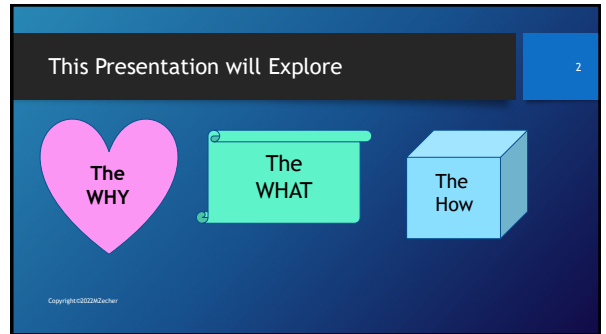


The Impact of Language-Based Learning Challenges in Mathematics

Marilyn Zecher, M.A., CALT
A Presentation of the Multisensory Math Approach
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1



This Presentation will Explore

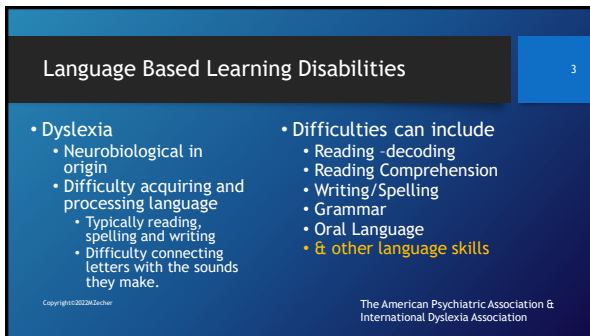
The WHY

The WHAT

The How

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2



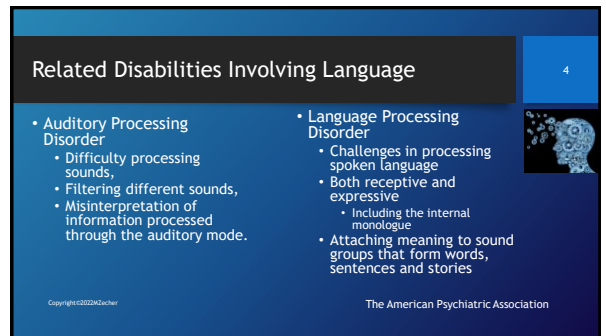
Language Based Learning Disabilities

- Dyslexia
 - Neurobiological in origin
 - Difficulty acquiring and processing language
 - Typically reading, spelling and writing
 - Difficulty connecting letters with the sounds they make.
- Difficulties can include
 - Reading -decoding
 - Reading Comprehension
 - Writing/Spelling
 - Grammar
 - Oral Language
 - & other language skills

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The American Psychiatric Association & International Dyslexia Association

3



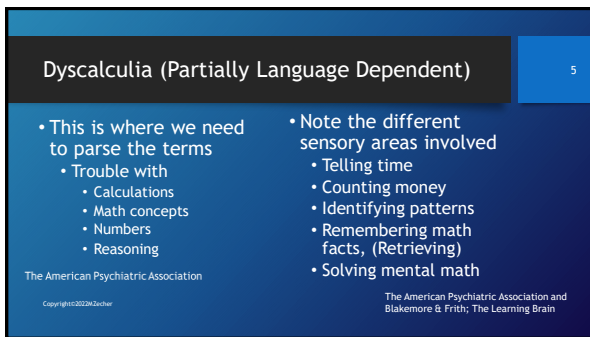
Related Disabilities Involving Language

- Auditory Processing Disorder
 - Difficulty processing sounds,
 - Filtering different sounds,
 - Misinterpretation of information processed through the auditory mode.
- Language Processing Disorder
 - Challenges in processing spoken language
 - Both receptive and expressive
 - Including the internal monologue
 - Attaching meaning to sound groups that form words, sentences and stories

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The American Psychiatric Association

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Dyscalculia (Partially Language Dependent)

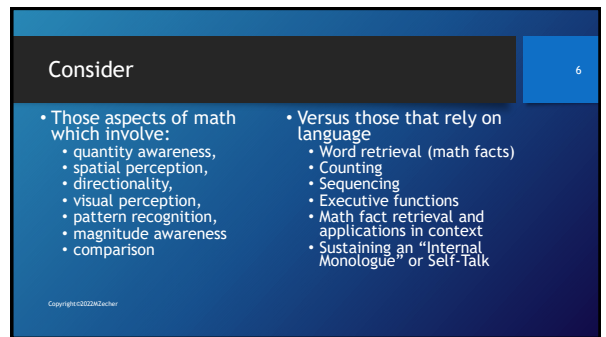
- This is where we need to parse the terms
 - Trouble with
 - Calculations
 - Math concepts
 - Numbers
 - Reasoning
- Note the different sensory areas involved
 - Telling time
 - Counting money
 - Identifying patterns
 - Remembering math facts, (Retrieving)
 - Solving mental math

The American Psychiatric Association

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The American Psychiatric Association and Blakemore & Frith; The Learning Brain

5



Consider

- Those aspects of math which involve:
 - quantity awareness,
 - spatial perception,
 - directionality,
 - visual perception,
 - pattern recognition,
 - magnitude awareness
 - comparison
- Versus those that rely on language
 - Word retrieval (math facts)
 - Counting
 - Sequencing
 - Executive functions
 - Math fact retrieval and applications in context
 - Sustaining an "Internal Monologue" or Self-Talk

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Dr. Sally Shaywitz on Dyslexia

- Impacted by difficulties with language of math
- Difficulty with
 - Organization
 - Retrieval
 - Expression
 - Sequencing
- Calculation/ computation

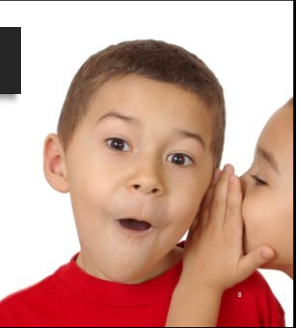
Shaywitz, Sally, *Overcoming Dyslexia*, Alfred Knopf, 2003



7

So, We Must Be Careful

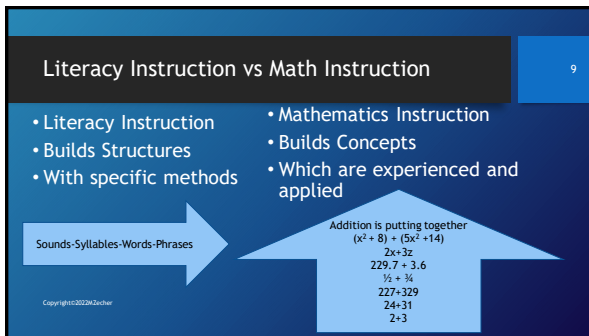
- In defining the impact of dyslexia and language processing disabilities to those aspects of mathematics which depend more on language *input* and *output* and those which don't
- Our approach must be diagnostic and prescriptive
- And offer instruction that meets the needs of all kinds of learners



8

Literacy Instruction vs Math Instruction

<ul style="list-style-type: none"> Literacy Instruction Builds Structures With specific methods <p>Sounds-Syllables-Words-Phrases</p>	<ul style="list-style-type: none"> Mathematics Instruction Builds Concepts Which are experienced and applied <p>Addition is putting together $(x^2 + 8) + (5x^2 + 14)$ $2x + 3z$ $229.7 + 3.6$ $\frac{1}{2} + \frac{3}{4}$ $227 + 329$ $24 + 31$ $2 + 3$</p>
--	---



9

Language Based Challenges

The WHAT

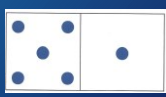
- Math Fact Retrieval
 - Basic addition/subtraction
 - Multiplication/Division
- Evidence suggests that **Multiplication is language based**
- Addition/Subtraction Facts are Supported through pattern recognition and subitizing
- Different Facts require different instructional approaches.

10

Neuroscience

The WHAT

- Shows us that early numeracy or quantity recognition can be built with visual imagery - subitizing
- This supports learning addition/subtraction facts and basic operations.
- We can create multiple memory sources for early math facts.



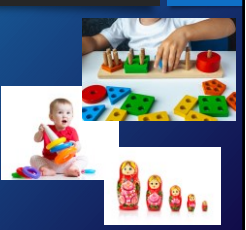
Chinn & Ashcroft, *Mathematics for Dyslexics and Dyscalculics*

11

Quantity Awareness and Math Concepts

The WHAT

- Begin in early childhood.
- One to One Correspondence
- Pattern Recognition
- The language of Math relationships
 - Longer/shorter & same/different
 - More, bigger/smaller

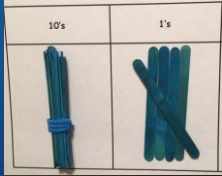


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Sequencing

The WHAT 13

- Counting & Cardinality
- Operations and sequential processing of information
- Depends on an internal monologue and comprehension of the operation. "The Meaning Behind the Math"



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The Problem with Procedural Instruction

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- Just "telling" a student what to do and in what order
- Is language dependent.
- The student may not automatize steps and sequential information that has no other memory source.

- Example: Subtraction with Regrouping



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Applications and Calculations

The WHAT 15

- Depend on comprehension of the larger math concepts
 - Examples
 - Place Value
 - Composition & Decomposition of Quantities
 - Adding is "putting together"
- Students must be able to understand what they are doing
- And, Reason through how they do it.
- This can be supported through multiple modalities.

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Why? What is the depth of the problem?

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- On the NAEP- the National Assessment of Educational Progress
- The average score in much of the USA is basic or below proficient.
- The average score for special education students is basic or below. More often than not, below basic."

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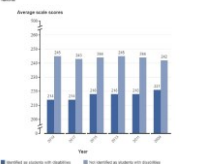
16

National NAEP Scores 2009-2019

17

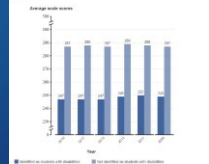
Mathematics, Grade 4, Disability status of student, including those with IDEA plan - 2

Data Chart 1



Mathematics, Grade 4, Disability status of student, including those with IDEA plan - 1

Data Chart 1



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National Data from the NAEP

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Percent of students earning Proficient or Advanced on the Mathematics portion of the 2013 National Assessment of Education Progress

Grade	National All Students	MD All Students	National Special Education	MD Special Education	National Gap	MD Gap
4	41	47	18	19	23	28
8	34	37	8	10	26	27

Copyright©2022M.Zecher MSDE, 2014; National Center for Education Statistics, 2013)


18

Consider if you will. . .

The How

Instruction & Accommodations

- We do have evidence-based strategies for supporting students with disabilities
- Many are appropriate for inclusion settings and most, if not all students.



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What is "Typical" is the list of accommodations.

20

- Teachers often rely on accommodations to meet the needs of students with disabilities
- These include things such as
 - Preferential seating
 - Extra time on assignments and tests
 - Technological accommodations such as calculators, speech to text/print
 - Writing test answers in a test booklet
 - Resource room support, a scribe



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Accommodations vs Instructional Strategies

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- **Accommodations - Student Centered**
 - "Level the playing field"
 - Make participation easier & equitable
 - Allow for multiple options in student **output**
 - Do not change content
 - Often do little to change the instruction
- **Instructional Strategies - Teacher Centered**
 - "Level the playing field"
 - Make participation easier & more equitable
 - May not change the curriculum content/concepts
 - Create multiple options for content **input**

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Instructional Strategies: **Input Accommodations**

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- Require the teacher to be cognizant of how instruction impacts student needs.
 - Visual
 - Auditory
 - Tactile/Kinesthetic
 - Memory -Short Term/ Working /Long Term
- Retrieval *
- Processing Speed-visual or Auditory
- Attention
- Executive Functions
- Spatial /Directional
- Fine Motor Deficits/ Dysgraphia

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Input Accommodations

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- Change *instructional* behavior
- To support learning in the first place
- Using evidence based instructional strategies

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The What Works Clearinghouse

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- Is a component of the US Department of Education
- It publishes **Practice Guides** on instructional strategies supported by evidence which lead to recommendations.
- These are practices teachers can use in the classroom to directly impact student learning.
- Information is freely accessible.


Google Search: "What Works" - What Works Clearinghouse Practice Guides

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24

Students with Language Based Learning Disabilities:
 Strategies for Success

25



The rope is too short
 Or the pitcher is broken
 Though the well is far from dry

I Ching


Strategies: The How

25

1. Multisensory Exposure/Instruction

The How

26



- Use as many sensory modalities as possible...simultaneously
- This enhances learning and memory


Paul J. Laurienti, M.D., Ph.D. Department of Radiology, ANSIR, Advanced Neuroscience Imaging Research, Wake Forest University

26

Multisensory

27

- The more of the brain that is involved in learning
- The stronger the associations, memory & retrieval



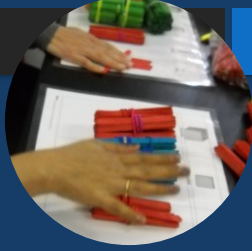
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Multisensory - Uses Multiple Modalities

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- Hearing-receptive language
- Seeing- visual & visuospatial
- Speaking-expressive
 - Internal/external
- Touching- tactile/ kinesthetic with
- Simultaneous Processing



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Think of Applications in "Hands-On" Learning

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- Often found in science, multisensory instructional strategies can be used in almost any content area.
- Paired with simultaneous language & engagement it enhances memory in math.
- We construct, describe, see, touch and do to create linkages.



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An Instructional Sequence: CRA Concrete Manipulatives

30

- Form the first step in initial concept instruction
- Evidence supports using the CRA or CPA instructional sequence
- They are not to be used as inefficient calculators
- The goal of using them is to move beyond their need
- But, they form an essential link for many students

Concrete-Representational-Abstract

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30

2. Explicit Instruction & Multiple Representations

The How 31

- This strategy reappears in several of the *What Works Clearinghouse Practice Guides*.
- It includes the use of manipulative objects (concrete and semi-concrete) to explicate math concepts.
- When students use manipulatives, they work with multiple sensory areas which build memories in different parts of the brain aiding memory and retrieval.

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This includes pattern recognition at the basic level but also pattern recognition in algebra & geometry 32

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Neuroscience has produced evidence that subitizing is the core deficit in mathematics

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- Douglas Clements argues there are two levels of subitizing
 - **Perceptual:** I see it. I know it.
 - **Conceptual:** Recognizing one or more quantities as sets within a set.

Dehaene, Stanislas; (1997) The Number Sense
 Clements, Douglas; (1999) Subitizing - What is it? Why Teach It?
 Chinn & Ashcroft; (2017) Mathematics for Dyslexics & Dyscalculics

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Pattern Recognition

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- Visual patterns aid students in retrieving and applying numeracy.
- Each pattern creates a unique visual memory
- They need to know all the ways to construct all numbers under ten.

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Multiple Representations: Fraction Concepts

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- Research suggests that students who only color/shade figures do not understand and retain concepts as well as students who cut and break things.
- Students also need to understand fractions as numbers on a number line.

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Multiple Representations: Fraction Concepts

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- Students must also understand the meaning of all operations and not simply learn procedures.

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3. Explicit Instruction in Sub-skills : Subitizing & Linkages- The Automatic Recognition of Quantity

- The student who does not learn that $3+4=7$
- May not recognize
 - $30+40=70$
 - $3-7=-4$
 - $4x^2 - 7x^2 = -3x^2$
- Mathematics is a vertical hierarchy of concepts
- Use this idea in intervention by providing practice in subskills that support grade level content

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Sub-skill practice with vertical alignment.

- Isolate sub-skills needed for content support.
- Spiral review into each lesson but with new representations.

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Subskill Practice: Algebra

- Students need to understand magnitude in exponential place values for working with exponents and variables.
- They build. They know.

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4. Restricted/Targeted Fact Practice

- Restricted Number Facts for NEW INTRODUCTIONS
- Accommodations for independent work, quizzes and tests
- Warm-Up/Do Now

Chinn & Ashcroft
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Implications from Research

- "During multiplication, brain activity shifts toward the left/language hemisphere. [language]"
- This fits with the notion that **multiplication is dependent on** regions in the L.H. associated with **language**"

Sarah-Jayne Blakemore & Uta Frith, *The Learning Brain: Lessons for Education*, 2005 Blackwell Publishing, Malden MA
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Students with Language Based Disabilities

- May be impacted by difficulties with language.
 - Organization
 - Retrieval
 - Expression
 - Sequencing
 - Calculation/computations
- Teach fewer facts *at a time*
- To develop fluency *over time*

Dr. Sally Shaywitz, *Overcoming Dyslexia*
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Look for Patterns. Teach Inverse Operations at the Same Time

43

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

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- Color in the products of a times table in a 100's chart.
- Look for patterns that make retrieval easier.
- Chunk facts into meaningful groups and practice them in daily work.

43

5. Near-Point References

The How

44

Example:

- Use a Blank fact chart
- Ask students to fill in ONLY facts targeted for fluency development
- Keep it available during class
- Apply those number facts during class instruction

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Student Generated Graphic Organizers or Tools

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- Early in the lesson
- Students generate an organizer of targeted math facts for practice
- It is kept on the desk for reference as needed.
- Partial math facts chart with only targeted facts
- Number Line
- Sequential model
- Concept card
- Reference sheet
- Visual Dictionary

1	2	3	4	5	6	7	8
---	---	---	---	---	---	---	---

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Near Point References

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6. Formatting

The How

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- Students with
 - visual difficulties,
 - figure ground difficulties,
 - attention difficulties,
 - dysgraphia
 benefit from easy to navigate formatting

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Formatting

48

This means:

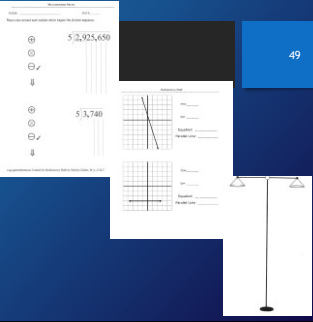
- Larger font
- Ample white/work-space
- Fewer problems on a page
- A worked example on things sent home

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Formatting

- Students can use notebook paper turned sideways to aid alignment.
- Graph paper or large grid paper may be too busy.

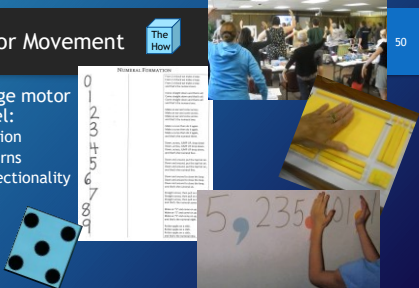


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7. Gross Motor Movement

- Students use large motor muscles to model:
 - Numeral formation
 - Numeracy Patterns
 - Sequence & directionality
 - Concepts
 - Operations




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When Students Use Gross Motor Movements

- They embed math concepts, operations, or sequences in muscle memory
- Tied to language this functions to cue calculations and fluency




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Gross Motor Movement Ideas

- Numeral Formation
- Directionality in Operations
 - Touch the Sign, Follow the Line
 - Multi-digit Multiplication
 - Long Division
 - Four attributes of Slope
 - Function Practice



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8. Explicit Instructional Language*

Concise


Memorable

Repeatable

Retrievable

Mathematically Accurate

- Example: What is it made of?
- What is its name?
- Expanded form tells you what a number is "made of"
- Standard form tells you its name



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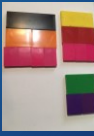
Inaccurate language leads in inaccurate concept formation

- Think of the most common errors in fraction operations.
- $1/3 + 1/3 = 2/6$

Morphology is an answer

- Num- means to number
- Nom- means to name

- The denominator names the fractional part.



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Instructor Strategies to Note 55

- Rate of Speech
- Processing Pauses
- Rhythm & Chanting
 - Tied to visual and kinesthetic memory
- Rules for Exponents
- The 9 times table
- Solving Equations
- Sequential Steps for Long Division
- Simplifying Fractions
- Simplifying Radicals
- Write in “factored form”

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Special Needs Group 2: ESOL 56

- Any strategy used to support language difficulties works well for students who are second language learners.
- Articulate clearly with processing pauses
- Tie math language to concrete manipulatives for linkages between language, concepts and operations
- Use multisensory instructional strategies

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Evidence Based Strategies 57

- Multisensory Input
- Multiple Representations
- Explicit Instruction
- Targeted Fluency Practice
- Gross Motor Practice
- Explicit Instructional Language
 - Concise
 - Repeatable
 - Explicit rate of speech for new concepts
- Near-point References & Graphic Organizers

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WWPG: Assisting Students Struggling with Math in the Early Grades 58

1. Systematic Instruction -to promote understanding of mathematical ideas
2. Mathematical Language-Clear & Concise
3. Representations-concrete & semi-concrete
4. Use Number Lines
5. Provide deliberate instruction in word problems
6. Multiplication Activities *
 - Targeted Facts
 - Students compete against themselves for growth

What Works Clearinghouse Practice Guide

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WWPG: Assisting Students Struggling with Math, RTI Elementary & Middle School 59

1. Instruction in intervention should be Explicit & Systematic (Strong)
2. Instruction in word problems based on underlying structures (Strong)
3. Interventions should include opportunities to work with visual representations (Moderate)
4. Interventions should devote 10 minutes per day to developing fluency with math facts (Moderate)

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WWPG: Improving Mathematical Problem Solving in the Grades 4 Through 8 60

1. Teach students how to use visual representations
2. Assist Students in Monitoring and Reflecting on the Problem Solving Process
3. Help Students Recognize and Articulate Mathematical Concepts & Notation
4. Expose Students to Multiple Problem Solving Strategies

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WWPG: Organizing Instruction & Study to Improve Student Learning

61

- Ask deep explanatory questions (strong)
- Space learning over time (moderate)
- Interweave worked examples with problem solving
- Combine graphics with verbal descriptions
- Connect & integrate concrete & abstract representations
- Use quizzes to re-expose students to key concepts

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References

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- Blakemore, Sarah-Jayne; Frith, Uta; (2005) *The Learning Brain, Lessons for Education*, Malden MA, Blackwell Publishing
- Butterworth, Brian, (1999). *The Mathematical Brain*, London, Macmillan
- Steve Chinn; Richard Ashcroft; (2017) *Mathematics for Dyslexics and Dyscalculics*, Malden MA, Wiley Blackwell
- Dehaene, Stanislas, (1997). *The Number Sense: How the Mind Creates Mathematics*, New York, NY, Oxford University Press.
- Deshler, Donald D., S. Ellis, Edwin B., Lenz Keith, *Teaching Adolescents with Learning Disabilities: Strategies and Methods*, 1979 Love Publishing Company, Denver, Colorado 80222 ISBN 95-073397
- Intervention: A Position of the National Council of Teachers of Mathematics (2011)
- Mercer, Cecil D. and Mercer, Ann R. *Teaching Students with Learning Problems* Merrill Prentice-Hall, Upper Saddle River, New Jersey (1993)

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References

63

- Montaigne & Jitendra, *Teaching Mathematics to Middle School Students with Learning Difficulties*, Guilford Press, New York, 2006
- Shaywitz, Sally, *Overcoming Dyslexia*, Alfred Knopf, 2003
- Van De Walle, John A. et al. *Elementary and Middle School Mathematics, Teaching Developmentally*, Eighth Edition 2013, Pearson Education, Upper Saddle River, NJ
- What Works Practice Guides <https://ies.ed.gov/ncee/wwc/PracticeGuides>
- 7 Learning Disabilities Every Psychology Professional Should Study, Walden University <https://www.waldenu.edu/online-masters-programs/ms-in-psychology/resource/seven-learning-disabilities-every-psychology-professional-should-study>

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References

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64