UNDERSTANDING RTI IN MATHEMATICS

Session 3: Effective Instructional Practices in Mathematics for Tier 2 Instruction

New York State Webinars on RTI Mathematics

Tuesday, December 2 , 2014

4:00 – 5:15 pm EST

Russell Gersten, Ph.D.

Director, Instructional Research Group

Professor Emeritus, University of Oregon

Instructional Research Group

POLL QUESTIONS 1 AND 2

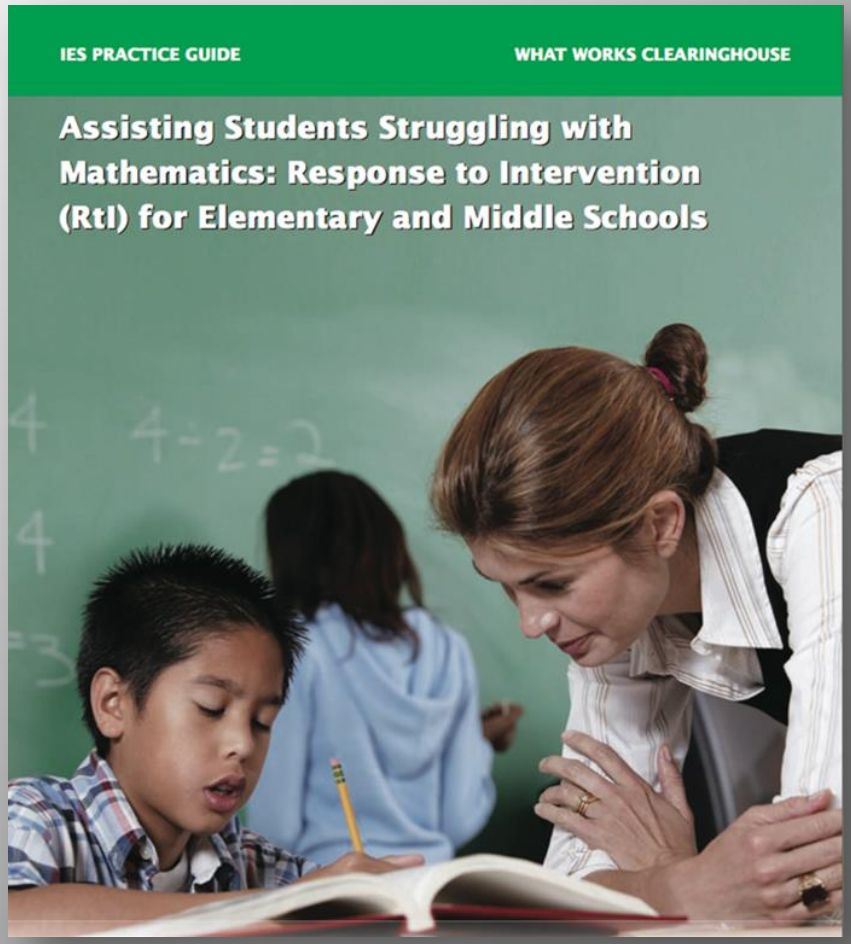
SESSION 3

Webinar Title	Date/Time	Agenda
Effective Instructional Practices in Mathematics for Tier 2 Instruction	Tuesday, December 2nd 4:00-5:15 pm EST	• What to Teach • Nature of Instruction: Controversies and what we know about the nature of explicit instruction • Intervention Materials/Resources • Roadblocks & Suggestions

Instructional Research Group

FRAMEWORK FOR MATHEMATICS INTERVENTION

1. Russell Gersten (Chair)
2. Sybilla Beckman
3. Ben Clarke
4. Anne Foegen
5. Laurel Marsh
6. Jon R. Star
7. Bradley Witzel



Instructional Research Group

POLL ITEM 3/4

3. Satisfaction with current mathematics intervention curricula materials or supports for Tier 2 small group intervention:

4. Areas where you need help in terms of evidence based practice for Tier 2 intervention: (Fill in as many as appropriate)

RECOMMENDATION 2:
FROM PRACTICE GUIDE (2007)
WHAT TO TEACH IN INTERVENTION

Instructional materials for students receiving interventions should focus in-depth on:

- Whole numbers in kindergarten through grade 6
- Rational numbers in grades 4 through 8
- Applications to geometry and measurement

Level of Evidence: **Minimal**

WHAT IS NEW EVIDENCE?

1. Evidence discussed in Webinar 2 on important predictive power of learning and understanding fractions by grade 5 for algebra success.
2. To some extent, recent evidence on strong role number line estimation/magnitude comparison plays in predicting future success in mathematics by Siegler, Clarke and others.

NEW EVIDENCE (CONT.)

3. Intervention research (Tier 2) by Fuchs and colleagues (e.g., Schumacher, Powell) that interventions with such a focus lead to short term benefits if focus is intense on:
   - Number line and magnitude in 1st grade (Rolfhus, Gersten et al., in press).
   - Linear representation of fractions and magnitude comparison of fractions in 4th grade (Fuchs et al., in press).
4. Expert opinions in for example, National Mathematics Advisory Panel.

EVIDENCE BASE (CONCLUDED)

Yet none of this evidence is scientifically adequate to say “it is proven.”

Note: Long term role of geometry and visual spatial skill not well studied.

EMERGING CONSENSUS ON BEST WAY TO TEACH MATHEMATICS

These ideas are likely relevant for Tier 2 (preventative) instruction especially in terms of instructional design (as opposed to delivery):

1. Instruction should include, and **sometimes** ***integrate***
   - procedures
   - AND concepts
   - AND word problems
2. Whole number work consistently links operations to number properties
3. Same true for work with rational number (fractions/decimals)

POLL 5 & 6 HERE

BROAD ASSUMPTIONS

1. Tier 2 intervention will need to lower the cognitive load on students **temporarily.**
   - **(Due in part to issues with working memory deficits and or problems in dealing with abstractions)**
2. Examples might be starting with a simpler set of denominators when teaching fractions, lowering how many numbers used when teaching multiplication, simplifying **initial** range of word problems involving division taught.

BROAD ASSUMPTIONS (CONT.)

3. Systematic or cumulative review is essential. Especially for intervention.

4. Some time devoted to fluency is a great idea. Goal is to build **quick retrieval.**

5. Much more practice and feedback required than typical Tier 1 instruction. (Engelmann et al., 1988) and meta-analysis (Gersten, Chard, Jayanthi et al., 2009).

SOMEWHAT CONTROVERSIAL PIECES

1. When possible, teach grade level standards using the above practices.
2. The same practices urged for Tier 1 instruction (stressed in Webinar 1) should be basis for instruction in Tier 2.
3. The ultimate goal is the same for Tier 1 and Tier 2 – *Building not only proficiency and fluency with operations but also understanding and insight into the mathematical ideas.*

THE HOW TO TEACH: RECOMMENDATIONS AND EVIDENCE BASE

HOW TO TEACH FROM PRACTICE GUIDE

Recommendation	Level of Scientific Evidence
3. Systematic, focused instruction	Strong
4. Solving word problems	Strong
5. Visual representations	Moderate
6. Building fluency with basic arithmetic facts	Moderate
8. Use of motivational strategies	Minimal

Instructional Research Group

RECOMMENDATION 3

Instruction during the intervention should be **systematic** and include models of proficient problem-solving, **verbalization of thought processes**, guided practice, corrective feedback, and frequent cumulative review.

Level of Evidence: **Strong**

Instructional Research Group

EVIDENCE

1. Six randomized controlled trials met standards
2. Key themes
   - Extensive practice with feedback over several lessons *
     - ✓Need not be boring
   - **Very systematic in terms of introducing new mathematical ideas, cumulative review***
   - Let students provide rationale for their decisions
   - **Instructors and model approaches to problem solving***
   - Fellow students think aloud and model

* Evidence based (as opposed to expert opinion)

ROADBLOCKS

Intervention curricula may not have explicit instruction and may underestimate the amount of practice and review needed by Tier 2 and Tier 3 students.

Suggested Approach:

1. Develop guidebooks for school staff to adapt the lessons.
2. Add new review problems and provide more practice.

ROADBLOCKS (CONT.)

Intervention curricula may not ever ask students to explain their reasoning thru words or visual representations.

Suggested Approach:

1. Develop guidebooks for school staff to adapt the lessons.
2. Provide sample formats for interventionists to use

VIDEO EXAMPLE OF EXPLICIT INSTRUCTION WITH THINKING ALOUD

Instructional Research Group

RECOMMENDATION 5

Intervention materials should include opportunities for the student to work with visual representations of mathematical ideas and interventionists should be proficient in the use of visual representations of mathematical ideas.

Level of Evidence: **Moderate**

Instructional Research Group

SUGGESTIONS

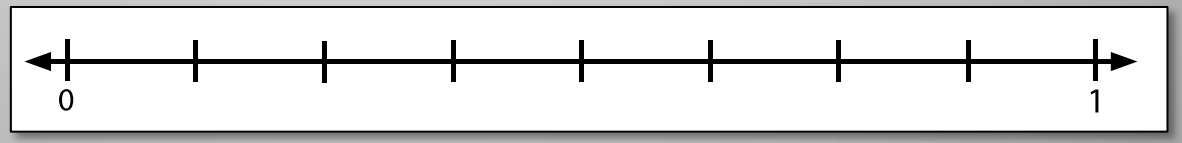
1. Use visual representations such as number lines, arrays, and strip diagrams.
2. If necessary, consider **expeditious** use of concrete manipulatives before visual representations. The goal should be to move toward abstract understanding.

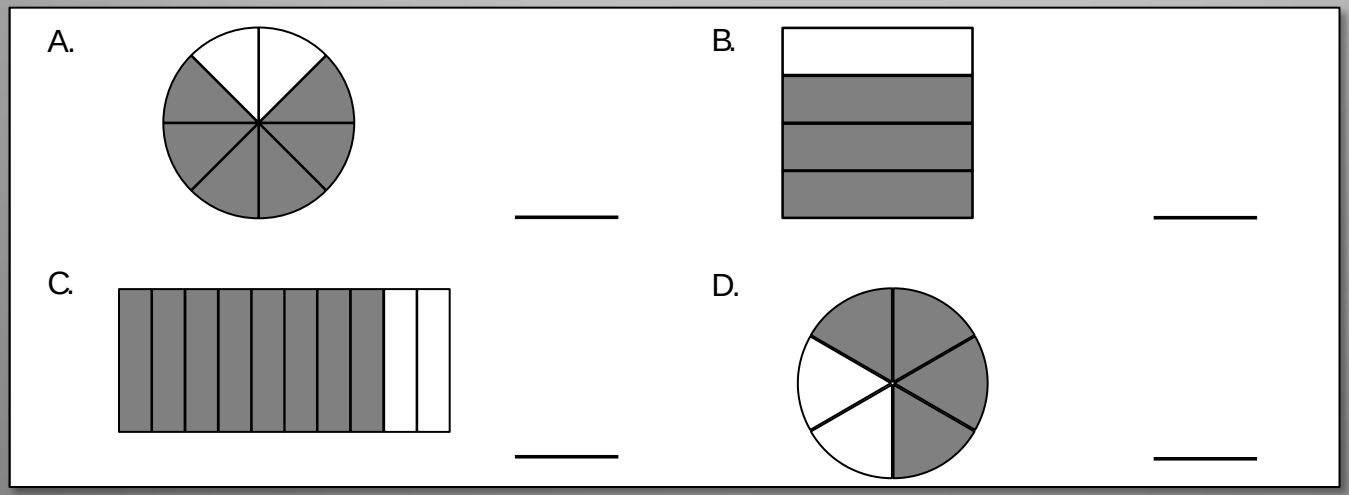
NAMING FRACTIONS/ NUMBER LINE

FUCHS ET AL (2013)

- Introduce unit fractions with **Circles and Tiles** CONCRETE
- Show fractions with unshaded regions to show Unit fractions (VISUAL-see below)
- Show how *unit fractions* make larger fractions with manipulatives, number lines, and numbers
- Name fractions from shaded representational regions (see example below)

$$\frac{1}{8}+\frac{1}{8}+\frac{1}{8}+\frac{1}{8}+\frac{1}{8}=\frac{5}{8}$$



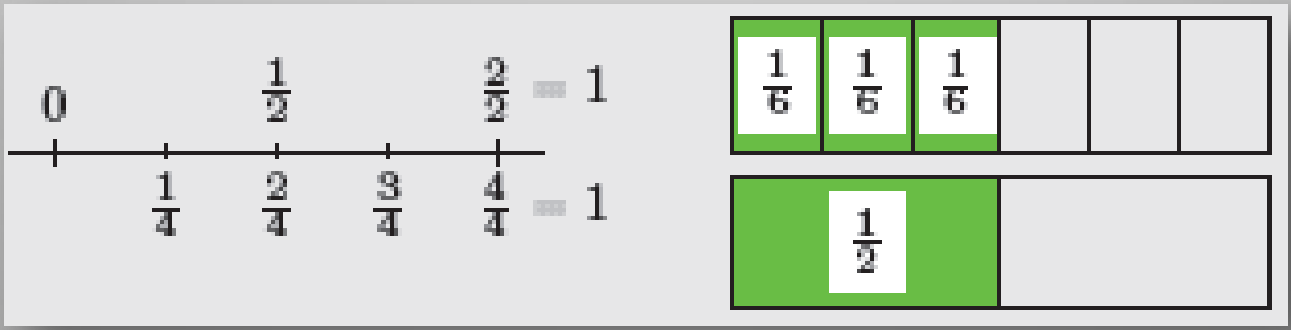


USE OF STRIP DIAGRAMS/ RECTANGULAR REPRESENTATION

1. As an easy way to phase into number line
2. As a means for building up sophistication of students' visual number line

EXAMPLE OF A STRIP DIAGRAM

Using the number line and fraction strips to see fraction equivalence



Instructional Research Group

USE OF STRIP DIAGRAMS TO SOLVE PROBLEMS

1. Solve the problem:
2. Think about how you solved the problem

Shauntay spent 2/3 of the money she had on a book that cost $26. How much money did she have before she bought the book?

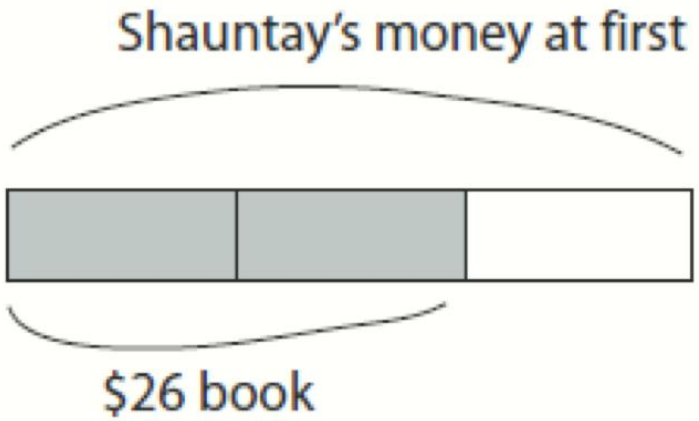
USUAL RESPONSES

1. Simple linear algebraic equation: 2/3 X= $26
2. Thinking that two parts or two shares of the ‘whole” or “whole three shares” equals 26
   - So one share/part is 13 and
   - Three parts is one whole or 39
3. Just intuitively answered

NOTE HERE THE LINKAGE BETWEEN ARITHMETIC (WORD PROBLEMS AND ALGEBRA)

STRIP DIAGRAMS CAN HELP STUDENTS MAKE SENSE OF FRACTIONS

Shauntay spent 2/3 of the money she had on a book that cost $26. How much money did Shauntay have before she bought the book?



2 parts ⟶ $26
1 part ⟶ $26 ÷ 2 = $13
3 parts ⟶ 3 × $13 = $39

Shauntay had $39

Instructional Research Group

TEMPORARY REDUCTION OF COGNITIVE LOAD

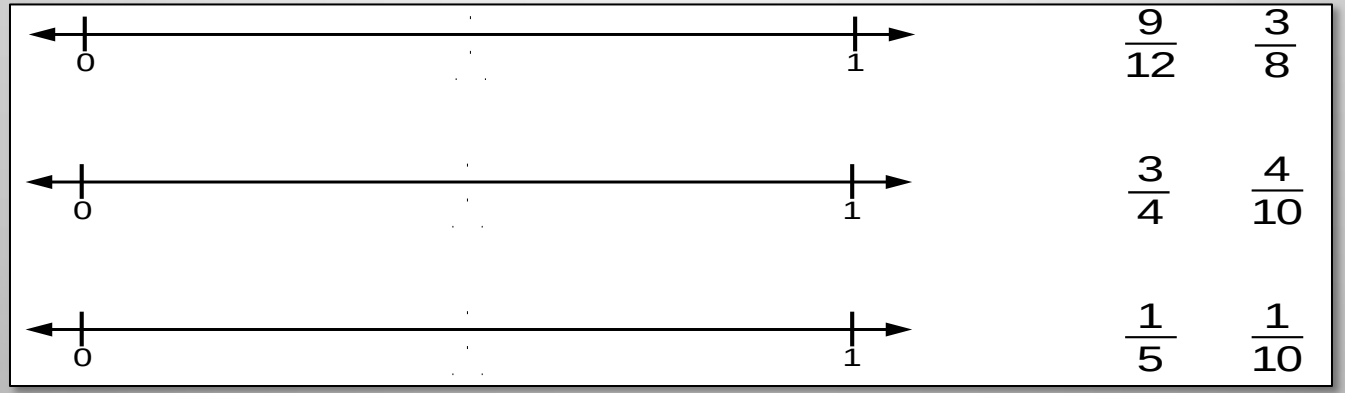
To help reduce cognitive load temporarily, a good deal of time went into using ½ as a benchmark in the 0 to 1 number line

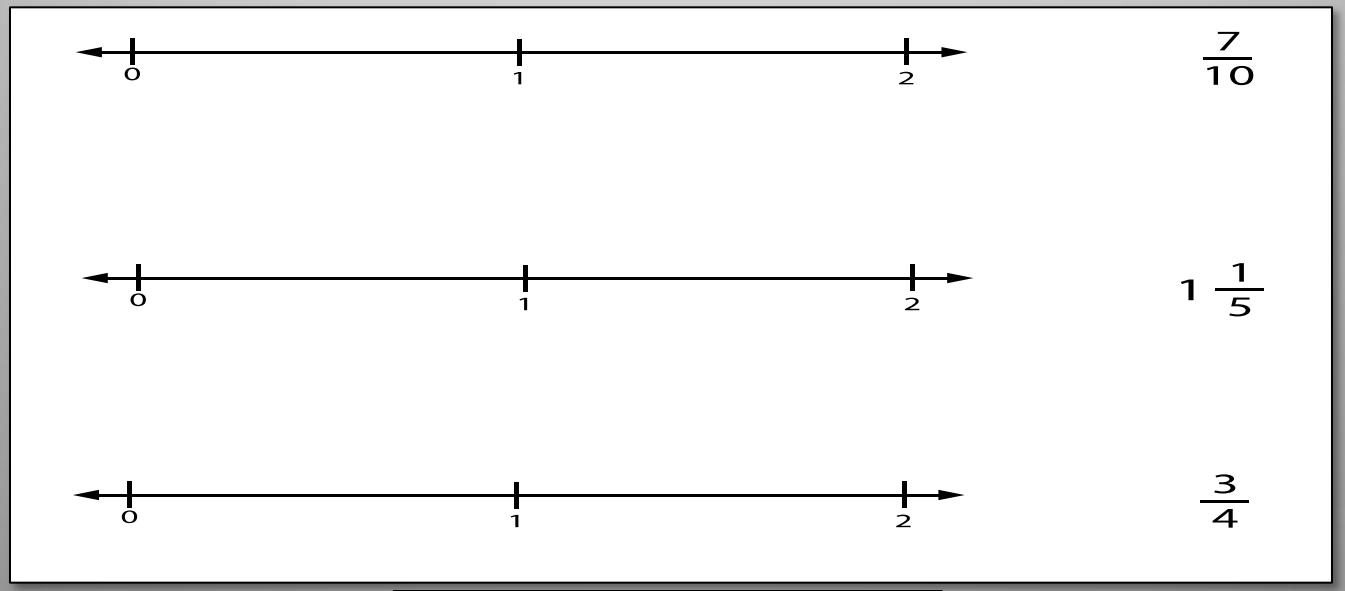
NUMBER LINES 0 – 1

FROM FUCHS ET AL. (IN PRESS)

1. Extension of Comparing & Ordering
2. Extends measurement understanding
3. 0-1 introduced first
4. **½ benchmark stressed (to temporarily reduce cognitive load)**

USE OF ½ AS BENCHMARK





Instructional Research Group

ULTIMATE GOALS: ORDERING OF THREE FRACTIONS

Most Advanced Card

Ordering

$\frac{a}{d}$ $\frac{b}{e}$ $\frac{c}{f}$

Label:
Proper (P), Improper (I), or Mixed (M)
↓
Change I to M

Compare:

Same Denominators?
Bigger Numerator
Bigger Fraction

Same Numerators?
Fewer Parts
Bigger Fraction

All Different?

1. Compare to $\frac{1}{2}$ ***and***
   Write L, G, or =

2. LL or GG?
   Compare and write < or >

1. Extension of Comparing 2 Fractions
2. Challenges Working Memory

Order fractions from smallest to largest.

A. $\frac{3}{4}$ $\frac{1}{2}$ $\frac{2}{6}$ ____ ____ ____

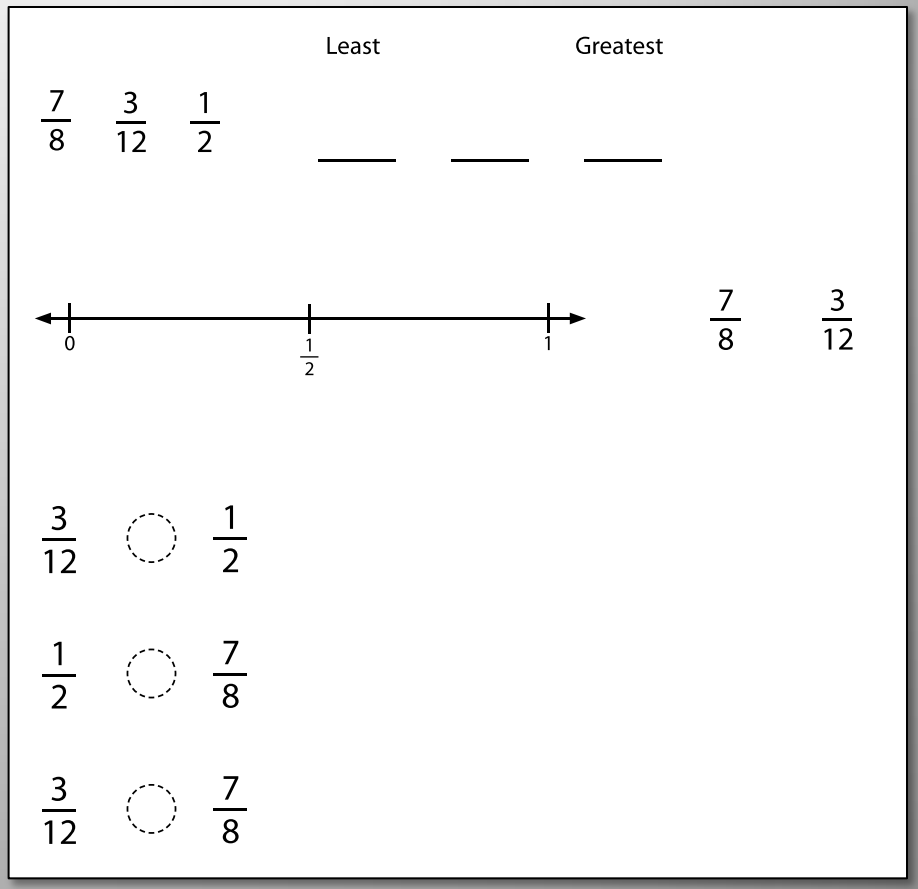
B. $\frac{1}{4}$ $\frac{1}{10}$ $\frac{1}{2}$ ____ ____ ____

C. $\frac{1}{2}$ $\frac{8}{12}$ $\frac{3}{8}$ ____ ____ ____

Instructional Research Group

EXAMPLES OF FULL ARRAY OF SUBTASKS

1. Relating Magnitude Activities
2. Use the same three fractions for each magnitude activity
   - Comparing
   - Ordering
   - Number Line
   - At the beginning, use ½ in many problems since it is known as benchmark



RECOMMENDATION 6

Interventions at all grades should devote about 10 minutes in each session to building fluent retrieval of basic arithmetic facts.

Level of Evidence: **Moderate**

Instructional Research Group

SUGGESTIONS

1. Provide 10 minutes per session of instruction to build quick retrieval of basic facts. **Consider use of strategies such as treating 9 as (10-1) for addition and multiplication.**
2. For student in K-2 grade explicitly teach strategies for efficient counting to improve the retrieval of math facts.
3. Teach students in grades 2-8 how to use their knowledge of math properties to derive facts in their heads.
4. Fluency activities can and should be used in other aspects of instruction (e.g. fractions magnitude representations)

RECOMMENDATION 8

Include motivational strategies in tier 2 and tier 3 interventions.

Level of Evidence: **Minimal**

ROADBLOCKS

1. Rewards can reduce genuine interest in mathematics by directing student attention to gathering rewards rather than learning math.

2. Suggested Approach: Rewards have not shown to reduce intrinsic interest. As students become more successful rewards can be faded so student success becomes an intrinsic reward.

MOTIVATORS: EXAMPLE FROM FUCHS ET AL. (2013)

Students have two opportunities to earn fraction money:

1. Denominations include:
   - Whole dollars
   - Half dollars
   - Quarter dollars
2. The Fraction Store opens every 3 days with prizes at various price points
3. Ways to Earn Money
4. On-Task Behavior
   - Unidentified intervals, group contingency
5. Solving problems correctly
   - Last activity of the day
6. Tutor discretion
   - Tutors were instruction to give bonus money to increase focus as needed based on group needs

RECOMMENDATION 4

Interventions should include instruction on solving word problems that is based on common underlying structures.

Level of Evidence: **Strong**

SUGGESTIONS

1. Teach students about the structure of various problem types, **how to categorize problems**, and how to determine appropriate solutions.

2. Middle step, is it:
   - Quantity (compare)
   - Change (over time)

EXPLICITLY TEACH THE UNDERLYING STRUCTURE

1. Addition and Subtraction Story Problems
   - Change problems
   - A quantity is increased or decreased
2. Group Problems
   - Two groups are combined to form a large group
3. Compare Problems
   - Two things are compared to find the difference

CHANGE, GROUP, OR COMPARE?

1. Dillon leaped 32 inches. Marcus leaped 27 inches. How many more inches did Dillon leap? (Everyday Math 4)
2. Uranus has 11 rings. Neptune has 4 rings. How many rings do they have altogether? (SF/AW 3)
3. There are 18 ducks. Then 5 more swim over. How many ducks are there now? (Math Expressions 1)

RESOURCES

1. National Center on Intensive Intervention: Tools Chart:

   http://www.intensiveintervention.org/

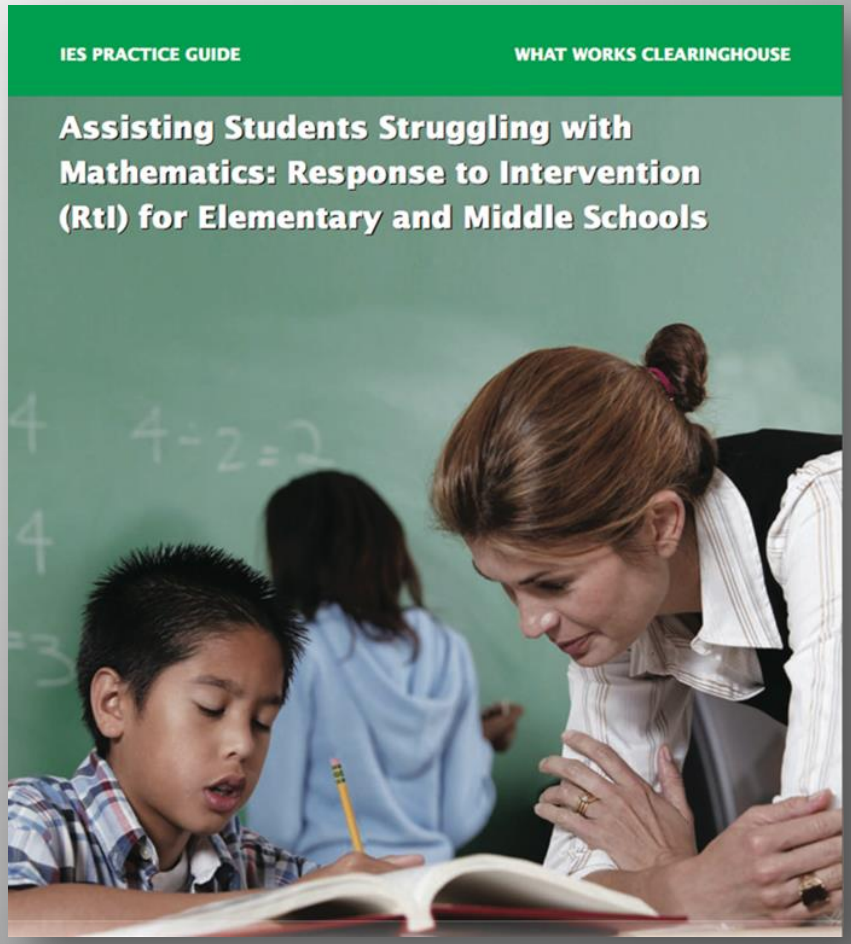
2. What Works Clearinghouse Mathematics:

   http://ies.ed.gov/ncee/wwc/

   Look under Mathematics

FRAMEWORK FOR MATHEMATICS INTERVENTION

1. Russell Gersten (Chair)
2. Sybilla Beckman
3. Ben Clarke
4. Anne Foegen
5. Laurel Marsh
6. Jon R. Star
7. Bradley Witzel



Instructional Research Group

CITATIONS

Engelmann, S., Becker, W. C., Carnine, D., & Gersten, R. (1988). The direct instruction follow-through model: Design and outcomes. *Education and Treatment of Children, 11*(4), 303-317.

Fuchs, L., Fuchs, D., Compton, D., Wehby, J., Schumacher, R., Gersten, R., & Jordan, N. (in press). Inclusion versus specialized intervention for very low-performing students: Very low performers, inclusion vs. specialized intervention and CCSS. *Exceptional Children*.

Fuchs, L. S., Schumacher, R. F., Long, J., Namkung, J., Hamlett, C. L., Cirino, P. T., Jordan N. C., Siegler, R., Gersten R., & Changas, P. (2013). Improving at-risk learners' understanding of fractions. *Journal of Educational Psychology, 105*, 683-700.

Gersten, R., Chard, D., Jayanthi, M., Baker, S., Morphy, P., & Flojo, J. (2009). Mathematics instruction for students with learning disabilities: A meta-analysis of instructional components. *Review of Educational Research, 79*(3), 1202-1242.

Rolfhus, E., Gersten, R., Clarke, B., Decker, L., Wilkins, C., & Dimino, J. (in press). Focused small-group intervention for first graders with limited number knowledge: Large-scale replication of a randomized controlled trial. *American Educational Research Journal.*

RECAP OF FRAMEWORK

1. Tier 2 intervention will need to lower the cognitive load on students **temporarily.**
3. Systematic or cumulative review is essential. Especially for intervention.
4. Some time devoted to fluency is a great idea. Goal is to build **quick retrieval.**
5. Much more practice and feedback required than typical Tier 1 instruction. (Gersten, Chard, Jayanthi et al., 2009).
6. When possible, teach grade level standards using the above practices.

The ultimate goal is the same for Tier 1 and Tier 2 – *Building not only proficiency and fluency with operations but also understanding and insight into the mathematical ideas!!!!*

QUESTIONS?