The Effects of Comprehension Strategy Instruction on English Language Learners' Word Problem Solving Skills

Michael J. Orosco, PhD

Associate Professor (Special Education)

KU THE UNIVERSITY OF KANSAS

Rock Chalk, JAYHAWK!

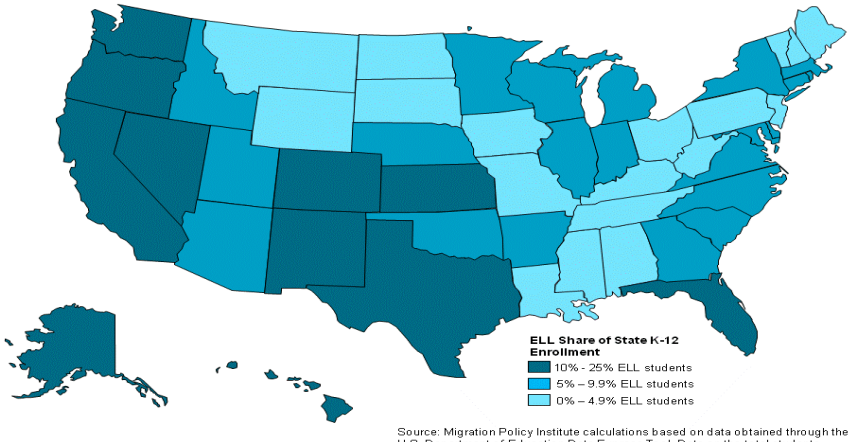
Comprehension Check

- Switzerland put one stone in the middle and piled guards in front of it before Swedish second Catharine Lindahl took out two stones with one shot to get the edge back. With her first stone, Swiss skip Mirjam Ott curled her rock around a guard, but it didn't get inside the Swedish rock that was sitting on the lip of the red 4-foot circle. Norberg cleared one of the stones away from the front so she would have a clean shot at the target, or house, if she needed it. If Norberg could convert with the hammer, the gold medal was theirs. They called timeout. The crowd made some noise. And then it fell quiet again. Norberg pushed out of the hack and let the rock slide. It bounced first off one yellow-handled Swiss rock and then the other, clearing them out of the scoring zone. As it came to rest in the white 8-foot circle - alone in the house - the Swedes celebrated.

Background Information

- About 4.85 million students enrolled in public schools were not yet fully proficient in English in the 2012-2013 school year, representing nearly 10 percent of the total public school student enrollment (U.S. Department of Education National Center for Education Statistics (NCES), 2015).
- Spanish-speaking ELLs make up a large percentage (73.1%) of the ELL population (Batalova & McHugh, 2010), and represent a substantial number of students who do not demonstrate proficiency in mathematics.

States with the Highest ELL Student Density, SY 2012-2013



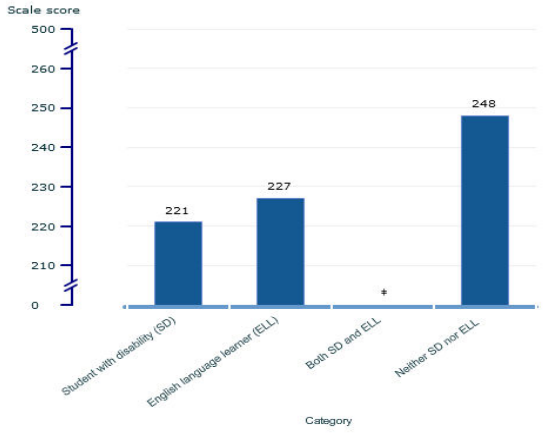
Source: Migration Policy Institute calculations based on data obtained through the U.S. Department of Education Data Express Tool. Data on the total students enrollment derive from the Common Core of Data (CCD). Data on enrollment of ELL students by state derive from the Consolidated State Performance Report (CSPR).

Program for International Student Assessment (PISA)

- In 2012, the American public school student received about 250 minutes of math instruction a week.
- Less than 50% of American students are exposed to algebraic type word problems during math instruction.
- The difference in exposure between advantaged and disadvantaged students to problem solving tasks is even larger and is statistically significant in all countries and economies except three countries (e.g., Macao-China, Liechtenstein, and Shanghai-China).

4th Grade Math Scores for ELLs

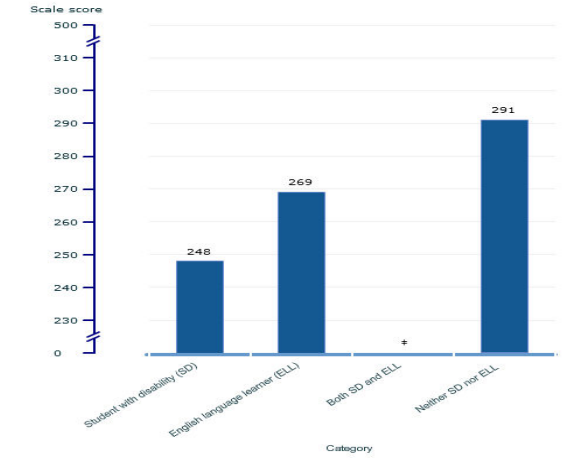
Average scale scores for mathematics, grade 4 by student disability or English Language Learner status [SDELL] for year and jurisdiction: 2015
2015, Kansas



‡ Reporting standards not met.
NOTE: The NAEP Mathematics scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Mathematics Assessment.

8th Grade Math Scores for ELLs

Average scale scores for mathematics, grade 8 by student disability or English Language Learner status [SDELL] for year and jurisdiction: 2015
2015, Kansas



+ Reporting standards not met.
NOTE: The NAEP Mathematics scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Mathematics Assessment.

Problem Solving

- The teacher of mathematics has a great opportunity. If he fills his allotted time with drilling his students with routine operations he kills their interest, hampers their intellectual development, and misuses his opportunity. But if he challenges the curiosity of his students by setting them problems proportionate to their knowledge, and helps them to solve their problems with stimulating questions, he may give them a taste for, and some means of, independent thinking (Polya, 1973).

Word Problem Solving (WPS) Challenges

(a) a limited working knowledge of comprehension strategies (e.g., making connections, questioning, inferring, and determining importance);

(b) a limited working knowledge of how to use and apply comprehension strategies within a word problem's concepts, tasks, and terminology; and

(c) the lack of affirmation and use of rich, linguistic knowledge (i.e., topics and the related terminology, phrases, and concepts that are unique to math content) in math text-related learning, particularly word problems.

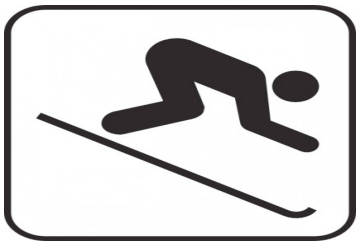
Conceptualizing WPS

- Part 1. Word problem reading involves the translation of printed words into verbal input (e.g., linguistic processing) involving both accuracy and efficiency.

- Part 2. Comprehension (e.g., abstract-problem representation) reflects the cognitive processes, math skills, and knowledge involved in understanding word problem information and translating this into a written statement for solution.

Word Problem Solving Challenges

"Thomas bought a new pair of **skis** for $350. He **put $110 down** and received a **student discount** of $30. His mother gave him **1/2 of the balance** for his birthday. **How much** does he **owe**? Please explain your answer."



Direct Instruction

Teacher: Well if Thomas bought skis for $350 (which is a good deal) and he **puts down** $110.00 and received a **student discount** of $30.00 ($350-110.00-30.00=$210.00). He should owe $210.00. [Students are sitting quietly listening. Some are playing with their pencil sharpeners.]

Teacher: So if his **balance** is $210.00, and his mom gives him **50% of the balance** ($210.00 x ½ = $105). He **owes** $105.00. [Students are asked to work on independent problems. Although the students are observed working at their desks passively (well-behaved), many of the word problems that were assigned were solved incorrectly or never completed.]

Teacher: "There is just too much math needs to help everyone on a daily basis. I do well teaching them how to setup the problem solving such as calculation with numbers, but when it comes actually making them comprehend word problems I struggle."

Building Evidence Based Practices

- **Recommendation 1:** Teach a set of academic vocabulary words intensively across several days using a variety of instructional activities. (Strong)
- **Recommendation 2:** Integrate oral and written English language instruction into content-area teaching. (Strong)
- **Recommendation 3:** Provide regular, structured opportunities to develop written language skills. (Weak)
- **Recommendation 4:** Provide small-group instructional intervention to students struggling in areas of literacy and English language development. (Moderate)

http://ies.ed.gov/ncee/wwc/PracticeGuide.aspx?sid=19

Explicit Instruction

- (a) verbal strategies that teach conceptual understanding of concepts and principles of word problems…
- (b) instructional strategies designed to create a connection between verbal input and conceptual understanding by creating a mental model…
- (c) instructional feedback with student collaboration and verbalization with the problem solving process…

My Research

- My research investigates whether strategies directed toward comprehension within word problems improve solution accuracy in ELLs at risk for math learning difficulties (MLD).

- Research Question : Do strategies focused on comprehension within word problems facilitate solution accuracy for English Language Learners students at risk for math learning disabilities?

Method

- Seventy-eight ELL children 78 (42 boys, 36 girls) at risk for MLD from 18 third-grade U.S. elementary classrooms participated in this study, and were assigned to treatment (n = 48) or control (n = 30) condition within each classroom.
- ELLs were defined as students who spoke Spanish as their native language, and were identified as coming from Latin American descendants (e.g., Latino), and who were in the process of acquiring English as a second language, and/or who were fully bilingual, and/or who were English dominant.

Identification of ELLs at risk for MLD

- (a) teacher recommendation for intervention based on students who had continued to experience word-problem-solving challenges, and who had not responded well to general math instruction, district and state mandated tests over a three year period;
- (b) students who had performed in the lower 25th percentile on standardize word problem solving achievement measures (e.g., Test of Mathematical Abilities; see pre and posttest measures section for a description); and
- (c) Spanish spoken as their native language, as determined by the school's home language survey; and
- (d) parent consent.

Pretest-Post Test Control Group Design

Random Assignment	Pretest	Treatment	Post Test
Experimental Group *(Comprehension Strategy Instruction)*	T_1	X_b	T_2
Control Group (General Education)	**GE**	**Business as Usual**	**GE**

Measures

- **Calculation Ability**: the Wide Range Achievement Test-Third Edition (WRAT; Wilkinson, 1993) and the numerical operations subtest for the Wechsler Individual Achievement Test (WIAT; Psychological Corporation, 1992)
- **Problem Solving Ability:** Test of Mathematical Abilities (TOMA; Brown, Cronin, & McIntire, 1994), KeyMath (Connolly, 1998), and the Story Problem subtest from the Comprehensive Mathematical Abilities Test (CMAT; Hresko, Schlieve, Herron, Swain, & Sherbenou, 2003).
- **Reading Comprehension**: Test of Reading Comprehension (TORC-4)-Passage Comprehension (Brown, Hammile, & Wiederholt, 1995).

Tier 2 Intervention

- This study's treatment model supplemented general education math teaching by providing small-group instruction (3-5 students per group) to the intervention group.
- Word problem types (e.g., joining problems, separating problems, part-part-whole problems, and comparing problems) followed those used in the general-education curriculum).
- Each participant received a booklet of twenty lessons (Cronbach's = .77) consisting of five word problems per lesson from the general education curriculum.
- Students in the treatment condition received intervention by trained tutors for "30 minutes" twice a week for a period of 10 weeks, for a total of "20" lessons.
- Students in the control condition received general-education instruction only.

Intervention Fidelity

- Tutors participated in a 4-hr training session.
- Each tutor received training administering all “20” scripted lessons during this training (via and practice delivering lessons during lessons to other tutors and the project director).
- Tutors had to meet mastery criteria (90% or better on a 10-item fidelity rubric checklist) prior to administration of intervention.
- The research team observed tutors (every 5-7 lessons or 17.5% of total study) at randomized lesson time points using a 10-item fidelity rubric checklist.
- This checklist covered all categories of the lesson intervention implementation.
- Mean implementation fidelity of the intervention was 95.75% with additional training provided to any tutor who fell below 90%.

Intervention Procedure (cont.)

- **Restatement of the Question**: The teacher reads the word problem aloud and models finding the question and understanding what the question was about. Next, students were asked to restate the question and to think about (i.e., develop a mental model) through teacher verbalization what the question was asking. [Students wrote down the question in a full sentence in their notebook.]
- **Relevant information.** Students are shown how to find and understand relevant information (e.g., numbers and vocabulary) that was needed to comprehend and solve the word problem. By finding relevant information related to word problems students were taught to activate background knowledge (i.e., relating what was in the word problem to other problems they may have practiced). [Students wrote down relevant information in their notebook.]

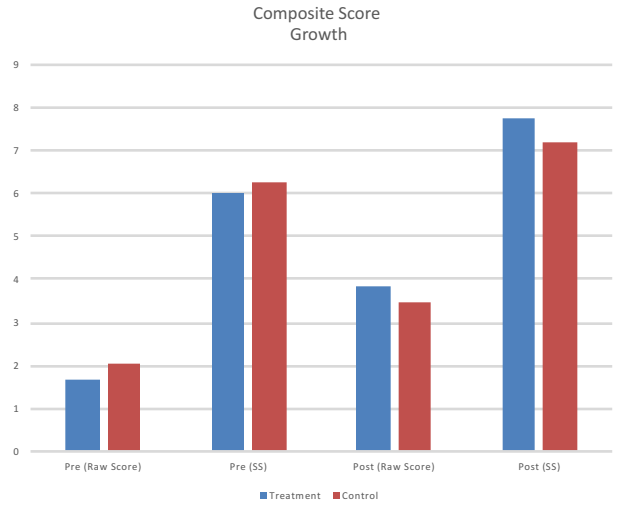
Intervention Procedure

- **Irrelevant information.** Also, the teacher showed students how to find and understand irrelevant information (e.g., sentences) that was not needed to solve the word problem. This step allowed students to determine the importance of the information they were reading, and analyze nonessential information. [Students wrote down irrelevant information in their notebook.]
- **Collaboration for solution.** Finally, students spent time collaborating (in pairs) for accuracy and practicing applying the aforementioned steps to word problems for solution.
- **Independent practice.** The independent practice phase of the lesson directed students to solve three word problems, similar in difficulty to the previously modeled and guided practice word problems. The time allocation for independent practice phase was 15 min.

Lesson Example

- Refer to Teacher Lesson Script and Student Lesson Examples

Problem Solving Improvement



*Pretest PS scores were below average for both groups.

*Posttest PS for treatment group improved more than control group (an increase in raw scores 1.69 to 3.84; or scale score from 6.02 to 7.78 for treatment)

*Hedges' G: 0.22 for CSI condition

Pushing the Field Forward

- The findings from this study support the use of comprehension strategies for improving word problem solving performance in ELLs at risk for MLD.
- In particular focusing on relevant language and providing collaborative support significantly improve word problem solving solution.
- More research is needed in understanding how ELLs' word problem solving skills can be improved through comprehension strategy training.

References

- Please contact author for list of references at mjorosco@ku.edu

- Thanks!