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Effects of an Integers Intervention on the Mathematics Performance of Seventh-Grade Students With Mathematics Difficulties

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PURPOSE

Several high-quality research studies show that success in algebra is linked to increased achievement in secondary and postsecondary education and to higher-paying jobs. But algebra is a particularly difficult challenge for students who persistently struggle in mathematics. To succeed in algebra, students need background mathematics knowledge—knowledge that many struggling students don't have. Teachers need concrete tools to arm their students with these important mathematics skills.

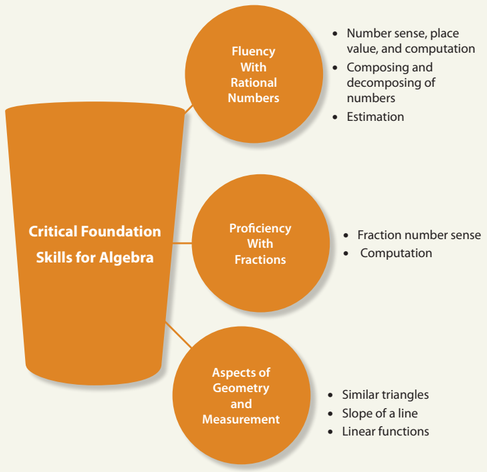
The purpose of this study was to examine the results of lessons on integers conducted with seventh-grade Tier 2 students who received instruction from mathematics intervention teachers.

RESEARCH QUESTIONS

1. What are the effects of the Project AIM 2 integer lessons on the performance of the seventh-grade Tier 2 treatment group compared to the seventh-grade Tier 2 "business-as-usual" group on a proximal measure (easyCBM)?
2. What are the effects of the Project AIM 2 integer lessons on the performance of the seventh-grade Tier 2 treatment group compared to the seventh-grade Tier 2 business-as-usual group on a distal measure (Group Mathematics Assessment and Diagnostic Evaluation [GMADE])?

BACKGROUND

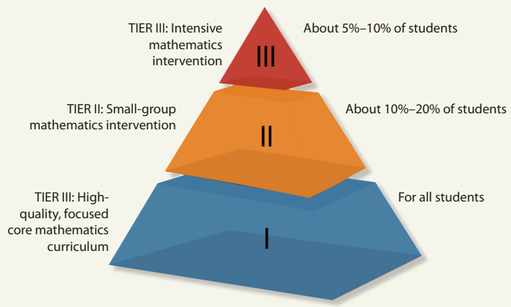
Quality Content and Algebra Readiness



Response to Intervention

- Universal screening
- Tiers 2 and 3: Evidence-based intervention that supplements, not supplants, core instruction (general education)
- Progress monitoring (critical component)
- Fidelity to intervention
- Measures of social validity

3-Tier Intervention Model



METHOD

Setting and Participants

- Sixteen middle schools in six cities in Central and North Texas participated.
- The sample size was 380 students (210 treatment, 170 control).
- Students were district-identified as struggling in mathematics, based primarily on poor performance on the previous year's high-stakes state mathematics test.
- Demographic characteristics for each group are presented in Table 1.
- Informed consent from parents and guardians and assent from students were obtained in accordance with the university's Internal Review Board procedures.

Table 1
Demographic Characteristics of the Student Sample, Postattrition

	Treatment	Comparison
Total	210	170
Gender		
Female	45%	48%
Male	55%	52%
Ethnicity		
Asian/Pacific Islander	2%	2%
African American	12%	14%
Hispanic	66%	67%
Euro-American	15%	14%
Mixed	5%	3%
English language learners	23%	24%
Free or reduced-price lunch	68%	72%

Design

- A high-quality randomized controlled trial experimental design was selected to meet the criteria in the What Works Clearinghouse *Procedures and Standards Handbook* (Institute of Education Sciences, 2013) for examining the effectiveness of an intervention.
- A pretest-posttest control group design was used.
- Students in intervention classes were randomly assigned to a treatment or comparison group at the beginning of the school year.

Measures

Research Question 1 Proximal Measure: easyCBM Algebra Test

The easyCBM (University of Oregon, 2008) has considerable evidence of technical adequacy, given the national norming process (see Anderson et al., 2014).

Research Question 2 Distal Measure: GMADE

- Level M of the GMADE (Pearson, 2004) used for grade 7
- Two subtests (Operations and Computation and Process and Applications) administered
- Raw scores summed to form a composite Total Mathematics score
- Pretest (Form A) administered in fall
- Posttest (Form B) administered in spring
- Reliability of each measure established (all coefficients exceeded .80)
- Validity of scores established (content, concurrent and predictive, construct)

Module Checks

Both the treatment and control groups took the module checks. See below for examples.

3. Which has the least value?
- **a.** –6
- **b.** –5
- **c.** –4

4. A diver is 100 feet below the sea. She dives 50 feet deeper. Where is she now?
- **a.** –150 feet
- **b.** –50 feet
- **c.** –75 feet

Intervention Lessons

- Delivered by mathematics interventionists
- 15 lessons per module
- Scripted
- Weekly: At least 3 days per week
- Time: 45 minutes, one class period

INSTRUCTIONAL COMPONENTS

Warming Up
- Connection to and review of skills already learned
- Basic skills

Learning to Solve ("I do")
- "Meat" of the lesson
- Teacher guidance with modeling
- Student engagement
- Hands-on peer sharing
- Misconceptions

Practicing Together ("We do")
- Increased student participation
  - Different models
  - Peer sharing
- Less teacher modeling
- Open-ended questions
- Different activities
  - Games
  - Activity sheets
- Writing in small groups and peer pairs

Trying It on Your Own ("You do")
- Measures how well students did with the lesson's objective
- Done independently
- Data collection, graphing

Wrapping It Up
- Exit ticket
- Wrap-up of lesson
  - Something to think about
  - Something explained in a different way
  - Takeaway message

Appendix Lessons
- Additional lessons and practice are provided for students needing more instruction in a particular skill.
- These lessons must be taught if the majority of a class (51%) has a score of less than 85% accuracy (score of 2 or fewer out of 4 problems) on Trying It on Your Own.
- The whole class is taught the appendix lesson, not just the students with a score below 85%.

Extra Practice Sheets
- Used for more practice
- Not actual lessons
- Connected to specific lessons

Multiplication & Division Facts
- Used to promote fluency
- Include graphing (self-monitoring, self-evaluation, motivation)

LESSON DESIGN

Overview
- Modules on fractions, decimals, integers, ratios and proportions, and expressions and equations
- Connection with background knowledge
- Mathematical ideas presented conceptually
- Concrete, semi-concrete, abstract/symbolic presented together

Multiple Representations
- Representations presented concurrently rather than sequentially
- Verbal, symbolic, graphical, tabular, and physical material representations

Student Talk
- Thinking aloud about problem-solving methods, mathematical understanding, or solution justification
- Communicating using mathematically precise language modeled by teachers
- Communicating in writing how a solution was derived
- Considering other ways to derive a solution
- Questioning
- Solving problems in pairs or small groups
- Responding on wipe boards to multiple-choice or open-ended items
- Identifying mistakes and misconceptions

Questions to Promote Problem Solving and Generalizations
- Students are typically asked more skill questions because their textbooks are filled with problems like 458 + 397.
- Many students are capable of performing the algorithm but have difficulty explaining the relationship that this expression represents.
- The goal was to change the level of thinking by developing deeper questions, such as in the following examples.

INTERVENTION EXAMPLES

"Reversibility" Item

3. Which pairs of integers both have a product of –30?
- **a.** (5, 6) and (–2, 15)
- **b.** (–6, –5) and (–10, –3)
- **c.** (5, 6) and (30, 1)
- **d.** (–15, 2) and (–3, 10)

"Flexibility" Item

Max added 8 + (–11). The sum was –3. Ella said, "Now I know the sum of 8 + (–15) without adding." How did Ella find the sum?
- **a.** One addend is 4 less than Max's problem. The sum is –7.
- **b.** One addend is 4 less than Max's problem. The sum is –3.
- **c.** One addend is 4 more than Max's problem. The sum is –7.
- **d.** It is not possible for Ella to find the sum without adding.

Helpful resource: Dougherty, B., Bryant, D. P., Bryant, B. R., Darrough, R. R., & Pfannenstiel, K. H. (2015). Constructing success in algebra: Developing generalizations to build algebraic thinking. *Intervention in School and Clinic, 50*(5), 273–281. doi:10.1177/1053451214560892

INTERVENTION EXAMPLES (continued)

"Generalization" Item

Cassie added $\frac{2}{3} + \frac{3}{4}$. Her sum was $\frac{5}{7}$. What would you say to Cassie?

- **a.** You are correct because you should add the numerators and the denominators.
- **b.** You are correct because your sum should be close to 1.
- **c.** You are incorrect because your sum should be more than 1.
- **d.** You are incorrect because you should cross multiply to get $\frac{8}{9}$.

Table 2
Examples for Two Different Modules

Question Type	Fractions Module *Standard:* ½ x ¾	Integers Module *Standard:* -3 + -8
Reversibility	Find two fractions whose sum is ⅝.	Find two integers whose sum is -11.
Flexibility	½ x ¾ ½ x ¾ ½ x ¼ How are these problems related?	-3 + -8 -4 + -8 -5 + -8 How are these problems related?
Generalization	If the factors of a multiplication problem are between 0 and 1, what can you predict about the size of the product?	Find two negative integers whose sum is negative. Find a positive integer and a negative integer whose sum is negative. Find two positive integers whose sum is negative. What do you notice?

RESULTS

Research Question 1

- The treatment group outperformed the comparison on the easyCBM (proximal measure) total score.
- The differences were statistically significant (p =.002).
- The Benjamani-Hochberg procedure did not alter the pattern of significant findings.
- Means and standard deviations for the posttest (*M, SD*), *f* and *p* values, and the effect size (Hedges' *g*) are provided in Table 3.

Research Question 2

- Results were less favorable. No significant differences were found between groups for the GMADE (distal measure).
- Means and standard deviations for the posttest (*M, SD*), *f* and *p* values, and the effect size (Hedges' *g*) are provided in Table 3.

Table 3
Comparison of Treatment and Control Groups

Measure	Group	Posttest *M*	Posttest *SD*	*f*	*p*	Hedges' *g*
easyCBM	Treatment	11.77	3.75	14.11	000	.32
	Control	10.48	4.31			
GMADE	Treatment	18.24	5.63	2.45	.119	.08
	Control	17.79	6.21			

DISCUSSION

- Students in the treatment condition demonstrated statistically significantly higher scores than comparison students on the easyCBM Total Score.
- The results demonstrated that seventh-grade students with mathematics difficulties can benefit from integers instruction that includes instructional elements from the special education and mathematics education disciplines.
- Instructional features included modeling with think-alouds, multiple opportunities for practice, checking for understanding, error correction and reinforcement, and progress monitoring and student graphing.
- Lessons included opportunities for students to communicate mathematically and explore other ways to solve problems, in addition to mathematical features such as reversibility, flexibility, and generalization.
- Limitations included some classes having students with severe mathematics difficulties who exhibited chronic behavior problems and the small return of consents.
- Future research should focus on how enhancements in algebra can translate to improved performance in other mathematical areas.