“Math competence rests, fundamentally, on the construction of a rich set of conceptual relationships among these worlds.”

(Griffin, 375-376 in Berch & Mazzocco, (Eds). 2009.)

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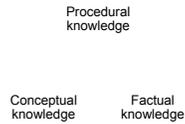
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## Math Competence



“The cooperation of [these] different types of knowledge leads to meaningful and efficient processing.”

(Zamarian, López-Rolón, & Delazer, 260 in Berch & Mazzocco, (Eds). 2009.)

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## Definitions of MLD

“Dyscalculia can best be defined as a deficit in the **representation or processing** of specifically numerical information.”

quoting Landerl et al. (Jordan, 111 in Berch & Mazzocco, (Eds). 2009.)

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### Definitions of MLD

which “affects **the ability to acquire mathematical skills** despite appropriate instruction.”

(Chinn & Ashcroft, 13)  
(Gersten, Clarke, and Mazzocco, 22 in Berch & Mazzocco, (Eds). 2009.)

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### Definitions of MLD

DSM-V:

- Specific Learning Disorder with impairment in math
  - number sense
  - memorization of arithmetic facts
  - accurate or fluent calculation
  - accurate math reasoning

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### Definitions of MLD

- No biological markers
- No qualitative markers

“obscure term lacking distinct boundaries”



(Berch & Mazzocco, (Eds). 2009.)

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### Cognitive processes in math

- Domain general (Geary)
  - basic processes
  - underlie many tasks
  - ~ overlaps with other LDs
- Domain specific (Butterworth)
  - hard-wiring for math
  - “number module”
  - ~ MLD

(Jordan in Berch & Mazzocco, (Eds). 2009.)

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### Domain General Problems

- Language processing
  - Dyslexia or other language-based difficulties
  - Difficulties with information representation and manipulation in the language system
  - Deficit in the ability to retrieve facts from a semantics-based long-term memory network

(Gersten, Clarke, and Mazzocco, 19 in Berch & Mazzocco, (Eds). 2009.)

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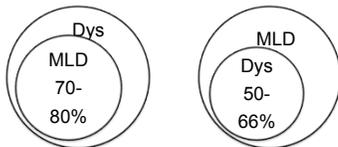
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### Dyslexia and MLD

- 70-80% of kids with Dyslexia have MLD
- 50-66% of kids with MLD have Dyslexia



(Dolan, 168 & Jordan, 106 & Shalev, 54 in Berch & Mazzocco, (Eds). 2009.)

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## Dyslexia and MLD

- Students with language impairments need
  - Explicit instruction in language of math
    - “Shaded in”
    - Multiple ways to say same concept



15+3

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## Domain General Problems

- Working memory impairments
  - Often in both Dyslexia & ADHD
  - Memorizing facts
  - Procedural breakdowns



(Geary, Hoard, Nugent, Byrd-Craven, 92 in Berch & Mazzocco, (Eds). 2009.)

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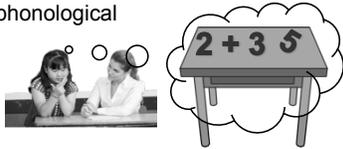
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## Domain General Problems

- Memorizing facts
  - to learn math facts, parts of equation and answer must both be simultaneously active in the phonological buffer (loop).



(Geary, Hoard, Nugent, Byrd-Craven, 92 in Berch & Mazzocco, (Eds). 2009.)

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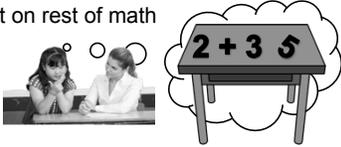
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### Domain General Problems

- Memorizing facts
  - Inefficient and inaccurate retrieval of math facts one of the hallmarks of MLD
  - Domino effect on rest of math
  - Takes up precious processing power



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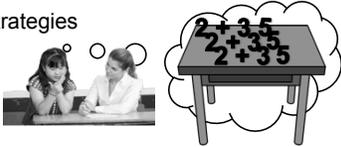
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### Domain General Problems

- Memorizing facts
  - Need facts taught explicitly
  - May not make connections on their own
  - Give visual strategies
    - 100's chart
    - number line
    - blocks



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### Domain General Problems

- Procedural Breakdowns
  - How many steps?

$$0.3 \overline{) 2305}$$



(Zentall, 221 in Berch & Mazzocco, (Eds). 2009.)

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### Domain General Problems

- Procedural breakdowns
  - Exacerbated by lack of automaticity
  - Processing resources filled by inefficient fact recall
  - Takes away from more complex processing



(Bull, summary, 289 in Berch & Mazzocco, (Eds). 2009.)

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### Domain General Problems

- Procedural breakdowns
  - Accommodations for math facts (off-load processing)
  - Mnemonic or checklist for order of procedures
  - Sample problems
  - “No offense, but I don’t listen...”



(Bull, summary, 289 in Berch & Mazzocco, (Eds). 2009.)

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### Domain General Problems

- Processing Speed
  - Often part of Dyslexia and ADHD
  - Affects decay rate in phonological loop
  - Teachers use speed as proxy for automaticity
  - For kids w/slow processing, **not a good proxy**



(Geary, Hoard, Nugent, Byrd-Craven, 93 in Berch & Mazzocco, (Eds). 2009.)

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**Domain General Problems**

- Central executive
  - Main weakness in ADHD
  - Poor inhibition of irrelevant associations



(Geary, Hoard, Nugent, Byrd-Craven, 92 in Berch & Mazzocco, (Eds). 2009.)

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**Domain General Problems**

- Central executive
  - Main weakness in ADHD
  - Poor inhibition of irrelevant associations
  - Attention control



(Geary, Hoard, Nugent, Byrd-Craven, 92 in Berch & Mazzocco, (Eds). 2009.)

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**Domain General Problems**

- Central executive
  - Main weakness in ADHD
  - Poor inhibition of irrelevant associations
  - Attention control
  - Clutters WM and further limits it



(Geary, Hoard, Nugent, Byrd-Craven, 93 in Berch & Mazzocco, (Eds). 2009.)

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**ADHD and MLD**

- 31% of kids with ADHD have MLD
- 25% of kids with MLD have ADHD

(Zentall, 220 & Shalev in Berch & Mazzocco, (Eds). 2009.)

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**ADHD and MLD**

- Generally NOT an issue of conceptual understanding
- Biggest challenge is in memorizing and recalling math facts
- ADHD brain has weak executive functions

(Zentall, 221 in Berch & Mazzocco, (Eds). 2009.)

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**ADHD and MLD**

- ADHD brain habituates to stimuli very fast
  - Difficult to maintain attention to repetitive stimulus
    - Spend less time rehearsing
    - More errors, especially during later trials of rote or overly familiar tasks

(Zentall, 221 in Berch & Mazzocco, (Eds). 2009.)

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### ADHD and MLD

- Detail analysis
  - Signs, operations, exponents
  - $-4^2 + (-5^2) \div 7$

(Zentall, 227 in Berch & Mazzocco, (Eds). 2009.)

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### ADHD and MLD

- ADHD brain low frustration tolerance
  - Pushing through difficult problems
  - Self-image more affected by mistakes



(Zentall, in Berch & Mazzocco, (Eds). 2009.)

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### ADHD and MLD

- ADHD brain helped by
  - color-coding  $-4^2 + (-5^2) \div 7$
  - games
    - with public acknowledgement
    - on a computer
  - Learning self-monitoring and goal setting
    - charting progress

(Pickering & Gathercole, 2004 quoted in Zentall, 22 in Berch & Mazzocco, (Eds). 2009.)

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### ADHD and MLD

- ADHD brain helped by
  - Verbalizing problems
  - Sorting types of word problems
  - Music, Gum, Bouncy-ball, Utzie cushion (stimulation)



(Pickering & Gathercole, 2004 quoted in Zentall, 22 in Berch & Mazzocco, (Eds). 2009.)

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### ADHD and MLD

- ADHD brain helped by
  - stimulant medicine increases
    - number of attempted problems
    - number of responses correct
    - number of responses correct per minute
    - number of self-corrected errors

(Zentall, 231 in Berch & Mazzocco, (Eds). 2009.)

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### Domain General Problems



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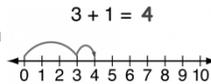
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### Domain General Problems

- Visuospatial representations
  - May contribute to Dyslexia or stand alone
  - Weakness in representations of number magnitude
  - influences early acquisition of calculation
  - may underpin retrieval difficulties



(Bull, summary, 266 in Berch & Mazzocco (Eds). 2009.)

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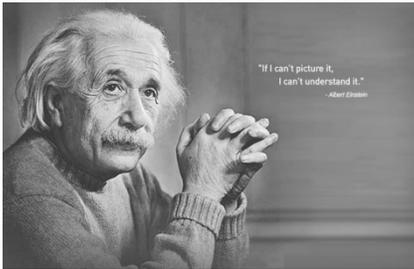
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### Domain General Problems



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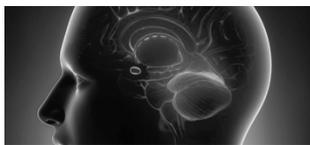
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### Math Anxiety Problems



The amygdala: traffic cop of the brain  
Where do signals go?

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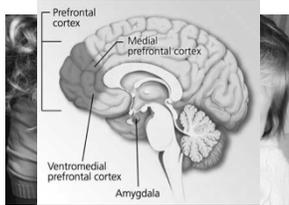
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### Math Anxiety Problems



Frontal lobe

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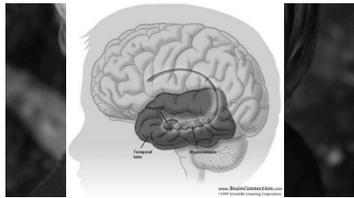
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### Math Anxiety Problems



Frontal lobe

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### Math Anxiety Problems



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### Math Anxiety Problems

The only problem is that the amygdala cannot tell the difference between...



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### Math Anxiety Problems

“[W]hen parents frequently help their children with math homework, increased **math anxiety in the parents** leads to decreased end-of-year math achievement in their children.”



Maloney et al (2015) Intergenerational effects

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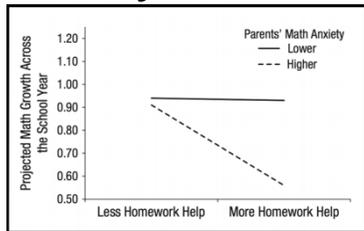
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### Math Anxiety Problems



Maloney et al (2015) Intergenerational effects

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## Math Anxiety Problems

- Anxious kids need
  - Growth mindset
    - Jo Boaler: youcubed  
<https://www.youcubed.org/>
  - Self-soothing techniques
  - Games
    - laughter is the anti-stress




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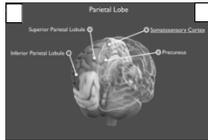
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## Domain Specific Problems

- Number module
  - for detecting, comparing, manipulating 'numerosity parameter'
  - system for representing & retrieving arithmetical knowledge
  - Parietal lobes



(Butterworth and Reigosa in Berch & Mazzocco, (Eds). 2009.)

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## Domain Specific Problems

- Number module

**Number Module:**  
Approximate number; allows for estimation -- Nonverbal, nonsymbolic

**Verbal System:**  
Exact number; words allow representation, memory & calculation of exact numbers -- Verbal, symbolic

(Zamarian, López-Rolón, & Delazer, 258 in Berch & Mazzocco, (Eds). 2009.)

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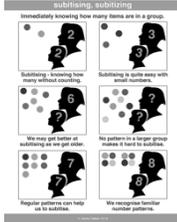
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### Domain Specific Problems

- Number module
  - Poor subitizing



(Gersten, Clarke, and Mazzocco, 20; Jordan in Berch & Mazzocco (Eds). 2009.)

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### Domain Specific Problems

Subitizing: Rainman

(Gersten, Clarke, and Mazzocco, 20; Jordan in Berch & Mazzocco (Eds). 2009.)

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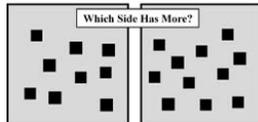
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### Domain Specific

- Number module
  - Poor comparison of amounts



(Illustration David Mills, Dyscalculia <http://mathdifficulties.blogspot.com/>)  
(Gersten, Clarke, and Mazzocco, 20; Jordan in Berch & Mazzocco (Eds). 2009.)

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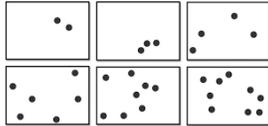
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### Domain Specific

- Number module
  - Poor sequencing of amounts



(Illustration <http://daily.zhihu.com/story/4066465>)  
(Gersten, Clarke, and Mazzocco, 20; Jordan in Berch & Mazzocco (Eds), 2009.)

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### Agenda

- What is a math learning disability (MLD)?
  - Connections to Dyslexia & ADHD.
- What to do about it?



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### What to do about an MLD?

- Concept-procedure integration
- Explicit, explicit, explicit
- Increment, increment, increment
- Games
- Accommodations

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### Concept-procedure integration

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### Concept-procedure integration

“Math wars”

- Not either / or
- Need to bridge all three
- Language as the bridge

Procedural knowledge

Conceptual knowledge

Factual knowledge

David Berg, Making Math Real™ <http://www.makingmathreal.org/>

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### Concept-procedure integration

- Bring out the base ten blocks!
- The missing piece: making the connection
  - Concrete →
  - Semi-concrete →
  - Semi-abstract →
  - Abstract



David Berg, Making Math Real™ <http://www.makingmathreal.org/>

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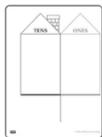
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### Concept-procedure integration

- Concrete = Manipulatives
- Record (color-coded) what the manipulatives demonstrate



$$\begin{array}{r} 56 \\ + 33 \\ \hline 89 \end{array}$$

David Berg, Making Math Real™ <http://www.makingmathreal.org/>

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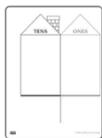
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### Concept-procedure integration

- Make explicit that manipulatives and symbols “Tell the same story.”
- Language becomes the bridge



$$\begin{array}{r} 56 \\ + 33 \\ \hline 89 \end{array}$$

David Berg, Making Math Real™ <http://www.makingmathreal.org/>

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### Concept-procedure integration

- Semi-concrete
  - Part I: go through the concrete steps
  - Part II: redo the problem with just the math prompts
  - To give student practice with only symbols, but with manipulatives and recording fresh in memory

David Berg, Making Math Real™ <http://www.makingmathreal.org/>

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## Concept-procedure integration

- Semi-abstract
  - Just symbols
  - Color-coded

$$\begin{array}{r} 56 \\ + 33 \\ \hline 89 \end{array}$$

David Berg, Making Math Real™ <http://www.makingmathreal.org/>

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## Concept-procedure integration

- Abstract
  - Just the symbols without color-coding
  - *If* student loses the picture, go back to earlier stage
  - This is where most textbooks and worksheets start

$$\begin{array}{r} 56 \\ + 33 \\ \hline 89 \end{array}$$

David Berg, Making Math Real™ <http://www.makingmathreal.org/>

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## Explicit, explicit, explicit!

- Facts
- Problem solving strategies
- Self-monitoring
- Checking work
- Using accommodations
- Anything else you can think of!

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### Explicit, explicit, explicit!

- Problem solving strategies
  - Explicitly teach problem solving strategy
  - Once mastered, explicitly teach how to transfer to novel situations, structure
  - Explicitly teach categorization
  - Best when taught with self-regulated learning strategies

(Fuchs and Fuchs in Berch, D.B. & Mazzocco, M.M. (Eds). 2009.)

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### Increment, increment, increment

- Task analysis
  - How many new concepts are introduced between the first and the second problem?

243	803
<u>+415</u>	<u>+419</u>

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### Increment, increment, increment

- Task analysis
  - Understand which changes represent a new concept
  - Explicitly teach one new concept at a time
  - New concept, old content; new content, old concept
  - If kids are confused, break it down further

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## Games

- Why games?
  - ADHD attention
  - Anxiety and laughter
  - Makes overlearning fun
  - “Need to know”



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## Games

- Make sure you are targeting what you want to target
  - Simply fact memorization?
  - Concept?
  - Procedure?
  - Number sense?

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## Games

- General purpose
  - Problems on board with sticky ball
  - Teacher/Parent vs student
  - Sports ball
  - Game board



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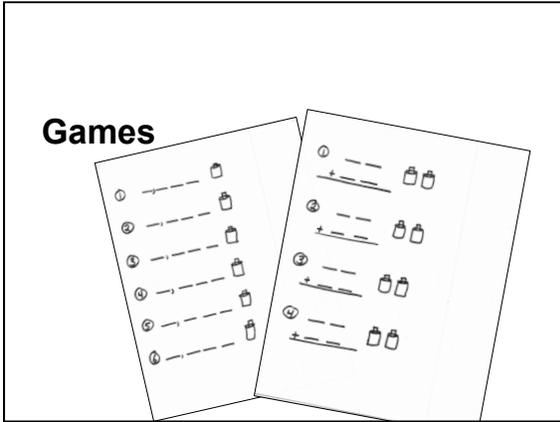
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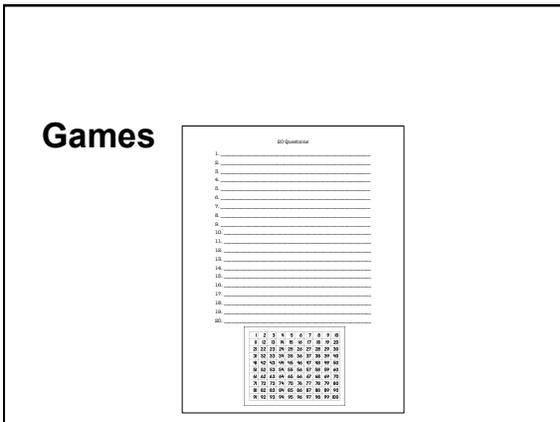
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**Accommodations**

- Assignments and tests need discrete goals
- Use accommodations to support non-goal tasks

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### Accommodations

- Effective accommodations
  - need to be taught explicitly
  - some are *disposable crutches*
  - some are lifetime supports
  - integrate throughout classes & at home

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### Accommodations

- Extended time
- Modified homework load (time-based versus length-based)
  - Check in with students: “Sasha”
- Number line
- Multiplication chart or nine-lines



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### Accommodations

**FAIR**  
*does not mean*  
Same



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"Mathematics is one of the essential emanations of the human spirit--a thing to be valued in and for itself, like art or poetry."

--Oswald Veblen



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**Thank You**

**Diana Kennedy, MA, ET/P**

Educational Therapist, Author, Speaker

[www.MindSparkLearning.com](http://www.MindSparkLearning.com)

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