The Vanderbilt University Learning Disabilities Hub is funded by Grant # R24 HD075443 from the Eunice Kennedy Shriver National Institute for Child Health and Human Development to Vanderbilt University. The purpose of this project is to increase understanding about how difficulty in understanding oral language and reading comprehension affect learning disabilities (LD) in the area of word problems.

**Over of the Vanderbilt LD Hub**

Despite important advances in LD intervention, the dominant intervention approach—direct skills instruction—fails to meet the needs of 25-40% of students with LD. Therefore, innovative approaches are needed to target the specific needs of subgroups of students with LD (i.e., LD subtypes) to expand the framework for LD intervention.

This Project addresses a subset of the LD population that has been understudied. This population experiences disproportionately poor response to intervention and has a distinctive set of needs. These students have difficulty in math problem solving and reading comprehension.

With this understudied population, a transdisciplinary team of researchers, spanning learning sciences, speech-language sciences, and LD, investigates an innovative approach to LD intervention on math problem solving. This approach involves embedding tutoring on language comprehension in the same academic material that is used for direct skills math problem-solving intervention.

This LD Hub has the potential impact science by increasing understanding about this LD subtype (with combined reading comprehension and math problem-solving difficulty) as an LD subtyping framework and about the role of language comprehension in math problem-solving and comorbidity. The Project has the potential to impact clinical practice by testing the viability of this LD subtype as a framework to differentiate instruction, via a novel intervention, and thereby meet the needs of a greater proportion of students with LD.

**What This Link Provides**

This link provides information on the Vanderbilt LD Hub’s research papers, as well as other Vanderbilt papers related to the topic of the LD Hub. This link also provides information about procedures for database usage.

**Requesting Papers**

See below for citations, with abstracts, to the Vanderbilt LD Hub’s publications and other relevant Vanderbilt studies. To request an email copy of a paper, contact kelsey.m.dillahey@vanderbilt.edu with the reference of the paper you are requesting.


The purpose of this study was to compare subgroups of students with various forms of learning difficulties (< 25th percentile) on cognitive and mathematics characteristics. Students with mathematics difficulty (MD, n = 105), reading difficulty (RD, n = 65), both (MDRD, n = 87), or neither (NoLD, n = 403) were evaluated on an array of cognitive measures (e.g., working
memory and language) and on mathematics measures of foundational numerical competencies, computation, and problem solving. Results revealed expected level differences among groups in both domains: NoLD outperformed RD, and MD outperformed MDRD. Profile differences were noted among pairs of subgroups on cognitive measures. On mathematics measures, profile differences were noted between RD and other subgroups, but not between MD and MDRD subgroups. The most discriminating cognitive measures were processing speed and language; the most discriminating mathematics measures depended on the subgroups being compared. Results were further evaluated according to more severe (< 10th percentile) criteria for MD and RD, which generally affected level differences more than the profile patterns. Results have implications for understanding comorbid MD and RD and for conceptualizing core deficits in MD.


Three cohorts of 3rd-grade students (N = 813) were evaluated on achievement, cognitive abilities, and behavioral attention according to contrasting research traditions in defining math learning disability (LD) status: low achievement versus extremely low achievement (LA-LD) and IQ-discrepant versus strictly low achieving LD (IQ-ACH). We use methods from these 2 traditions to form math problem solving LD groups. To evaluate group differences, we used MANOVA based profile and canonical analyses to control for relations among the outcomes and regression to control for group definition variables. Results suggest that basic arithmetic is the key distinguishing characteristic that separates low achieving problem solvers (including LD, regardless of definition) from typically achieving students. Word problem solving is the key distinguishing characteristic that separates IQ-ACH discrepant from strictly low achieving LD students, favoring the IQ-ACH discrepant students.


The focus of this study was enhancing word-problem and calculation achievement in ways that simultaneously support pre-algebraic thinking among 2nd-grade students with strong risk for mathematics difficulty (i.e., students with concurrently low performance at the start of 2nd grade on word problems and calculations). Intervention relied on a multi-tier support system (i.e., responsiveness-to-intervention or RTI) in which at-risk students participate in general classroom instruction and receive supplementary small-group tutoring. Participants were 265 students in 110 classrooms in 25 schools. Teachers were randomly assigned to 3 conditions: calculation RTI, word-problem RTI, and business-as-usual control. The 17-week intervention provided research-based linkages between calculations or word-problem (depending on condition) instruction with pre-algebra. Multilevel modeling indicated that calculation RTI improved calculation but not word-problem outcomes; word-problem RTI enhanced proximal word-problem outcomes as well as performance on some calculation outcomes; and word-problem RTI provided a stronger route than calculation RTI to pre-algebraic knowledge.


In this paper, we consider evidence from our intervention research programs on whether students with concurrent difficulty in reading and mathematics respond differentially to intervention and therefore represent distinct forms of learning disability (LD) requiring distinctive forms of intervention. We begin by examining academic and cognitive profiles of reading LD versus mathematics LD versus comorbid LD, thereby generating hypotheses about differential instructional needs of students with comorbid reading and mathematics LD. Then, to gain
insight into the tenability of these hypotheses, we report analyses conducted on extant databases to consider whether and if so how students with LD in comorbid versus one area of disability respond differentially to word-problem intervention, to math facts intervention, and to most intensive forms of reading intervention. We conclude with recommendations for future research to promote valid identification of comorbid LD samples and to extend understanding of LD subtyping frameworks for improving the field’s success in helping students with LD achieve greater academic success.


The purpose of this study was to examine predictors of growth in word problem solving (WPS) among elementary students in the context of problem and situation model accounts of WPS. At the beginning of 3rd, 148 students were measured on academic achievement and cognitive abilities. The students were assessed 4 times from the beginning of 3rd through end of 5th grade on 3 measures of WPS of varying complexity. As expected, predictors of intercept and growth varied according to complexity and experience. Computation, language, inattentive behavior, nonverbal problem solving (NVPS) and concept formation (but not word reading, reading comprehension, working memory, or processing speed) predicted WPS intercepts. Only inattentive behavior, NVPS, and concept formation predicted WPS growth. Predictors of intercepts and growth in WPS varied with word problem complexity. Computation predicted WPS performance for low and moderate-complexity problems but not high-complexity problems. NVPS predicted growth in WPS skill for moderate- and high- but not low-complexity word problems.


The purpose of this study was to assess whether understanding relational terminology (i.e., more, less, and fewer) mediates the effects of intervention on compare word problems. Second-grade classrooms (n = 31) were randomly assigned to 3 conditions: researcher-designed word-problem intervention, researcher-designed calculation intervention, or business-as-usual (teacher-designed) control. Students in word-problem intervention classrooms received instruction on the compare problem type, which included a focus on understanding relational terminology within compare word problems. Analyses, which accounted for variance associated with classroom clustering, indicated that (a) compared to the calculation intervention and business-as-usual conditions, word-problem intervention significantly increased performance on all three subtypes of compare problems and on understanding relational terminology; and (b) the intervention effect was fully mediated by students’ understanding of relational terminology for 1 subtype of compare problems and partially mediated by students’ understanding of relational terminology for the other 2 subtypes.


The purposes of this study were to assess the efficacy of remedial tutoring for 3rd graders with mathematics difficulty; to investigate whether tutoring is differentially efficacious depending on students’ math difficulty status (mathematics difficulty alone vs. mathematics plus reading difficulty); to explore transfer from number combination (NC) remediation; and to examine the transportability of the tutoring protocols. At 2 sites, 133 students were stratified on mathematics
difficulty status and site and then randomly assigned to 3 conditions: control (no tutoring) or tutoring on automatic retrieval of NCs (i.e., Math Flash) or tutoring on word problems with attention to the foundational skills of NCs, procedural calculations, and algebra (i.e., Pirate Math). Tutoring occurred for 16 weeks, 3 sessions per week and 20-30 min per session. Math Flash enhanced fluency with NCs with transfer to procedural computation but without transfer to algebra or word problems. Pirate Math enhanced word-problem skill as well as fluency with NCs, procedural computation, and algebra. Tutoring was not differentially efficacious as a function of students’ mathematics difficulty status. The tutoring protocols proved transportable across sites.


The purpose of this study was to explore patterns of difficulty in 2 domains of mathematical cognition: computation and problem solving. Third graders (n = 924; 52.7% male) were representatively sampled from 89 classrooms; assessed on computation and problem solving; classified as having difficulty with computation, problem solving, both domains, or neither domain; and measured on 9 cognitive dimensions. Difficulty occurred across domains with the same prevalence as difficulty with a single domain; specific difficulty was distributed similarly across domains. Multivariate profile analysis on cognitive dimensions and chi-squares on demographics showed that specific computational difficulty was associated with strength in language and weaknesses in attentive behavior and processing speed; problem-solving difficulty was associated with deficient language as well as race and poverty. Implications for understanding mathematics competence and for the identification and treatment of mathematics difficulties are discussed.


The primary purpose of this study was to assess the effects of strategic counting instruction, with and without deliberate practice with those counting strategies, on number combination (NC) skill among students with mathematics difficulties (MD). Students (n = 150) were stratified on MD status (i.e., MD alone vs. MD with reading difficulty) and site (proximal vs. distal to the intervention developer) and then randomly assigned to control (no tutoring) or 1 of 2 variants of NC remediation. Both remediations were embedded in the same validated word-problem tutoring protocol (i.e., Pirate Math). In 1 variant, the focus on NCs was limited to a single lesson that taught strategic counting. In the other variant, 4-6 min of practice per session was added to the other variant. Tutoring occurred for 16 weeks, 3 sessions per week for 20-30 min per session. Strategic counting without deliberate practice produced superior NC fluency compared to control; however, strategic counting with deliberate practice effected superior NC fluency and transfer to procedural calculations compared with both competing conditions. Also, the efficacy of Pirate Math word-problem tutoring was replicated.


The purpose of this study was to assess the effects of preventative tutoring on the math problem solving of 3rd-grade students with math and reading difficulties. Students (n = 35) were assigned randomly to continue in their general education math program or to receive secondary preventative tutoring 3 times per week, 30 min per session, for 12 weeks. Schema-broadening
tutoring taught students to (a) focus on the mathematical structure of 3 problem types, (b) recognize problems as belonging to those 3 problem-type schemas; (c) solve the 3 word-problem types; and (d) transfer solution methods to problems that include irrelevant information, 2-digit operands, missing information in the 1st or 2nd positions in the algebraic equation, or relevant information in charts, graphs, and pictures. Also, students were taught to perform the calculation and algebraic skills foundational for problem solving. Analyses of variance revealed statistically significant effects on a wide range of word problems, with large effect sizes. Findings support the efficacy of the tutoring protocol for preventing word-problem deficits among third-grade students with math and reading deficits.

Fuchs, L.S., Fuchs, D., & Prentice, K. (2004). Responsiveness to mathematical problem-solving instruction among students with risk for mathematics disability with and without risk for reading disability. Journal of Learning Disabilities, 4, 293-306. This study assessed responsiveness to a 16-week mathematical problem-solving treatment as a function of students’ risk for disability. Among 301 third graders, TerraNova scores were used to categorize students as at risk for both reading and mathematics disability (MDR/RDR; 20 control and 12 experimental), at risk for mathematics disability only (MDR-only; 5 and 8), at risk for reading disability only (RDR-only; 12 and 15), or not at risk (NDR; 60 and 69). Interactions among at-risk status, treatment, and time showed that as a function of treatment, MDR/RDR, MDR-only, and RDR-only students improved less than NDR students on computation and labeling, and MDR/RDR students improved less than all other groups on conceptual underpinnings. Exploratory regressions suggested that MDR/RDR students’ math deficits or their underlying mechanisms explained a greater proportion of variance in responsiveness to problem-solving treatment than reading deficits or their underlying mechanisms.

Requesting Information on Database Usage
Descriptions of research methods will become available as papers are published. Data usage requests will be considered after LD Hub publications are complete. Such requests will then be consider only (a) after the outside user has submitted a written request describing variables of interest and related research purpose and methods of the study for which these variables will be used and (b) if the Principal Investigator and Investigators approve that request. If approved, the outside user will have to sign a Data Use Agreement Form (supplied by the LD Hub and specific to the request) that outlines the terms for data use and guarantees that publications are credited to the Hub and entered in PubMed. For information on variables and data-collection procedures, see asterisked publications. For additional information, contact lynn.fuchs@vanderbilt.edu.