Published in final edited form as:

Learn Disabil Q. 2019 November ; 42(4): 244–251. doi:10.1177/0731948719827489.

The Mathematical Performance of At-Risk First Graders as a Function of Limited English Proficiency Status

BrittanyLee N. Martin, M.Ed., Lynn S. Fuchs, PhD.

Vanderbilt University

BrittanyLee N. Martin: brittanylee.n.martin@vanderbilt.edu; Lynn S. Fuchs: lynn.s.fuchs@vanderbilt.edu

Abstract

The purpose of this study was to explore interactions between limited English proficiency (LEP) status, as a function of risk status (low math performance at the start of the school year), on computation and word-problem solving performance. Among 260 1st-grade students, classified as at-risk (AR) or not at-risk (NAR) for math disability, we compared the performance of LEP students to native English-speaking peers. A series of 2-way ANOVAs were conducted on computation and word-problem solving skill at 2 time points, fall and spring of 1st-grade. On fall computation measures, there was no main effect for LEP status and no interaction between LEP and risk status. On spring computation, a main effect for LEP status had emerged, but again no interaction. By contrast, on fall word-problem solving, there was an interaction between LEP and risk status; however, this interaction was no longer significant by spring. Results suggest that language proficiency is an important factor in the development of computation and word-problem solving skill. Implications for future research are discussed.

Keywords

risk for math disability; limited English proficiency; computation; word-problem solving

In 1990, only 1 in 20 public school students were English learners (ELs). In the 2014–2015 school year, approximately 1 in 10, or an estimated 4.6 million students, were EL (National Center for Educational Statistics, 2017). With ELs comprising a substantial portion of the public-school population, the academic achievement gap between ELs and native English speakers persists. For all years with available data since 1996, the National Assessment of Educational Progress reports the scores of EL students at grades 4 and 8 are consistently lower than their native English-speaking peers (NAEP, 2015). In 2015, the average mathematics score for fourth-grade EL students was 25 points below that of native English-speaking peers; in eighth-grade, 38 points lower than native English-speaking peers. At the same time, the growing EL population means that mathematics achievement in U.S. schools will increasingly depend on the achievement of EL students (Larazin, 2006). It is not surprising, therefore, that interest in decreasing this gap and improving the mathematics skills of EL students has become a topic of vigorous discussion and activity in U.S. schools.

The reasons for this growing achievement gap are not clearly understood. Previous work has found that the use of language-heavy assessments likely masks the numerical knowledge of ELs (Salillas & Wicha, 2012). Other work has shown that ELs perform worse on problems requiring high levels of linguistic demands compared to problems requiring the same math computations with simpler language (Abedi & Lord, 2001). A powerful link between oral language abilities and mathematical development is well established, not only in the development of calculation skills (Dehaene, Spelke, Pinel, Tsivkin, 1999; Gordon, 2004; Powell, Driver, & Fall, 2017; Purpura & Ganley, 2014) but also in the development of word problem solving ability (Fuchs, Gilbert, Fuchs, Seethaler, & Martin, 2017). Yet, many educators continue to believe that mathematics is solely based on the understanding of numerals and symbols (Janzen, 2008) and that English proficiency is not prerequisite for understanding and achieving in math (Lee & Jung, 2004).

Contrary to this belief, mathematics depends on language demands (Cavanagh, 2005). Although many students struggle to make sense of the numerals and symbols, EL students often face additional comprehension obstacles related to the conventions of the English language (e.g., verb phrase, conditional clauses, and question phrases), the increasingly difficult mathematics vocabulary involved, and the language structure of mathematics word problems (Abedi, Lord, & Plummer, 1997). However, teachers rarely allocate sufficient instructional time to the development of mathematical vocabulary, thereby hindering student access to other aspects of mathematics instruction (Monroe & Orme, 2002).

Mathematics is more than just numbers. Effective math instruction involves terminology and concepts, oral and written instruction for tasks, and the language used during classroom instruction. Although some students may appear to have English proficiency because they can participate in simple conversation, they have only mastered a conversational level of English and are yet to develop competence with academic language. Academic language can be abstract, complex, and challenging for English language learners and ELs face the challenge of learning the English language while learning academic content in their non-native language. Studies show that it takes between 5 and 7 years for ELs to develop mastery of academic English language (Hakuta, Butler, & Witt, 2000). While developing this language, it is challenging for them to learn at the same rates as native English speakers when instruction is offered only in English (Abedi, Herman, Courtney, Leon, & Kao, 2004).

With limited understanding of the technical language of mathematics and limited proficiency in English, ELs tend to rely heavily on their knowledge of algorithms to complete basic computations (Lee & Jung, 2004). Yet, progress on higher-level computations may suffer. Moreover, computational skill alone is not sufficient for advanced tasks such as word-problem solving (Fuchs, Fuchs, Compton, Hamlett, & Wang, 2015; Fuchs et al., 2008). This is not surprising considering word-problem solving requires text processing to decipher the problem situation and an interaction between language comprehension processes and problem-solving strategies (Fuchs et al., 2015; Kintsch & Greeno, 1985).

At the same time, difficulties with language comprehension and problem solving are not unique to ELs. They are also common in other students at-risk for mathematics difficulty. Because mathematics and problem-solving delays tend to persist and become more

pronounced with time due to the cumulative nature of mathematics instruction (Baroody & Ginsburg, 1990), it is critical to identify differences in EL and native-English speakers' mathematics development early in the formal schooling process. Moreover, although studies have demonstrated that the cognitive abilities underlying word-problem solving and calculation skills differ (Fuchs et al., 2008), few studies have examined the extent of these differences in students with limited English proficiency (LEP) and whether students' initial risk status (at start of first grade) moderates this relation.

We hypothesized that LEP status would affect the mathematical abilities of at-risk (AR) as well as not-at-risk (NAR) students, but that the performance gap between LEP and native-English speakers would be more pervasive and severe for AR students. The purpose of this study was to explore the interaction between students' LEP status and mathematics risk status on two dimensions of early mathematical competency, computation and word-problem solving. To accomplish this purpose, we relied on data from an ongoing research project, exploring mathematical performance as a function of students' risk status (AR vs. NAR for mathematics difficulty), as a function of LEP status (LEP vs. native English-speaking peers). By examining these subcategories, we hoped to provide insight into how the achievement gap between LEP students and native English-speaking students emerges over first grade.

Method

Sampling

To address our research question, we analyzed data from a larger, ongoing research project. This larger project is being conducted in a southeastern metropolitan school district of approximately 75,000 students in the United States. Participants from this larger study were sampled from first-grade classrooms and stratified by risk status based on mathematics performance at the start of first grade. Of the 1,726 students with parental consent who completed the study screening measures, 462 students were considered AR for poor mathematics outcomes. An additional 239 students who were NAR for poor mathematics outcomes were included for follow-along purposes; these children did not receive any intervention. Because no true cut-point exists for academic risk, a latent class approach was used with the first cohort to derive the criterion for AR and NAR status by combining the screening scores across calculations and concept applications into a single latent factor. Latent variables, which are derived from structural equation models are not directly measured, and thus avoid measurement error (Cai, 2012). For the other cohort, the same cut-points were used for consistency. We also administered the two subtest Wechsler Abbreviated Scales of Intelligence (WASI; Wechsler, 1999). Because the study was not about intellectual disability, we excluded students if they scored below the 10th percentile on both subtests. In the larger study, three-quarters of AR students were randomly assigned to intervention; one-quarter to control.

Participants

For the present analysis, we included NAR students as well as AR control group students who did not move outside the reach of the study during first grade ($N = 260$). We did not

include AR students who received intervention, because intervention was designed to disrupt the natural course of development, which was the focus of this study. Fifty-three students met criteria as AR; 207 as NAR.

The sample of 260 children in this data set were from 118 first-grade classrooms in 25 schools. For these 260 students, the mean age was 6.52 years ($SD = 0.33$ months) in fall of first grade. Of the 260, 49% were female; 87% received subsidized lunch (i.e., qualified to participate in the federal program that provides lunch without charge or at reduced rates); 37% were African American, 30% non-Hispanic white, 26% white Hispanic, 3% Asian, and 4% other. Thus, the sample was representative of most urban centers in the United States.

LEP status was established using the district/state eligibility criteria, operationalized as a demonstrated lack of academic English language skills as measured by the World-Class Instructional Design and Assessment Placement Test (WIDA; Wisconsin Center for Education Research, 2014), a measure of English proficiency levels in listening, speaking, reading, and writing. As is common in most states, the amount of English language services a student is eligible to receive is commensurate with their score(s) on screening and placement tests. In the district where this study was conducted, students scoring less than five on any domain of the WIDA qualify for English language services. Students receiving a composite score of 3.6 or below receive a minimum of one hour of language services per school day (Tennessee Department of Education, n.d.). Students who were considered LEP but did not receive English language services during the course of the study (i.e., were in a transition phase having exited services) were excluded. The remaining LEP students ($n = 56$) were included in the analysis. See Table 1 for demographic data by risk status and by LEP status.

Measures

Screening measures to constitute the sample.—The *First-Grade Test of Computational Fluency* (Fuchs, Hamlett, & Fuchs, 1990) is a 25-item test sampling the typical first-grade computation curriculum: adding two single-digit numbers (9 items), subtracting two single-digit numbers (10 items), adding three single-digit numbers (2 items), adding two 2-digit numbers without regrouping (2 items), and subtracting a 1-digit number from a 2-digit number (2 items). Students have 2 min to complete as many items as possible. Staff entered responses into a computerized program on an item-by-item basis, with 15% of tests re-entered by an independent scorer. Data-entry agreement was 99.6. On a previous sample of first-grade students, α was .96 (Fuchs et al., 2013).

The *First-Grade Test of Mathematics Concepts and Applications* (Fuchs et al., 1990) is a 25-item test sampling the typical first-grade concepts/applications curriculum (i.e., numeration, concepts, geometry, measurement, applied computation, money, charts/graphs, word problems). The tester reads each item aloud. For 20 items, students have 15 s to respond; for 5 items, 30 s. Staff entered responses into a computerized program on an item-by-item basis, with 15% re-entered by an independent scorer. Data-entry agreement was 98.5%. On a previous sample of first-grade students, α was .94 (Fuchs et al., 2013).

The two-subtest *Wechsler Abbreviated Scale of Intelligence* (WASI; Wechsler, 1999) was administered as a measure of general cognitive ability. *WASI-Vocabulary* (Wechsler, 1999) requires students to identify objects in pictures (4 items) and construct definitions for words (remaining items). At ages 6–11, test stability is .85. *WASI-Matrix Reasoning* (Wechsler, 1999) measures a student's nonlinguistic reasoning abilities. For each item, students must select 1 of 5 items that complete a visual pattern. At ages 6–11, test stability is .79.

Measures to index calculation and word-problem performance.—Computation performance was measured using the *Test of Arithmetic Fluency* (Fuchs, Hamlett, & Powell, 2003), which comprises 25 addition problems with answers from 0 to 18, presented vertically on one page and 25 subtraction problems with answers from 0 to 18, presented vertically on one page. Students have 1 min to write answers on each page. The score is the number of correct answers. Staff entered responses into a computerized scoring program on an item-by-item basis, with all tests re-entered by an independent scorer. Data entry agreement was 100%. On a previous sample of first-grade students, α was .96 (Fuchs et al., 2013).

Story Problems (Jordan & Hanich, 2000) comprises 14 story problems involving sums or minuends of 9 or less, with change, combine, compare, and equalize relationships. The tester reads each item aloud; students have 30 s to respond and can ask for rereading(s) as needed. The score is the number of correct answers. A second scorer independently rescored all protocols, with agreement of 100%. On a previous sample of first-grade students, α was .86 (Fuchs et al., 2013).

First-Grade Vanderbilt Story Problems (Fuchs, Seethaler, & Craddock, 2013) is an 18-question assessment sampling combine, compare, and change word-problem types. Some problems include irrelevant information; some require graph reading to identify relevant information. All problems are read aloud to students, who have 1 min to construct a response. Students may ask for rereading(s) as needed. The score is the number of correct numbers and labels in answers. On a previous sample of first-grade students, α was .91 (Fuchs et al., 2013).

Procedure

Students were screened at the beginning of the school year on the *Test of Computational Fluency* and the *Test of Mathematics Concepts and Applications* in whole class settings. The *WASI* was administered individually. Students entering the study were administered the *Test of Arithmetic Fluency* and *Story Problems* individually in the fall and were administered the *Test of Arithmetic Fluency* and *Vanderbilt Story Problems* in small groups in the spring. Two different word-problem assessments were used to avoid the possibility of a ceiling on performance. We used *Vanderbilt Story Problems* in the spring because it tends to be more difficult than *Story Problems* and therefore avoids a ceiling effect. In the larger study, 20% of assessments were selected randomly and checked by an independent scorer for scoring accuracy. Agreement exceeded 99%. All data were double entered for verification.

Data Analysis and Results

Demographic Comparability

To check for relations between our subgroup categories and demographic variables, chi-square tests for independence were conducted. There was no significant relation between risk status and race, $\chi^2(1, n = 260) = 7.41, p = .116$; risk status and gender, $\chi^2(1, n = 260) = 1.60, p = .205$; or risk status and socioeconomic status, $\chi^2(1, n = 257) = 1.00, p = .317$. There was no significant relation between LEP status and gender, $\chi^2(1, n = 260) = 0.25, p = .619$. As might be anticipated, there was a significant relation between LEP status and race, $\chi^2(1, n = 260) = 146.34, p < .001$ and between LEP status and socioeconomic status, $\chi^2(1, n = 257) = 6.59, p = .005$.

Effects of LEP Status and Risk Status

Two-way between-group analysis of variance (ANOVAs) were conducted to assess interactions between risk (AR vs. NAR) and LEP status (LEP vs. native-English speaking) on computation and word-problem performance. Effect sizes (ESs) were calculated by subtracting means and dividing by the standard deviation (*SD*) of the NAR or the native-English speaking groups. See Tables 2 and 3 for means, *SD*s, and *ES*s.

On computation performance, we conducted two ANOVAs, one for fall and the other for spring performance. At fall, the main effect for LEP status was not significant, $F(1, 256) = 0.31, p = .576$, indicating the computation performance of LEP and native English-speaking students was comparable. The main effect for risk status was significant, $F(1, 256) = 63.39, p < .001$ ($ES = 1.33$), and the interaction effect between language status and risk status was not significant $F(1, 256) = 0.77, p = .382$. However, at spring, the main effect for LEP status was significant, $F(1, 256) = 5.48, p = .02$, with higher performance for native-English speakers than LEP students ($ES = 0.58$). The main effect for risk status remained significant, $F(1, 256) = 40.35, p < .001$ ($ES = 1.13$), and the interaction effect between LEP status and risk status again was not significant, $F(1, 256) = 1.03, p = .311$.

On word-problem solving, we again conducted two ANOVAs, one for fall and the other for spring performance (see Figure 1). At fall, the main effect for LEP status was significant, $F(1, 256) = 5.19, p = .023$: native English speakers' performance exceeded LEP students' performance ($ES = 0.66$). The main effect for risk status was significant, $F(1, 256) = 83.65, p < .001$ ($ES = 1.60$), and the interaction between LEP status and risk status was also significant, $F(1, 256) = 5.94, p = .016$, thereby superseding both significant main effects. Post-hoc analysis indicated no significant difference between AR LEP and native English speakers, $t(52) = -0.21, p = .838$ ($ES = -.06$). However, there was a significant difference between NAR LEP and native English speakers, $t(206) = 4.03, p < .001$ ($ES = 1.00$). At spring, significant main effects remained for LEP status, $F(1, 256) = 7.08, p = .008$, with stronger performance for native English speakers than LEP students ($ES = 0.64$), and for risk status, $F(1, 256) = 37.19, p = .001$ ($ES = 1.12$). Yet, the interaction between LEP status and risk status was no longer significant, $F(1, 256) = 2.03, p = .156$. Thus, the main effects favoring the performance of NAR over AR and favoring the performance of native English speakers over LEP students held without qualification.

Discussion

The purpose of this analysis was to examine the effect of LEP status on two dimensions of early mathematical competency understood to be impacted by oral language ability, while testing whether initial risk status (i.e., mathematics delays at start of first grade) moderates the effect of LEP. We anticipated a main effect for risk status on both computation and word-problem solving because students had been designated as at-risk for mathematics disability based on performance on screening measures that assessed computation as well as math concepts and applications. Findings on our fall computation and word-problem assessments corroborated the sample's risk status classifications with independent measures, administered approximately one month after screening for study entry had been conducted. *ESs* favored NAR over AR status with an *ES* of 1.33 on computation and 1.60 on word problems.

The effects of LEP status at the start of first grade were, however, more complicated. Although LEP students and their native-English speaking peers performed comparably on computation skill at the start of first grade, reliable differences at this time point favored the word-problem performance of native-English speaking students over those with LEP, with an *ES* of 0.64. This suggests that the effects of oral language ability manifest more clearly on mathematical word-problems than for calculation problems, which do not require students to decipher problem narratives, build problem models, and identify a number sentence before completing the calculation(s) necessary for problem solution. This echoes prior work showing that oral language ability is more involved in determining individual differences in first graders' word-problem development than in their development of calculation skills (e.g., Fuchs et al., 2008).

Yet, for word problems, the main effects of risk status and LEP status were further complicated (superseded) by an interaction between these two factors. At the start of first grade, the word-problem performance of AR learners with and without LEP was comparable (*ES* = -0.06). The main effect for LEP status was instead accounted for by the NAR children, for whom LEP status conveyed a clear disadvantage: The word-problem performance of NAR LEP students was reliably lower than of NAR native-English speakers, with a large *ES* of 1.00.

Thus, it appears that risk for math disability at start of first grade, identified via screening measures focused on calculations and general math concepts and applications (which included only a handful of word-problem items), overwhelmed the effects of LEP status specifically on word-problem performance. The two groups of AR students, with and without LEP, performed comparably poorly. By contrast, the effects of LEP status within the subgroup of NAR students were clear, with English-speaking students outperforming LEP students in both computation and word-problem solving.

Even so, by spring, the effects of LEP status were revealed on both dimensions of math performance, and these effects were no longer moderated by risk status on the word-problem outcomes. By the end of first grade, the main effect of LEP status produced similar *ESs* for calculations and word problems (0.58 and 0.64, respectively), favoring native-English

speakers over students with LEP. The initially comparable (uniformly low) performance on word problems for AR students with and without LEP at the start of year suggests that early intervention, beginning at the start of first grade, is critical in both populations of learners. The differentially low word-problem performance of AR LEP students compared to native-English speakers at the end of first grade suggests that word-problem intervention over the course of first needs to be more intensive and differentiated for AR LEP students to address their learning of a new language.

To understand the year-end achievement gaps between native English-speaking students and LEP students on word problems as well as calculations, it is important to consider the language of classroom mathematics instruction. The first-grade curriculum places an emphasis on developing number sense and providing students with strategies for successful computation. A typical mathematics lesson, even one focused solely on computation skill, is laced with academic language. A teacher may use the terms *subtract*, *take-away*, *minus*, and *less* interchangeably within a single lesson. For a student who has yet to develop adequate mathematics vocabulary, this will limit their access to instruction and academic gain, as seen by the growing ES in computation skills between LEP and native English-speaking students. The same is true for word-problem instruction, to the extent that explicit instruction on word problems occurs in first-grade classrooms.

By contrast, our NAR students had stronger foundational math skills, as revealed in higher performance on the screening assessments. These foundational skills served as a platform for new content and academic vocabulary, making classroom instruction more accessible. Because language ability is a consistent predictor of word-problem solving performance, it is possible the language and academic vocabulary presented within the word problems proved to be less of a struggle for the NAR students who likely had stronger language ability and little trouble understanding the language of word problems.

Implications for Practice

Findings have several implications for the field. Most notably, teachers and administrators should keep a watchful eye on mathematics development of English learners, even if they initially appear to possess adequate mathematics abilities. Our results show at the beginning of the school year, LEP students on average performed relatively well, with only a mild achievement gap between NAR LEP students and their native English speaking peers. However, by the end of the school year, these same LEP students had fallen further behind their native English speaking peers. This speaks to the accessibility of instruction for students who do not possess adequate language skills to comprehend the instruction. Therefore, they require mathematics instruction that systematically includes objectives aimed at developing the academic language necessary for success with particular skills. This instruction should provide students with multiple exposures to words using varied methods. While supporting the development of mathematics vocabulary, teachers should provide ample opportunities for students to hear unfamiliar words used in and out of the context of mathematics instruction. Teachers should also provide students with written exposure to new terms and encourage students to use these terms in their mathematical explanations. A firm

understanding of the academic vocabulary associated with mathematics is a vital precursor to later conceptual understanding.

Our findings also counter the position that mathematics is solely based on understanding of numerals and symbols and provide evidence that English proficiency is a prerequisite for understanding and achieving in math. Schools need to refocus mathematics instruction to ensure educators are attentive to the nuances and complexities within the academic language of mathematics and that this is especially the case for LEP students at-risk for mathematics disability due to early mathematics delays. In recent years, there has been a reformative effort to increase the complexity of mathematics and to provide students with instruction that is situated in real-life contexts. While this may make learning more relevant for some learners, it may make instruction less accessible for students learning the English language (Adonious & Qing, 2014). Teachers must be able to provide instruction that balances procedural skills, conceptual understanding, as well as academic language development.

Limitations and Future Research

This study also sets the stage for future research due to three important limitations. First, our analysis did not account for the varying degrees of English proficiency likely present in our sample; instead, all students who were actively receiving language services were considered LEP for the purpose of this study. As discussed earlier in this article, many districts determine the amount of English language service to provide a student based upon that student's initial screening and placement test scores, with students scoring lower receiving a more services. Future research should explore possible relations between EL students' mathematics achievement and performance on placement tests (such as the WIDA), hours of language service required per week, and generational status (first or second generation English speakers). In addition, 87% of our sample were from families of low socioeconomic status (i.e., met eligibility for the school's subsidized lunch program). Future research should include more diverse samples. Our AR groups had relatively small sample sizes, and future work should remedy this with larger sample sizes. Finally, we relied on a single measure of computation ability and a single measure for word-problem solving, rather than a latent score of multiple measures, to evaluate performance in each domain. Future work should incorporate multiple instruments to assess performance on each dimension of mathematics performance.

The implications of these finding coupled with the continuing increase in the proportion of LEP students in public schools, lends itself to increased study in the future. Further understanding this link as it pertains to the LEP population will also extend the field's understanding of the associations between language comprehension, mathematics performance, and the effects of initially low math performance at the start of school.

Acknowledgments

This research was supported by 2 P20 HD075443 and 2 R01 HD053714 from the Eunice Kennedy Shriver National Institute of Child Health & Human Development to Vanderbilt University. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Eunice Kennedy Shriver National Institute of Child Health & Human Development or the National Institutes of Health.

References

- Abedi J, Herman J, Courtney M, Leon S, & Kao J (2004). English language learners and math achievement: A study on classroom level opportunity to learn. Los Angeles, CA, USA: University of California, National Center for Research on Evaluation, Standards, and Student Testing.
- Abedi J, & Lord C (2001). The language factor in mathematics tests. *Applied Measurement in Education*, 14, 219–234. doi:10.1207/S15324818AME1403_2
- Abedi J, Lord C, & Plummer JR (1997, Aug). Final report of language background as a variable in NAEP mathematics performance. Retrieved Jun 2, 2017, from UCLA: CRESST: <http://cresst.org/wp-content/uploads/TECH429.pdf>
- Adoniou M, & Qing Y (2014). Language, mathematics, and english language learners. *Australian Mathematics Teacher*, 70(3), 3–11.
- Baroody AJ, & Ginsburg HP (1990). Chapter 4: Children's mathematical learning: A cognitive view. *Journal for Research in Mathematical Education*, 4, 51–210.
- Cai L. (2012). Latent variable modeling. *Shanghai Archives of Psychiatry*, 24(2), 118–120. doi: 10.3969/j.issn.1002-0829.2012.02.010 [PubMed: 25324615]
- Cavanagh S (2005). Math: The not-so-universal language. *Education Week*, 24(42), 1–22.
- Dehaene S, Spelke ES, Pinel PS-C, & Tsivkin S (1999). Sources of mathematical thinking: Behavioral and brain-imaging evidence. *Science*, 284, 970–974. doi:10.1126/science.284.5416.970 [PubMed: 10320379]
- Fuchs LS, Fuchs D, Compton DL, Hamlett CL, & Wang AY (2015). Is word-problem solving a form of text comprehension? *Scientific Studies of Reading*, 19(3), 204–223. doi: 10.1080/10888438.2015.1005745 [PubMed: 25866461]
- Fuchs LS, Fuchs D, Stuebing K, Fletcher JM, Hamlett CL, & Lambert WE (2008). Problem-solving and computation skill: Are they shared or distinct aspects of mathematical cognition? *Journal of Educational Psychology*, 100, 30–47. doi: 10.1037/0022-0663.100.1.30 [PubMed: 20057912]
- Fuchs LS, Geary DC, Compton DL, Fuchs D, Schatschneider C, Hamlett CL, ... Bryant JD (2013). Effects of first-grade number knowledge tutoring with contrasting forms of practice. *Journal of Educational Psychology*, 58–77. doi: 10.1037/a0030127 [PubMed: 24065865]
- Fuchs LS, Gilbert JK, Fuchs D, Seethaler PM, & Martin BN (2018). Text comprehension and oral language as predictors of word-problem solving: Insights into word-problem solving as a form of text comprehension. *Scientific Studies of Reading*, 22(2), 152–166. doi: 10.1080/10888438.2017.1398259 [PubMed: 29643723]
- Fuchs LS, Hamlett CL, & Fuchs D (1990). First grade test of computational fluency and first grade test of mathematics concepts and application. Nashville, TN, USA: Vanderbilt University.
- Fuchs LS, Seethaler PM, & Craddock C (2013). First-Grade Vanderbilt Story Problems. Nashville, TN, USA.
- Gordon P (2004). Numerical cognition without words: Evidence from Amazonia. *Science*, 306, 496–499. [PubMed: 15319490]
- Hakuta K, Butler Y, & Witt D (2000). How long does it take English learners to attain proficiency? Santa Barbara, CA, USA: University of California Linguistic Minority Research Institute.
- Janzen J (2008, 12). Teaching english language learners in the content areas. *Review of Educational Research*, 78(4), 1010–1038. doi: 10.3102/0034654308325580
- Jordan NC, & Hanich L (2000). Mathematical thinking in second-grade children with different forms of VD. *Journal of Learning Disabilities*, 33, 567–578. doi:10.1177/002221940003300605 [PubMed: 15495398]
- Kintsch W, & Greeno JG (1985). Understanding and solving word arithmetic problems. *Psychological Review*, 92, 109–129. doi:10.1037/0033-295X.92.1.109 [PubMed: 3983303]
- Larazin M (2006). Improving assessment and accountability for english language learners in the no child left behind act. National Council of La Raza (NCLR), Washington, D.C.
- Lee H, & Jung W (2004, 1). Limited english proficient (LEP) students and mathematical understanding. *Mathematics Teaching in the Middle School*, 9(5), 269–272.

- Monroe EE, & Orme MP (2002). Developing mathematical vocabulary. *Preventing School Failure*, 46, 139–142. doi:10.1080/10459880209603359
- National Assessment of Educational Progress (NAEP). (2015). Digest of education statistics: 2015. Institute of Education Sciences, U.S. Department of Education, Washington, D.C.
- National Center for Educational Statistics. (2017, March). English Language Learners in Public Schools. Retrieved from The Condition of Education: <http://nces.ed.gov>
- Powell SR, Driver MK, & Fall A (2017). An analysis of the mathematics vocabulary knowledge of third- and fifth- grade students: Connections to general vocabulary and mathematics computation. *Learning and Individual Differences*, 57, 22–32. doi: 10.1016/j.lindif.2017.05.011
- Purpura DJ, & Ganley CM (2014). Working memory and language: Skill-specific or domain-general relations to mathematics? *Journal of Experimental Child Psychology*, 122, 104–121. doi: 10.1016/j.jecp.2013.12.009 [PubMed: 24549230]
- Salillas E, & Wicha NY (2012). Early learning shapes the memory networks for arithmetic: Evidence from brain potentials in bilinguals. *Psychological Science*, 23(7), 745–755. doi: 10.1177/0956797612446347 [PubMed: 22707225]
- Tennessee Department of Education. (n.d.). English Learner (EL) Assessments. Retrieved May 31, 2017, from TN Department of Education: www.tennessee.gov/education/topic/english-learner-assessments
- Wechsler D (1999). Wechsler Abbreviated Scale of Intelligence. San Antonio, TX, USA: Psychological Corporation.
- Wisconsin Center for Education Research. (2014). W-APT. Retrieved May 31, 2017, from WIDA: <http://www.wida.us/assessment/W-APT/>

Figure 1.
Effect size on word-problem solving between Native English speakers and LEP students

Table 1

Demographics by Subgroup

Characteristic	At-Risk		Not At-Risk	
	Limited English Proficiency (<i>n</i> = 19)	Native English Speakers (<i>n</i> = 34)	Limited English Proficiency (<i>n</i> = 37)	Native English Speakers (<i>n</i> = 170)
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Gender				
Female	12 (63%)	18 (53%)	17 (46%)	80 (47%)
Male	7 (37%)	16 (47%)	20 (54%)	90 (53%)
Race				
African American	0 (0%)	21 (62%)	1 (3%)	75 (44%)
White	0 (0%)	9 (26%)	0 (0%)	68 (40%)
Hispanic	17 (90%)	3 (9%)	31 (84%)	17 (10%)
Asian	1 (5%)	0 (0%)	3 (8%)	4 (2.5%)
Other	1 (5%)	1 (3%)	2 (5%)	6 (3.5%)
Low Income	19 (100%)	29 (85%)	35 (95%)	144 (85%)

Note. Low income was operationalized as qualifying for free or reduced-price lunch.

Table 2

Marginal Means and Standard Deviations by Subgroup

Measure	AR + NAR				LEP + English Speaking			
	LEP		English Speaking		AR		NAR	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Computation Fall	11.76	1.22	12.58	0.81	6.35	1.24	18.00	0.78
Computation Spring	21.37	2.05	27.14	1.37	16.42	2.08	32.08	1.32
Word Problem Fall	2.87	0.36	3.86	0.24	1.39	0.37	5.35	0.23
Word Problem Spring	19.87	0.50	21.47	0.33	18.84	0.51	22.5	0.32

Table 3.

Means and Standard Deviations by Risk by LEP Status

Measure	At-Risk					Not At-Risk				
	LEP		Non-LEP			LEP		Non-LEP		
	M	SD	M	SD	ES	M	SD	M	SD	ES
Computation Fall	6.58	5.89	6.12	4.48	0.10	16.95	8.0	19.05	9.53	0.22
Computation Spring	14.79	8.46	18.06	10.32	0.31	27.95	11.12	36.22	16.29	0.51*
Word Problem Fall	1.42	1.17	1.35	1.15	-0.06	4.32	2.04	6.36	2.93	0.70*
Word Problem Spring	18.47	1.74	19.21	2.67	0.28	21.28	2.72	23.73	3.69	0.66*

Note. Effect sizes are reported as Cohen's *d*. Effect sizes were calculated using the standard deviation of the English-speaking group. Significant effects are denoted with an asterisk ($p < .05$).