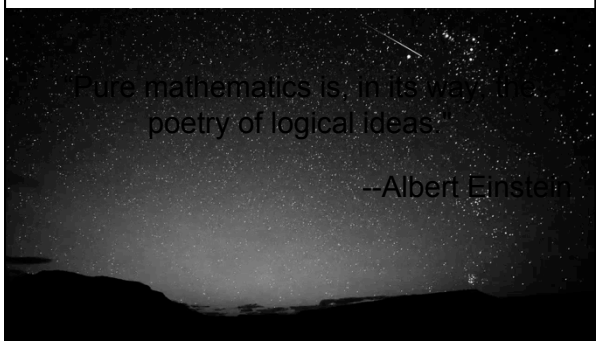
Math Learning Disabilities, Dyslexia and ADHD: Understanding and Remediating MLD

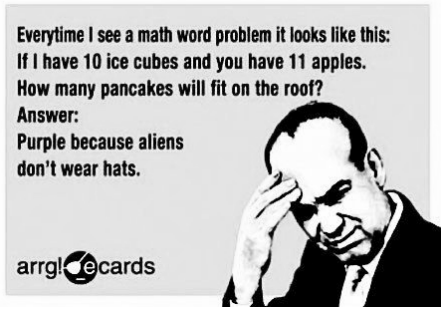
Diana Kennedy, MA, BCET

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/



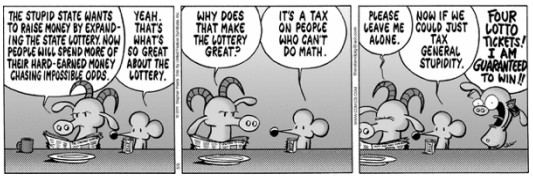


Prevalence

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

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

The "So What?"

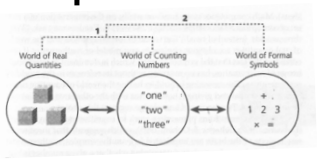


The "So What?"

Agenda

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

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.)

Math Competence

Procedural knowledge

Conceptual knowledge

Factual knowledge

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

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

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.)

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.)

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

Definitions of MLD

- No biological markers
- No qualitative markers

"obscure term lacking distinct boundaries"

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

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.)

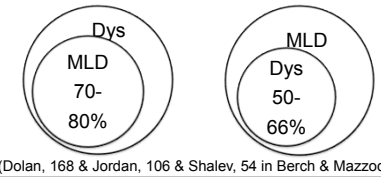
Domain General Problems

- Language processing
  - Dyslexia or other language-based difficulties
  - representing and manipulating verbal information
  - retrieving facts from semantics-based long-term memory
  - verbal mediation

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

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.)

Dyslexia and MLD

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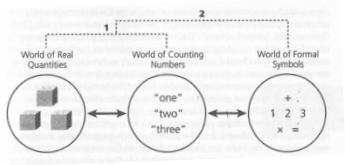
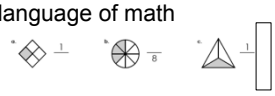


Dyslexia and MLD

- MLD with Dyslexia or other language-based difficulties more severe than MLD alone
- May have trouble using language as a compensatory strategy (verbal mediation)

Dyslexia and MLD

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



15÷3

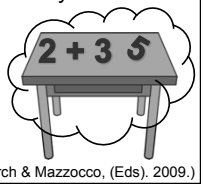
Domain General Problems

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

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

Domain General Problems

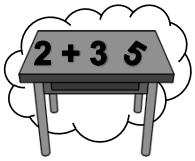
- Memorizing facts
  - to learn math facts, parts of equation and answer must both be simultaneously active in the phonological buffer (loop).



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

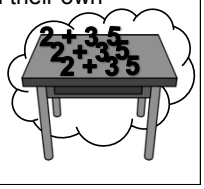
Domain General Problems

- 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



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



Domain General Problems

- Procedural Breakdowns
  - How many steps?

$$0.3\overline{)2305}$$

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

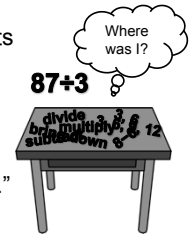
Domain General Problems

- 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.)

Domain General Problems

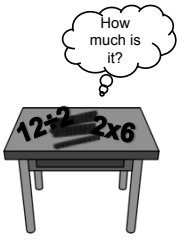
- Procedural breakdowns
  - Accommodations for math facts (off-load processing)
  - Mnemonic or checklist for order of procedures
  - Sample problems
    "No offense, but I don't listen..."



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

Domain General Problems

- Concept Development
  - Student J
  - Solutions?



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

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.)

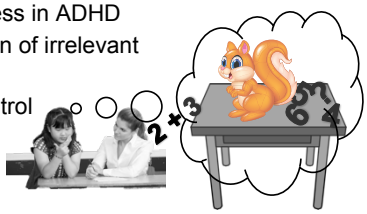
Domain General Problems

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

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

Domain General Problems

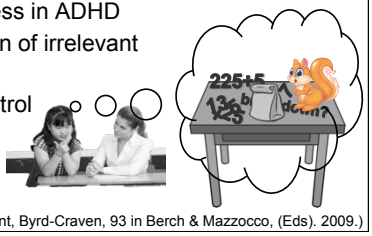
- Central executive
  - Main weakness in ADHD
  - Poor inhibition of irrelevant associations
  - Attention control



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

Domain General Problems

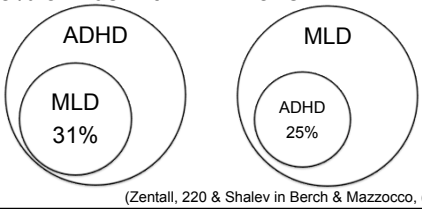
- Central executive
  - Main weakness in ADHD
  - Poor inhibition of irrelevant associations
  - Attention control
  - Clutters WM and further limits it



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

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.)

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.)

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 trails of rote or overly familiar tasks

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

ADHD and MLD

- Detail analysis
  - Signs, operations, exponents

$$-4^2 + (-5^2) \div 7$$

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

ADHD and MLD

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

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

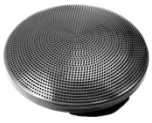
ADHD and MLD

- 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 inZentall, 22 in Berch & Mazzocco, (Eds). 2009.)

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 inZentall, 22 in Berch & Mazzocco, (Eds). 2009.)

ADHD and MLD

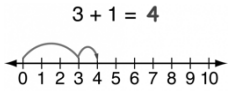
- ADHD brain helped by
  - stimulant medicine increases
    - number of attempted problems
    - number of responses correct
    - number of responses correct per minute
    - number of self-corrected errors

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

Domain General Problems

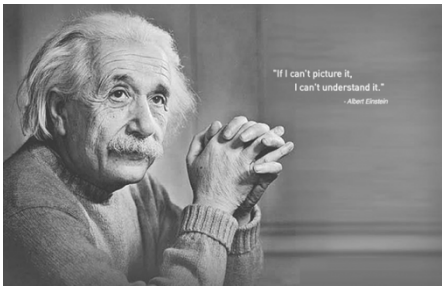
Domain General Problems

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



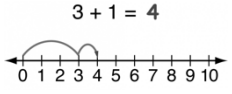
(Bull, summary, 266 in Berch & Mazzocco (Eds). 2009.)

Domain General Problems



Domain General Problems

- Visuospatial weakness brain needs
  - Time playing with 3D toys and games
  - Explicit instruction in visualizing
  - Explicit instruction on using verbal mediation



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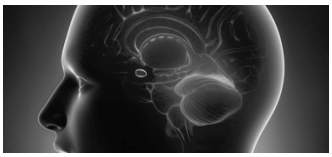
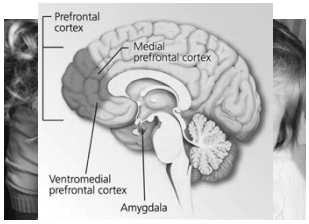
Math Anxiety Problems



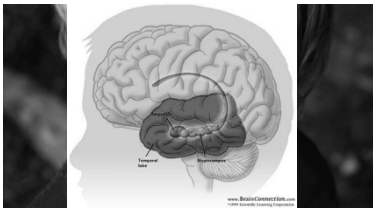
The amygdala: traffic cop of the brain
Where do signals go?

Math Anxiety Problems



Frontal cortex
Anterior?

Math Anxiety Problems

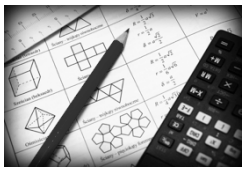


Rear brain
Danger?

Math Anxiety Problems

Math Anxiety Problems

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



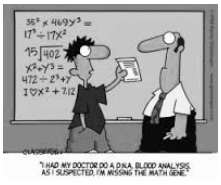
Math Anxiety Problems

- Timed Tests and Anxiety:
  - "Timed Tests and the Development of Math Anxiety"
  - Research links 'torturous' timed testing to underachievement

(Boaler, Jo. Education Week. July 3, 2012.)

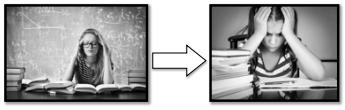
Math Anxiety Problems

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



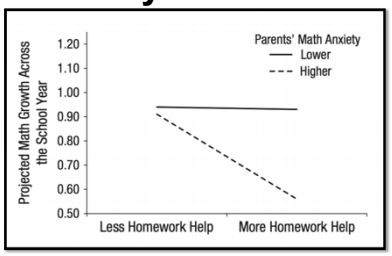
Math Anxiety Problems

"[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

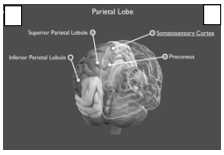
Math Anxiety Problems



Maloney et al (2015) Intergenerational effects

Domain Specific Problems

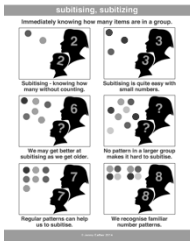
- Number module
  - for detecting, comparing, manipulating 'numerosity parameter'
  - system for representing & retrieving arithmetical knowledge
  - Parietal lobes



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

Domain Specific Problems

- Number module
  - Poor subitizing



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

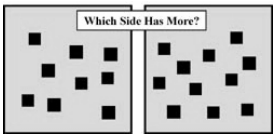
Domain Specific Problems

Subitizing: Rainman

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

Domain Specific Problems

- Number module
  - Poor comparison of amounts

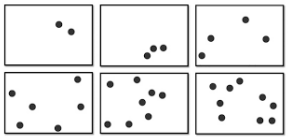


(Illustration David Mills, Dyscalculia http://mathdifficulties.blogspot.com/)

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

Domain Specific Problems

- Number module
  - Poor sequencing of amounts



(Illustration http://daily.zhihu.com/story/4066465)

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

Domain Specific Problems

- Number module
  - Distance effect
  - Magnitude effect
  - Implication for incrementation

382 vs −29

388 vs −79

(Illustration http://daily.zhihu.com/story/4066465)

(Dehaene, Stanislas, 61. 2009.)

Domain Specific Problems

- Number module
  - When children have trouble with basic number-module tasks, strong indication that they will have MLD as they enter and progress through school

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

Students with MLD need:

- Concept-procedure integration
- Explicit instruction
- Incremental instruction
- Games
- Accommodations

Concept-procedure integration

"Math wars"

- Need to bridge all three
- Language as the bridge

Procedural knowledge

Conceptual knowledge

Factual knowledge

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

Concept-procedure integration

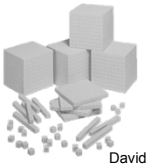
- Bring out the base ten blocks!
- The missing piece: making the connection

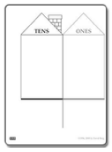
Concrete ➔
Semi-concrete➔
Semi-abstract➔
Abstract

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

Concept-procedure integration

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



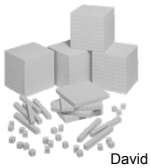


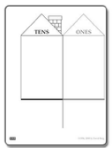
56
+ 33
89

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

Concept-procedure integration

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





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

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

Concept-procedure integration

- Semi-abstract
  - Just symbols
  - Color-coded

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

- Abstract
  - No color coding
  - *If* student loses the picture, go back to earlier stage

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

Explicit instruction

- Facts
- Finger strategies
- Problem solving strategies
- Self-monitoring
- Checking work
- Using accommodations

Explicit instruction

- 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.)

Incremental instruction

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

243	803
+415	+419

Incremental instruction

- 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

Games

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

Games

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

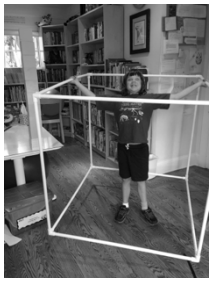
Games

- Building a million (not quite a game, but fun and engaging)

Games

Games

Games



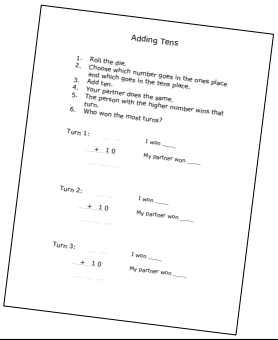
Games

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

Games

- Card games
  - Go fish
  - Slap jack
  - Memory

Games



Adding Tens

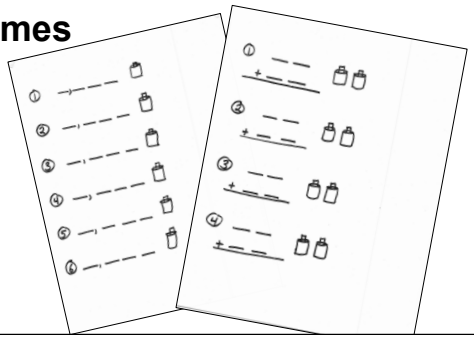
1. Roll the die.
2. Choose which number goes in the ones place and which goes in the tens place.
3. Add ten.
4. Your partner does the same.
5. The person with the higher number wins that turn.
6. Who won the most turns?

Turn 1: I won ____ My partner won ____

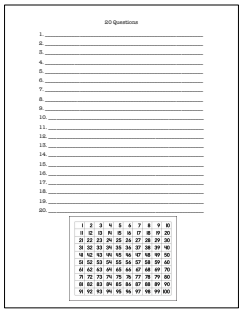
Turn 2: I won ____ My partner won ____

Turn 3: I won ____ My partner won ____

Games



Games



Accommodations

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

Accommodations

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

Accommodations

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

Accommodations

FAIR

does not mean

Same

“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

Thank You

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Adding Tens

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3. Add ten.
4. Your partner does the same.
5. The person with the higher number wins that turn.
6. Who won the most turns?

Turn 1: ___ ___ I won _____

+ 1 0 My partner won _____

___ ___ ___

Turn 2: ___ ___ I won _____

+ 1 0 My partner won _____

___ ___ ___

Turn 3: ___ ___ I won _____

+ 1 0 My partner won _____

___ ___ ___

Turn 4: ___ ___ I won _____

+ 1 0 My partner won _____

___ ___ ___

Turn 5: ___ ___ I won _____

+ 1 0 My partner won _____

___ ___ ___

Turn 6: ___ ___ I won _____

+ 1 0 My partner won _____

___ ___ ___

Turn 7: ___ ___ I won _____

+ 1 0 My partner won _____

___ ___ ___

20 Questions

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Guess My Digit

Guess	Digit	Place

Greatest Common Factor War

To practice quickly deciding what the greatest common factor is of any two given numbers (limited to multiples of 0-10). Automaticity with GCF helps students simplify fractions and figure out least common denominator, and will also be key in factoring quadratics in algebra.

The following sheets are formatted to be printed on business card paper, like Avery 8371, or a generic version. These sheets are perforated and save a TON of prep time, and all the cards come out exactly the same size for ease of shuffling, so even they are a bit pricey, they are totally worth it, imho.

Once you have printed out the deck and separated them, shuffle and split the deck evenly between you and your student or between two students. Each student flips over the top card of their pile and puts them in the middle. The winner of the hand is the student who has the highest GCF. For example, if I flip over 21, 14 and my partner flips over 24, 28, I win because my GCF is 7 and my partner's is 4. As in traditional war, if the cards have the same GCF, then players have a war: each player puts three cards face down and then flips over a fourth card and whoever has the higher GCF wins the whole pile. And who knows, players may even have a *double war!* As each player gets to the bottom of their pile, they flip over the cards they have won and keep playing until one player has all the cards.

Warning: it can take ***forever*** to win. If need be, whoever has the most cards at the end of a given time period wins, or whoever has won the most cards when the original piles are gone wins. But if you have time...

16, 32

35, 21

4, 6

8, 12

6, 9

12, 16

6, 12

12, 15

15, 20

4, 10

6, 8	3, 12
12, 24	11, 22
4, 5	5, 6
7, 11	11, 13
16, 24	21, 14

14, 16

10, 14

12, 18

3, 6

6, 15

9, 12

12, 15

12, 21

18, 24

20, 24

8, 16	8, 12
12, 16	12, 20
16, 20	24, 32
28, 16	32, 36
10, 25	15, 35

20, 30

6, 18

6, 24

12, 30

18, 30

14, 21

14, 28

21, 28

21, 35

28, 35

35, 42

14, 49

42, 48

8, 16

8, 24

16, 24

16, 32

24, 32

24, 40

32, 40

18, 27	18, 36
27, 45	27, 54
36, 45	36, 63
45, 72	54, 63
56, 16	9, 36

5

6

End!

Start

30 55 24 25

40 6 15 54

42

20

10

30

18 50 36 40 60 5 66 45 12 35

3

4

End!

Start

12	24	8	44	4	6	16	21	3	27
18									32
36									9
15	40	12	24	30	28	33	20		32

Race to a Dollar!

① _, _ _ _

② _, _ _ _

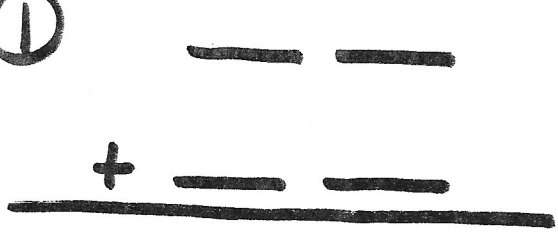
③ _, _ _ _

④ _, _ _ _

⑤ _, _ _ _

⑥ _, _ _ _

1



2

3

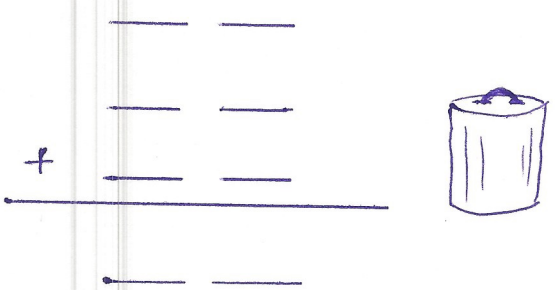
4

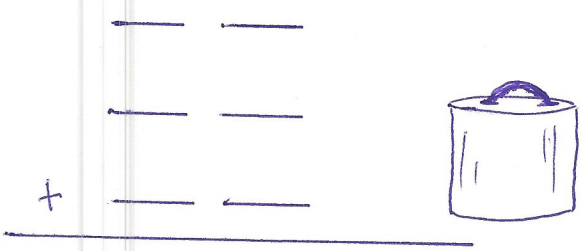
99 or Bust!

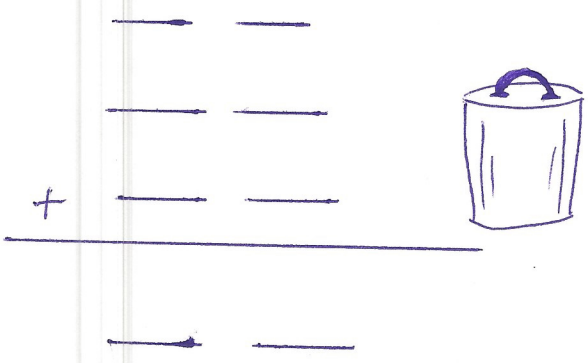
Name _____

Name _____

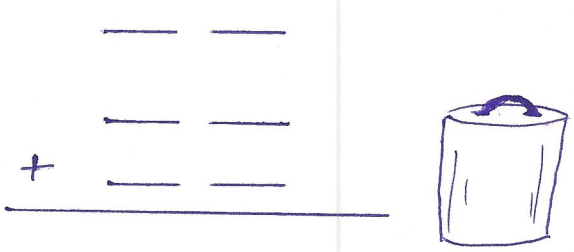
Player 1

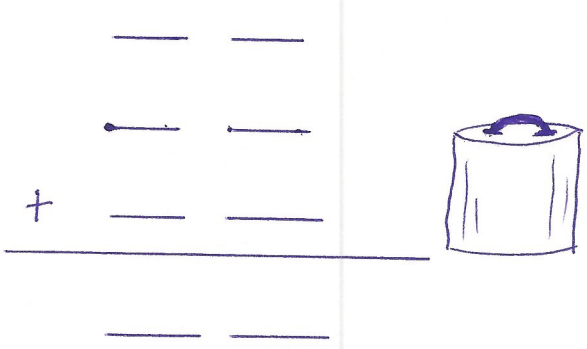


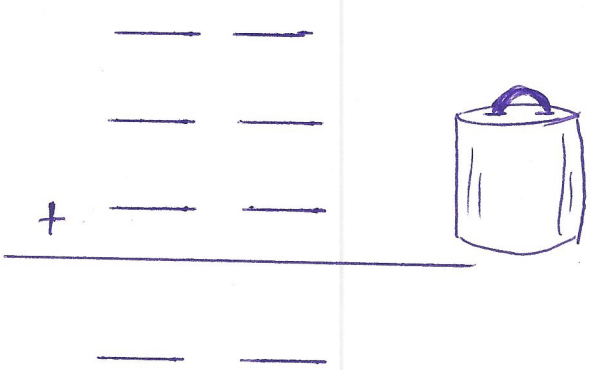




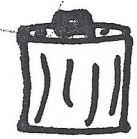
Player 2







① — — —
— — — +



□ □

② — — —
— — — +

□ □

③ — — —
— — — +

□ □

④ — — —
— — — +

□ □

⑤ — — —
— — — +

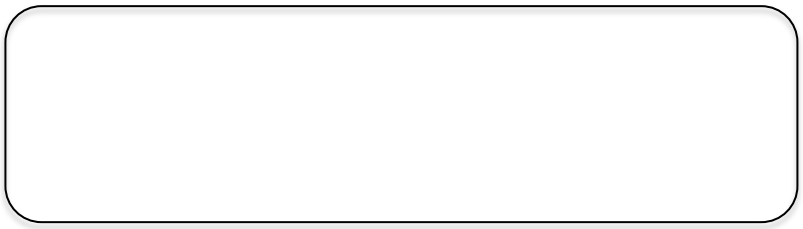
□ □

Student Analysis

Name	
Academic Strengths	
Academic Weaknesses	
Common or Possible Roadblocks	
Compensatory Strategies (already in use or potential)	

Background skills or scaffolding to provide	
Strategies to teach	
Modifications to make	
Accommodations to provide	
Teacher assumptions or emotions that need checking	

Task Analysis



1. What background skills do you assume students know to complete this problem?

2. How do you know they have those skills?

3. What is the goal skill of this problem?

4. List all the concepts, skills and facts included in this problem. Check each one that students have successfully completed on previous work.

5. How could you make this problem simpler?

6. What is the next one component you will add? What will it look like?