ASK A REL Response

Language and Mathematics
August 2013

Background

REL Southwest received a request for information seeking research to specifically address the belief that mathematics is so divorced from language as to lend itself to instruction in a "universal language" that may not be understood by the students.

Search of Databases and Websites

Institute of Education Sciences (IES) website (www.ies.ed.gov)

ERIC database (www.eric.ed.gov)

EBSCO's Academic Search Elite database

SEDL website (www.sedl.org)

Keywords and Search Strings Used in the Search

(Bilingual education OR bilingual students OR second language acquisition OR universal language OR native language OR English language learners) AND (math)

Criteria for Inclusion

REL Southwest selected the following resources that provide research on teaching math to English language learners (ELL) based on:

- State applications
- Classroom strategies
- Professional development for teachers

Results were further narrowed by the following factors:

Date of the Publication: The most current information (published from 2008 to the present) was included, except in the case of one 2005 publication from a publisher nationally known for covering education issues.

Source and Funder of the Report/Brief/Article: Priority was given to publications written by prominent authors or produced by well-known organizations in the field of English Language Learners. Most materials selected are readily accessible and free of charge on the Internet. The only four articles included that directly mention "universal language" are from resources that are not available free of charge on the Internet and are listed under Classroom Strategies.

State Applications

Flores, S. M., Batalova, J., & Fix, M. *The educational trajectories of English language learners in Texas.* (2012). Washington, DC: Migration Policy Institute, 35 pp. http://www.migrationpolicy.org/pubs/TexasELLs.pdf

From the ERIC abstract: About 5.3 million English Language Learners (ELLs)--students whose primary language is not English and whose English language skills are not sufficient to keep up with classes conducted only in English--are enrolled in PK-12 public schools across the United States. The number of these students increased dramatically in ten years, from 3.5 million in the school year (SY) 1998-99 to 5.3 million in 2008-09, reflecting broader national demographic and immigration trends. One in nine of today's public school students face the task of learning English. The educational outcomes for these students can either translate into a more productive, multilingual workforce or higher levels of academic failure and dropouts, with the attendant social costs. As the number and share of such students have grown over time, so has public interest and policymakers' attention to their educational outcomes, fueling debate over the most effective methods of language instruction for ELLs. The "No Child Left Behind" (NCLB) Act of 2001, the most recent comprehensive federal education policy, requires states to assess English language proficiency and holds them accountable for ensuring that ELLs both learn English and acquire the same academic knowledge as their English-speaking peers. Following enactment of the NCLB Act, states have paid greater attention to ELLs as a group, yet data limitations often constrain educators and policymakers from determining how well these students are doing in school compared with their English-speaking peers. To answer this question--at least in part--the authors have focused on Texas, the state with the second-largest number of ELL students in the nation (about 832,000 ELL students in 2011, behind California's 1.1 million). To do so, the authors use a unique longitudinal data set obtained from the University of Texas at Dallas Education Research Center (UTD-ERC) that tracks ELL and non-ELL students in Texas from the first grade through high school graduation and into their postsecondary careers. They analyze the performance and trajectories of several groups of students. One group is composed of students who entered Texas public schools as first graders in 1995 and who advanced through school, reaching the 12th grade "on time" in 2006. They refer to this group throughout the report as the "on-time cohort" (or "cohort" for short). It includes students who have ever been classified as ELLs ("ever-ELLs") and those who have never been ("non-ELLs"). The authors' analysis highlights substantial differences in test scores of ever-ELL students in the cohort by race and ethnicity; Asian students are the top-performing group, followed by white and then by Black and Hispanic students. Asian and white on-time cohort students who were ever classified as ELLs were almost as likely to graduate from high school as their non-ELL counterparts, while Black ever-ELLs were "more" likely to graduate.

Garcia, E. E., Lawton, K., & Dinez de Figueiredo, E. H. (2010). *The education of English language learners in Arizona: A legacy of persisting achievement gaps in a restrictive language policy environment.* Los Angeles, CA: The Civil Rights Project/ Proyecto Derechos Civiles, 16 pp. http://files.eric.ed.gov/fulltext/ED511328.pdf

From the ERIC abstract: This report reviews achievement gaps in both reading and math between ELL and non-ELL students in Arizona over the post-Proposition 203 period 2005-2009 and during the first year of implementation of the 4 hour ELD block,

2008-09. The study finds that Arizona has made little to no progress in closing the achievement gap between ELL and non-ELL students during this period. It also compares achievement gaps in reading and math over the same period between Arizona and Utah and Washington DC, two educational entities with vastly different spending policies. Here, the study argues that, notwithstanding changes in tests and proficiency thresholds in the states over this period of time, the relative position of Arizona vis-a-vis these comparison entities remains very similar, with Arizona continuing to lag behind both in percent of ELL students achieving proficiency in reading and math. The study concludes that Arizona is on the wrong path for closing achievement gaps for its ELL students and that this is due, at least in part, to its highly restrictive language instruction policies.

Classroom Strategies

Burchinal, M., Field, S., Lopez, M. L., Howes, C., & Pianta, R. (2013). *Instruction in Spanish and outcomes for pre-kindergarten English language learners* (Research Brief). http://files.eric.ed.gov/fulltext/ED544023.pdf

From the ERIC abstract: This study examined associations between classroom quality, amount of instruction in Spanish, and academic learning of Spanish-speaking 4 years-olds. Findings suggest that gains in reading and math were larger when children received more instruction in Spanish in classrooms with more responsive and sensitive teachers. It is possible that instruction in Spanish in high-quality classrooms may enhance the academic skills for children with limited English.

Cavanagh, S. (2005, July 13). Math: the not-so-universal language. *Education Week*, *24*(42), 1, 22. 2p. *Note: We were unable to locate a link to the full-text version of this resource. Although we typically limit our referrals to publicly available resources, based upon the abstract, we determined that this resource may be of interest to you. It may be found through university or public library systems.*

From the ERIC abstract: Abstract: In this article, the author discusses the problems faced by the students of non-English languages while they are studying mathematics in the U.S. While math has long been regarded as a **universal language** because of its foundation in numbers, the subject poses nearly as many hurdles for students with limited English as lessons that rely more heavily on reading, many educators say. That issue has gained renewed attention under the federal No Child Left Behind Act, which requires schools and districts to test students annually in both reading and math in grades 3-8 and one in high school and make yearly progress in those subjects. In addition, the law requires schools and districts to report separately the scores of English-language learners, a provision that many observers say has brought new scrutiny to the needs of that population.

Hansen-Thomas, H. (2009). Reform-oriented mathematics in three 6th grade classes: How teachers draw in ELLs to academic discourse. *Journal of Language, Identity, and Education, 8*(2-3), 88-106. *Note: We were unable to locate a link to the full-text version of this resource. Although we typically limit our referrals to publicly available resources, based upon the abstract, we determined that this resource may be of interest to you. It may be found through university or public library systems.*

From the ERIC abstract: Traditionally, mathematics has been considered easy for English language learners (ELLs) due to the belief that math is a "**universal language**." At the same time, reform-oriented mathematics curricula, designed to promote mathematical discourse, are increasingly being adopted by schools serving large numbers of ELLs. CMP, the Connected Math Project, is one such reform-oriented curriculum. Taking a community-of-practice approach, this article compares how three 6th grade mathematics teachers in a Spanish/English community utilized language to draw ELLs into content and classroom participation. Teacher use of standard language fell into 2 categories: (a) modeling and (b) eliciting student practice. In the teacher's class that regularly elicited language, ELLs were successful on academic assessments; whereas students in the other 2 classes were not. Results suggest that CMP facilitates ELLs' learning and that a focus on mathematical language and elicitation benefits the development of mathematical discourse and content knowledge.

Molina, C. (2012). *The problem with math is English: A language-focused approach to helping all students develop a deeper understanding of mathematics*. San Francisco, CA: Jossey-Bass, 304 pp. http://www.sedl.org/pubs/catalog/items/ms108.html

From the SEDL abstract: Published by Jossey-Bass in partnership with SEDL, *The Problem with Math Is English* illustrates how students often understand fundamental mathematical concepts at a superficial level. Written to inspire aha moments, the book enables teachers to help students identify and comprehend the nuances and true meaning of math concepts by exploring them through the lenses of language and symbolism. Using this perspective, the author delves into such essential topics as multiplication, division, fractions, place value, proportional reasoning, graphs, slope, order of operations, and the distributive property.

Quiroz, B., & Gonzalez, G. (2012). *Research-based strategies for teaching social studies, science, and mathematics to ELs at the secondary level* (Texas Comprehensive Center Briefing Paper No. 9). Austin, TX: SEDL, Texas Comprehensive Center, 18 pp. http://txcc.sedl.org/resources/briefs/number_9/index.php

From the TXCC/SEDL abstract: It is difficult for secondary-level ELs to achieve academic success comparable to their non-EL peers because of linguistic challenges specific to secondary-level core-content areas, in addition to barriers faced by ELs in general. Some promising strategies for use in mathematics, science, and social studies are reported.

Russakoff, D. (2011, January). *PreK–3rd: Raising the educational performance of English language learners (ELLs)* (PreK–3rd Policy to Action Brief No. 6). Washington, DC: Foundation for Child Development. http://files.eric.ed.gov/fulltext/ED542859.pdf

From the ERIC abstract: In 1974, the United States Supreme Court ruled in "Lau v. Nichols" that 1,800 Chinese-speaking children in the San Francisco public schools were entitled to English-language instruction or other support to help them understand what was happening in their classrooms. Thirty-six years later, state and local responsibilities to public school children who do not speak proficient English fill an entire section of the federal Elementary and Secondary Education Act (Title III). But it is a matter of serious

national debate whether the vast apparatus born of "Lau" provides a "meaningful education" to the nation's now five million English Language Learners (ELLs). The No Child Left Behind Act (NCLB) holds every state, district, and school accountable for students' academic progress. It also revealed the extent to which schools have failed non-English-speaking students by requiring states and districts for the first time to disaggregate their reading and math scores on annual assessments. The large achievement gap has moved educators, scholars, and policymakers to try urgently to reverse decades of neglect, even as the scale of the challenge is growing exponentially. This brief spotlights major issues facing those taking up this challenge and offers them emerging policy solutions. The primary focus will be on the 75 percent of ELLs who speak Spanish, and who are believed by scholars to be at high risk for school failure.

Sato, E., Rabinowitz, S., Gallagher, C., & Huang, C.-W. (2010). *Accommodations for English language learner students: The effect of linguistic modification of math test item sets. Final report*. (NCEE 2009-4079). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, 204 pp. http://ies.ed.gov/ncee/edlabs/regions/west/pdf/REL_20094079.pdf

From the ERIC abstract: This study examined the effect of linguistic modification on middle school students' ability to show what they know and can do on math assessments. REL West's study on middle school math assessment accommodations found that simplifying the language--or linguistic modification--on standardized math test items made it easier for English Language learners to focus on and grasp math concepts, and thus was a more accurate assessment of their math skills. The results contribute to the body of knowledge informing assessment practices and accommodations appropriate for English language learner students. The study examined students' performance on two sets of math items--both the originally worded items and those that had been modified. Researchers analyzed results from three subgroups of students--English learners (EL), non-English language arts proficient (NEP), and English language arts proficient (EP) students. Key results include: (1) Linguistically modifying the language of mathematics test items did not change the math knowledge being assessed; (2) The effect of linguistic modification on students' math performance varied between the three student subgroups. The results also varied depending on how scores were calculated for each student; and (3) For each of the four scoring approaches analyzed, the effect of linguistic modification was greatest for EL students, followed by NEP and EP students. The report is structured as follows. Following an Executive Summary and a Study Overview, Chapter 2 describes the study design, sample selection and recruitment, item set development processes, and standardized administration procedures. Chapter 3 describes the implementation of the accommodation (linguistic modification), including discussion of considerations and methods for data analysis. Chapter 4 presents findings from data analyses. Chapter 5 summarizes and interprets key findings, describes study challenges, comments on implications of the findings, and offers recommendations for future research. Appendices include: (1) Power analysis for primary research questions; (2) Operational test administration manual; (3) Student Language Background Survey; (4) Guide for developing a linguistically modified assessment; (5) Workgroup training materials; (6) Overview and protocol for cognitive interviews; (7) Item parameter estimates for IRT models; (8) Descriptive statistics from four scoring approaches; (9) ANOVA findings across four scoring approaches; (10) Cross-approach comparisons; (11) Results of the

classical item-level analyses; (12) Summary of differential item functioning findings; (13) Exploratory factor analysis results; (14) Operational item set--original; and (15) Operational item set--linguistically modified.

U.S. Department of Education, Institute of Education Sciences, What Works Clearinghouse. (2012, June). *WWC review of the report: Accommodations for English language learner students: The effect of linguistic modification of math test item sets* (WWC Single Study Review). Washington, DC: U.S. Department of Education, Institute of Education Sciences, What Works Clearinghouse. http://ies.ed.gov/ncee/wwc/pdf/single_study_reviews/wwc_linguisticmod_061212.pdf

From the ERIC abstract: The research described in this report is a randomized controlled trial in which seventh- and eighth-grade students were randomly assigned to complete a set of 25 math questions delivered with either standard language or language that had undergone "linguistic modification" by the research team. The purpose of the study was to assess the effects of using "linguistic modification" as a way of removing language barriers for English language learners and non-English language learners struggling with reading. Nearly 3,000 students from 13 middle schools in five school districts in California were randomly assigned to complete traditional math assessments or math assessments that had undergone "linguistic modification." Researchers then examined the results for three subgroups of students: Spanish-speaking English language learners (EL), non-English language learners who were not proficient in English language arts (NEP), and non-English language learners who were proficient in English language arts (EP). Comparisons were made between students who took the modified test and those who took the non-modified test. The study found a positive effect on math scores for students struggling with English who completed the "linguistic modification" item set relative to similar students who did not. The estimated six percentage-point gain on math achievement is statistically significant. The study found neither statistically significant nor substantively important differences for EP students who took the modified test, relative to those who did not. The research described in this report meets the What Works Clearinghouse (WWC) evidence standards without reservations. Appended are: (1) Study details; (2) Outcome measures for each domain; (3) Study findings for the mathematics achievement domain; and (4) Subgroup findings for the mathematics achievement domain. A glossary of terms is included.

What can a mathematics teacher do for the English language learner? Strategies and examples developed by SEDL Texas Comprehensive Center (TXCC) staff along with participants from Texas regional education service centers attending the TXCC session Strategies for English Language Learners in Secondary Mathematics, September 28–29, 2006. http://txcc.sedl.org/resources/ell_materials/mell/

From the TXCC/SEDL abstract: This interactive document was developed during a professional development session, led by the Texas Comprehensive Center, for mathematics and ESL specialists from the Education Service Centers in Texas. The first four links at the side of this page relate to ELLs' proficiency with the English language. The Student Language Proficiency levels, developed by the Texas Education Agency, proceed from Beginner through Intermediate and Advanced and culminate with Advanced High. The associated pages show typical characteristics for students at each level, as well as suggested strategies for teachers working with students at the different

levels. The strategies were created by participants at the professional development session, based upon what they learned during the session and from their own experience. The second four links provide descriptions and examples of some key components to include when designing lessons that will be comprehensible for ELLs. They will help the students master the math content and, additionally, will help them to progress in their English language acquisition.

Whiteford, T. (2009, December). Is mathematics a universal language? *Teaching Children Mathematics*, *16*(5), 276-283. *Note: We were unable to locate a link to the full-text version of this resource. Although we typically limit our referrals to publicly available resources, based upon the abstract, we determined that this resource may be of interest to you. It may be found through university or public library systems.*

From the ERIC abstract: Effectively teaching mathematics to speakers of other languages requires teachers to recognize, validate, honor, and support the math that these students have already learned before entering a U.S. classroom. To do so, they must become aware of procedures, types of math instruction, and students' current performance levels. They should be sensitive to cultural math differences that students may be experiencing. They need to make careful decisions as to whether students can continue to use procedures that differ from those taught in U.S. classrooms. They must take care not to assume that a student encountering difficulties in mathematics does so because of limited language proficiency. Once they have considered these issues, teachers can then identify and implement ways of modifying, adapting, or differentiating classroom experiences. In addition to the sample ideas and strategies identified in this article, more extensive strategies exist, such as sheltered instruction. Most of all, teachers ought to celebrate the diversity that English Language Learners bring to U.S. mathematics classrooms: other cultures' numbers, mathematical games, different number bases, and mathematical procedures. Recognizing cultural aspects and variations will help everyone better appreciate the multidimensional nature of mathematics.

Wolf, M. K., Kim, J., Kao, J. C., & Rivera, N. M. (2009). *Examining the effectiveness and validity of glossary and read-aloud accommodations for English language learners in a math assessment* (CRESST Report 766). Los Angeles, CA: National Center for Research on Evaluation, Standards, and Student Testing (CRESST), 69 pp. http://files.eric.ed.gov/fulltext/ED507754.pdf.

From the ERIC abstract: Glossary and reading aloud test items are often listed as allowed in many states' accommodation policies for ELL students, when taking states' large-scale mathematics assessments. However, little empirical research has been conducted on the effects of these two accommodations on ELL students' test performance. Furthermore, no research is available to examine how students use the provided accommodations. The present study employed a randomized experimental design and a think-aloud procedure to delve into the effects of the two accommodations. A total of 605 ELL and non-ELL students from two states participated in the experimental component and a subset of 68 ELL students participated in the think-aloud component of the study. Results showed no significant effect of glossary, and mixed effects of read aloud on ELL students' performance. Read aloud was found to have a significant effect for the ELL sample in one state, but not the other. Significant interaction effects between

students' prior content knowledge and accommodations were found, suggesting the given accommodation was effective for the students who had acquired content knowledge. During the think-aloud analysis, students did not actively utilize the provided glossary, indicating lack of familiarity with the accommodation. Implications for the effective use of accommodations and future research agendas are discussed. Three appendices are included: (1) Example of Read-Aloud Script; (2) Glossary Terms Used in Math Test; and (3) The Five Think-Aloud Items.

Professional Development for Teachers

Casteel, C. J., & Ballantyne, K. G. (Eds.). (2010). *Professional development in action: Improving teaching for English learners*. Washington, DC: National Clearinghouse for English Language Acquisition & Language Instruction Educational Programs, 140 pp. http://files.eric.ed.gov/fulltext/ED512636.pdf

From the ERIC abstract: This monograph showcases professional development projects by school districts and colleges of education that train teachers to work successfully with English learners (ELs) across the nation. The papers presented in this monograph offer real-life examples of successful and innovative practices, including institutionalized mentoring programs, new classroom methodologies, best practices for ELs with disabilities, collaboration between colleges of education and school districts, and the evaluation of PD programs. This monograph contains the following articles: (1) Professional Development in Action: Introduction; (2) The National Professional Development Program (Cynthia Ryan and Ana Garcia); (3) Guidelines for Professional Development: An Overview (Judith Wilde); (4) Facts, Figures & Further Resources; (5) Coaching and Mentoring in Practice (Mariana Castro); (6) Measuring the Effectiveness of an ESL Coaching Model (Annela Teemant); (7) Coaching and Implementation Level of English Language Learner Strategies in Teacher Practice (Janet Penner-Williams and Diana Gonzales Worthen); (8) Providing Teachers with Strategies and On-Going Support for Teaching English Language Learners At-Risk (Ramona Stowe); (9) Collaborative Mentoring among K-12 Teachers: Professional Development on the Effective Instruction of English Language Learners (Susan Spezzini and Julia S. Austin); (10) Satisfying Conclusion to a Five-Year Grant (Kristin Lems); (11) Content and Language: A Critical Overview (Phyllis Jacobson); (12) The Academic Literacy for All Project: A Professional Development Model (Holbrook Mahn and Melissa Bruce); (13) Meeting the Professional Development Needs of Teachers of ELLs (Carol Bearse); **(14) Math ACCESS: Building Mathematical Proficiency in Linguistically Diverse Schools (Mary Truxaw and Megan Staples)**; (15) Curriculum Mapping to Support the Linguistic and Academic Development of K-6 ELLs (Linda Roth, Lisa Sells-Asch and Andrea Honigsfeld); (16) Professional Development for Teaching ELLs with Disabilities (Laurene L. Christensen, Kristin Kline Liu, and Martha L. Thurlow); (17) The Role of Professional Development in Helping English Learners with Disabilities Achieve High
Standards (Jana Echevarria); (18) BiSped: Filling a Critical Shortage Area (Julie Esparza Brown and Bruce Miller); (19) School-University Collaborations for Culturally and Linguistically Diverse Students (Socorro Herrera and Kevin Murry); (20) Collaboration is the Key to Successful Professional Development: The STEP T for ELLs Program in Maryland (Joan Kang Shin, Lori Edmonds and Christopher Browder); (21) Professional Development in Eastern North Carolina: Collaboration in ESL (Diane Rodriguez and Jane Manner); (22) Project ESOL MIAMI: Infusing the Teacher Education Curriculum to Address the Needs of English Language Learners (Martha E. Castaneda, Amy E.

Fisher-Young and Bruce E. Perry); (23) Collaboration in Professional Development for ELL Content Achievement (Ye He and Kathryn Prater); (24) National Professional Development Project for Secondary Content Teachers of English Language Learners (Holly Hansen-Thomas and Pat Casey); (25) A Conversation with Thomas R. Guskey; (26) Quality Teacher Preparation for ELLs: Preliminary Findings from Florida (Maria R. Coady, Ester J. de Jong and Candace Harper); (27) Increasing Accountability in the Preparation of Teachers to Work with English Learners: The Teacher Education English Learner Survey (TEELS) (Nadeen T. Ruiz and Albert Lozano); (28) Project EXCELL (Laureen Cervone); (29) Implementing an English as a Second Language Institute in Higher Education (Maria G. De la Colina and Barbara Davis); and (30) Abstracts from 2007 National Professional Development Grantees.

De Oliveira, L. C. (2011, Fall). In their shoes: Teachers experience the needs of English language learners through a math simulation. *Multicultural Education, 19*(1), 59–62. http://files.eric.ed.gov/fulltext/EJ986899.pdf

From the ERIC abstract: Given the increase in the number of culturally and linguistically diverse students in American schools, it is vital for teacher education programs to address the needs of English Language Learners (ELLs) in their courses. Mainstream, general education teachers who did not previously experience this student population in their classes are now seeing high numbers of ELLs among their students. Therefore, all teachers, not just specialist English as Second Language (ESL) or bilingual professionals, need to be prepared to work with ELLs (Lucas & Grinberg, 2008). Teachers' attitudes and beliefs about ELLs can be influenced by their lack of empathy for these students' experiences and backgrounds. Many pre-service and inservice teachers need not only to learn strategies to work with ELLs but also to feel what it is like to be language learners themselves. This article describes a math simulation activity in Brazilian Portuguese designed to increase teachers' awareness of what learners feel when they are immersed in a language they do not understand. This simulation has been utilized in K-12 ESL methods courses and in professional development programs in Indiana. The author contextualizes the simulation through reflection questions that teachers address in their discussion after the simulation. As a way to demonstrate how teachers have engaged in the simulation and developed more empathy for ELLs, this article includes excerpts from teachers' reflections, collected over four years in different contexts.

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