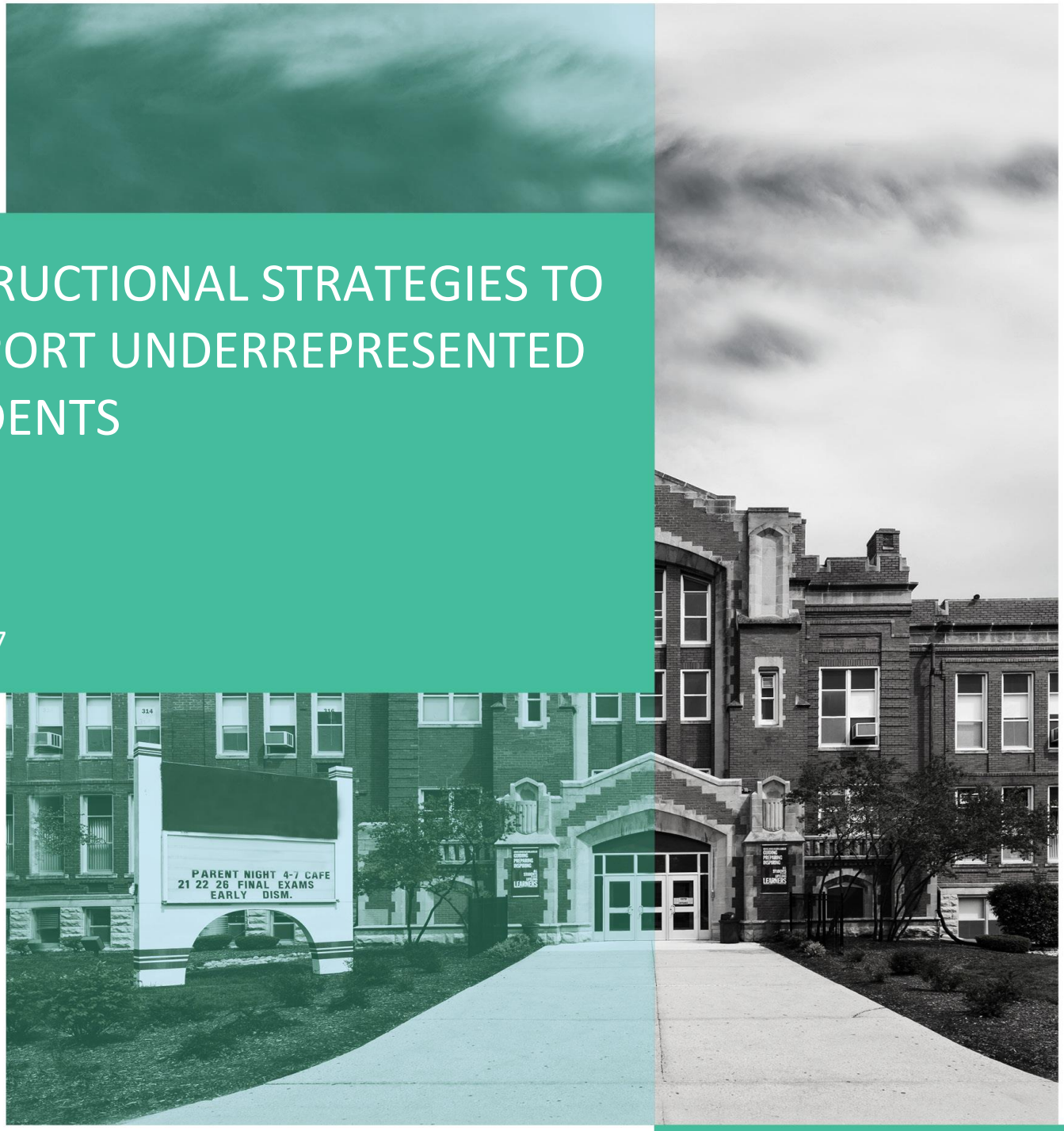
INSTRUCTIONAL STRATEGIES TO SUPPORT UNDERREPRESENTED STUDENTS

June 2017



In the following report, Hanover Research explores instructional strategies to support underrepresented students in literacy and mathematics. For each content area, the analysis highlights empirical research for effective teaching practices and presents intervention programs that exhibit these practices.

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EXECUTIVE SUMMARY AND KEY FINDINGS

INTRODUCTION

As the population of minority families in the United States continues to rise, it becomes increasingly important for school districts to seek ways to bolster the achievement of lower-performing or otherwise "at risk" students. Given there are many different groups that traditionally comprise underrepresented students (e.g., English language learners, minorities, and students from low-income households), educational interventions to support these students are numerous and highly varied.

In this report, Hanover Research primarily evaluates instructional strategies according to key educational content areas, which can influence the development and implementation of targeted programs for underrepresented students across a variety of different classrooms and grade levels. As such, this report comprises two main sections: **(I) Literacy** and **(II) Mathematics.** Within each of these primary content-based sections, this report addresses student achievement according to two main categories:

- **Teaching Practices** examines ways that teachers can develop pedagogies and classroom strategies that bolster the achievement of underperforming or underrepresented students.
- **Intervention Programs** pertains to classroom-based or school-wide programs that support teachers in the implementation of empirically supported instructional strategies.

METHODOLOGY

To this end, this report examines a compilation of studies and pertinent research based on empirical, data-driven studies and analyses. To identify studies with the largest impacts, Hanover Research reviewed a number of online databases of empirical and peer-reviewed studies, including Proquest, EBSCOHost, the Education Resources Information Center (ERIC), and ScienceDirect. This report also draws extensively from practice guides developed by the U.S. Department of Education's What Works Clearinghouse (WWC). The WWC is an office within the Institute of Education Sciences at the U.S. Department of Education. WWC expert panels develop practitioner guides on specific topics that identify the most impactful strategies to help students learn based on empirical studies that meet stringent standards of evidence.[1] These practitioner guides "summarize the results of WWC review" and identify specific recommendations for educators by strength of evidence (minimal, moderate, or strong).

These practice guides calculate estimated effect sizes (reported as *Cohen's d*) for oft-cited analyses, which are used to determine a study's validity, generalizability, and applicability and

[1] "What We Do." What Works Clearinghouse. http://ies.ed.gov/ncee/wwc/WhatWeDo

enable comparisons of interventions across multiple studies over time. Secondary, anecdotal literature supplements the research-based findings throughout the report to offer a holistic assessment of key efforts and strategies to support underrepresented students in K-12 education.

TEACHING PRACTICES

To identify the most relevant studies for partner school districts, Hanover primarily selected studies featured on WWC practice guides for literacy or mathematics that meet WWC design standards with or without reservations and that were published within the past 10 years (i.e., 2007 or later). Next, Hanover considered studies aligned with WWC recommendations for practices with the strongest level of evidence, since these practices are most likely to impact student achievement based on currently available empirical research (Figure 1.1).[2] Finally, Hanover reviewed the demographics of student participants in each review in order to select studies that focus predominantly on underrepresented students (i.e., minority, low SES, or ELL students).

Figure 1.1: WWC Levels of Evidence for Practice Guide Recommendations

MINIMAL EVIDENCE	MODERATE EVIDENCE	STRONG EVIDENCE
• **No causal evidence** for a practice guide recommendation. • The panel cannot point to a body of research that demonstrates the practice's positive effect on student achievement. In some cases, this simply means that the recommended practices would be difficult to study in a rigorous, experimental fashion. In other cases, it indicates that researchers have not yet studied this practice, or that there is weak or conflicting evidence of effectiveness. A minimal evidence rating does not indicate that the recommendation is any less important than other recommendations with a strong evidence or moderate evidence rating.	• **Limited evidence** for a practice guide recommendation. • This rating is assigned when the panel finds high quality causal research that links a practice with positive results, but the research may not adequately rule out other causes of the positive results, or the school and classrooms are not similar to those targeted by the guide.	• **Consistent evidence** supporting a practice guide recommendation. • This rating is assigned when the panel finds high quality causal research that links a practice with positive results, ruling out other causes of the positive results.

[2] Figure text reproduced verbatim from source: "Glossary." What Works Clearinghouse. https://ies.ed.gov/ncee/wwc/Glossary

INTERVENTION PROGRAMS

To select literacy and mathematics interventions to feature in this review, Hanover used two inclusion parameters:

- The U.S. Department of Education's What Works Clearinghouse (WWC) must classify it as an intervention with positive or potentially positive effects in at least one outcome domain for students in Grades K-12, where the extent of evidence is rated and at least small.[3]
- Studies reviewed to determine the effectiveness of the intervention program must focus on, or provide evidence of outcomes for, underrepresented students (e.g., minority, low SES, or ELL) based on the WWC's "Evidence Snapshot" that summarizes participant characteristics across all studies reviewed for the associated intervention program.

KEY FINDINGS

INSTRUCTIONAL STRATEGIES FOR LITERACY

- **Effective literacy instruction should *explicitly* teach students reading comprehension strategies, steps in the writing process, and vocabulary instruction**, among other items. Figure ES.1 below summarizes WWC instructional strategies for literacy with the strongest level of supporting research based on empirical research and other evidence.

Figure ES.1: Instructional Practices for Literacy

SUBJECT	STUDENTS	RECOMMENDATION
Reading	K-3	Develop awareness of the segments of sounds in speech and how they link to letters.
Reading	K-3	Teach students to decode words, analyze word parts, and write and recognize words.
Reading	K-3	Teach students how to use reading comprehension strategies.
Writing	K-6	Teach students to use the writing process for a variety of purposes.
Literacy	English Learners	Provide focused, intensive, and explicit instruction in small-groups for at-risk English learners in five core reading areas: phonological awareness, phonics, reading fluency, vocabulary, and comprehension.
Literacy	English Learners	Provide high-quality vocabulary instruction and teach essential content words in depth.
Reading	Struggling	Provide intensive, systematic instruction on up to three foundational reading skills in small groups to students who score below the benchmark score on universal screening.
Literacy	K-8 English Learners	Teach a set of academic vocabulary words intensively across several days using a variety of instructional activities.
Literacy	K-8 English Learners	Integrate oral and written English language instruction into content-area teaching.

[3] "Find What Works!" What Works Clearinghouse at the Institute of Education Sciences. http://ies.ed.gov/ncee/wwc/FindWhatWorks.aspx?o=8&n=Literacy&r=1&g=13

Subject	Students	Recommendation
Writing	6-12	Explicitly teach appropriate writing strategies using a Model-Practice-Reflect instructional cycle.
Literacy	4-12	Provide explicit vocabulary instruction.
Literacy	4-12	Provide direct and explicit comprehension strategy instruction.
Literacy	4-12	Make available intensive and individualized interventions for struggling readers that can be provided by trained specialists.

Source: What Works Clearinghouse

- **Discussion-based lessons can bolster struggling students' reading comprehension and writing fluency.** These lessons typically focus on one particular aspect of reading and/or writing – such as explicit vocabulary instruction or guided practice. In particular, dedicated lessons should target vocabulary, literacy strategies, and discussion-based interpretation. These dedicated lessons have been shown to have positive effects on lower-achieving students' English Language Arts test scores.

Instructional Strategies for Mathematics

- **Effective mathematics instruction should be explicit and systematic, with a focus on the problem-solving process, word problems, and use of visual representations**. Figure ES.2 below summarizes WWC instructional strategies for mathematics with the strongest level of supporting research based on empirical research and other evidence.

Figure ES.2: Instructional Practices for Mathematics

Students	Recommendation
4-8	Assist students in monitoring and reflecting on the problem-solving process.
4-8	Teach students how to use visual representations.
Struggling	Explicit and systematic instruction, which includes providing models of proficient problem solving, verbalization of thought processes, guided practice, corrective feedback, and frequent cumulative review.
Struggling	Interventions should include instruction on solving word problems that is based on common underlying structures.

Source: What Works Clearinghouse

- **For ELL students in particular, math instruction should include explicit instruction on math vocabulary and terminology.** Because ELL students are still mastering English, they will likely need direct literacy and vocabulary support in order to solve word problems and engage with higher-order instructional activities; even if the students possess the math skills and knowledge needed to solve the problem, they may not understand the use of certain vocabulary in context.

SECTION I: INSTRUCTIONAL STRATEGIES FOR LITERACY

In this section, Hanover Research discusses instructional strategies for reading and writing. Findings in this section come primarily from empirical analyses, and are supplemented by resources provided by national organizations. These strategies address considerations at various levels of schooling, such that primary- and secondary-level interventions are presented together. The section concludes with brief summaries of intervention programs that contain evidence of these instructional strategies.

SUMMARY ANALYSIS

TEACHING PRACTICES

The WWC has published eight Practice Guides since 2007 that focus on reading comprehension, writing instruction, and content literacy, among other literacy topics for K-12 students. Five of the Practice Guides provide recommendations for elementary school students, two focus on elementary and middle school students, and two target secondary school students. Of the 36 specific recommendations summarized across these eight studies, the WWC found a strong level of evidence for 15 of them. Notably, consistent recommendations across grade levels and student subgroups supported by a strong level of evidence include:

- **Explicit instruction** in reading comprehension strategies, the writing process, and academic vocabulary
- **Small-group interventions or differentiated instruction** for struggling readers, English learners, and at-risk students (typically within an RtI or similar framework)
- **Integrated** reading, writing, and content-area instruction

Figure 1.1 on the following page summarizes the recommendations highlighted within each of the eight Practice Guides while the remainder of this section explores the three themes above in greater detail.

Figure 1.1: WWC Recommendations for Literacy Instruction

Recommendation	Level of Evidence
Elementary School Students	
Foundational Reading Skills for Grades K-3[4]	
Teach students academic language skills, including the use of inferential and narrative language, and vocabulary knowledge.	Minimal
Develop awareness of the segments of sounds in speech and how they link to letters.	Strong
Teach students to decode words, analyze word parts, and write and recognize words.	Strong
Ensure that each student reads connected text every day to support reading accuracy, fluency, and comprehension.	Moderate
Improving Reading Comprehension in Grades K-3[5]	
Teach students how to use reading comprehension strategies.	Strong
Teach students to identify and use the text's organizational structure to comprehend, learn, and remember content.	Moderate
Guide students through focused, high-quality discussion on the meaning of text.	Minimal
Select texts purposefully to support comprehension development.	Minimal
Establish an engaging and motivating context in which to teach reading comprehension.	Moderate
Writing Instruction for Elementary School Students[6]	
Provide daily time for students to write.	Minimal
Teach students to use the writing process for a variety of purposes.	Strong
Teach students to become fluent with handwriting, spelling, sentence construction, typing, and word processing.	Moderate
Create an engaged community of writers.	Minimal
Literacy and English Language Instruction for English Learners[7]	
Conduct formative assessments with English learners using English language measures of phonological processing, letter knowledge, and word and text reading. Use these data to identify English learners who require additional instructional support and to monitor their reading progress over time.	Strong
Provide focused, intensive small-group interventions for English learners determined to be at risk for reading problems. Although the amount of time in small-group instruction and the intensity of this instruction should reflect the degree of risk, determined by reading assessment data and other indicators, the interventions should include the five core reading elements (phonological awareness, phonics, reading fluency, vocabulary, and comprehension). Explicit, direct instruction should be the primary means of instructional delivery.	Strong
Provide high-quality vocabulary instruction throughout the day. Teach essential content words in depth. In addition, use instructional time to address the meanings of common words, phrases, and expressions not yet learned.	Strong

[4] "Foundational Skills to Support Reading for Understanding Kindergarten Through 3rd Grade." What Works Clearinghouse, July 2016, p. 3. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/wwc_foundationalreading_070516.pdf

[5] "Improving Reading Comprehension in Kindergarten Through 3rd Grade." What Works Clearinghouse, September 2010, p. 9. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/readingcomp_pg_092810.pdf

[6] "Teaching Elementary School Students to Be Effective Writers." What Works Clearinghouse, June 2012, p. 9. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/writing_pg_062612.pdf

[7] "Effective Literacy and English Language Instruction for English Learners in the Elementary Grades." What Works Clearinghouse, December 2007, p. 6. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/20074011.pdf

Recommendation	Level of Evidence
Ensure that the development of formal or academic English is a key instructional goal for English learners, beginning in the primary grades. Provide curricula and supplemental curricula to accompany core reading and mathematics series to support this goal. Accompany with relevant training and professional development.	Low
Ensure that teachers of English learners devote approximately 90 minutes a week to instructional activities in which pairs of students at different ability levels or different English language proficiencies work together on academic tasks in a structured fashion. These activities should practice and extend material already taught.	Strong
Struggling Students[8]	
Screen all students for potential reading problems at the beginning of the year and again in the middle of the year. Regularly monitor the progress of students at risk for developing reading disabilities.	Moderate
Provide time for differentiated reading instruction for all students based on assessments of students' current reading level.	Low
Provide intensive, systematic instruction on up to three foundational reading skills in small groups to students who score below the benchmark score on universal screening. Typically, these groups meet between three and five times a week, for 20 to 40 minutes.	Strong
Monitor the progress of tier 2 students at least once a month. Use these data to determine whether students still require intervention. For those students still making insufficient progress, schoolwide teams should design a tier 3 intervention plan.	Low
Provide intensive instruction on a daily basis that promotes the development of the various components of reading proficiency to students who show minimal progress after reasonable time in tier 2 small group instruction (tier 3).	Low
Elementary and Middle School Students	
Academic and Content Literacy Instruction for English Learners[9]	
Teach a set of academic vocabulary words intensively across several days using a variety of instructional activities.	Strong
Integrate oral and written English language instruction into content-area teaching.	Strong
Provide regular, structured opportunities to develop written language skills.	Minimal
Provide small-group instructional intervention to students struggling in areas of literacy and English language development.	Moderate
Secondary School Students	
Writing Instruction for Secondary School Students[10]	
Explicitly teach appropriate writing strategies using a Model-Practice-Reflect instructional cycle.	Strong
Integrate writing and reading to emphasize key writing features.	Moderate
Use assessments of student writing to inform instruction and feedback.	Minimal
Literacy[11]	
Provide explicit vocabulary instruction.	Strong

[8] "Assisting Students Struggling with Reading: Response to Intervention (RtI) and Multi-Tier Intervention in the Primary Grades." What Works Clearinghouse, February 2009, p. 6. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/rti_reading_pg_021809.pdf

[9] Teaching Academic Content and Literacy to English Learners in Elementary and Middle School." What Works Clearinghouse, April 2014, p. 7. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/english_learners_pg_040114.pdf

[10] "Teaching Secondary Students to Write Effectively." What Works Clearinghouse, November 2016, p. 4. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/wwc_secondary_writing_110116.pdf

[11] "Improving Adolescent Literacy: Effective Classroom and Intervention Practices." What Works Clearinghouse, August 2008, p. 7. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/adlit_pg_082608.pdf

RECOMMENDATION	LEVEL OF EVIDENCE
Provide direct and explicit comprehension strategy instruction.	Strong
Provide opportunities for extended discussion of text meaning and interpretation.	Moderate
Increase student motivation and engagement in literacy learning.	Moderate
Make available intensive and individualized interventions for struggling readers that can be provided by trained specialists.	Strong

Source: What Works Clearinghouse

Figure 1.2 on the following page displays the key research-based studies that investigate teaching practices which address reading and writing skills in Grades K-12. Specifically, these analyses address how teaching practices can influence positive outcomes and draw data from classroom-level interventions. Where provided, effect sizes (Cohen's d) are reported based either on the researchers' calculations or those derived by WWC (and noted accordingly). Most the studies come from primary-level programs which is indicative of the overall trend in research on reading and writing, wherein the preponderance of the literature addresses student outcomes in English language arts (ELA) from the perspective of younger students. Additionally, many of the subsequent analyses segment results by reading level, English language learner status, or race/ethnicity. This can help to distinguish between effective ways to address the different learners' needs in reading and writing. Studies in the table are organized by grade level.

Figure 1.2: Summary of Selected Evidence for Instructional Strategies for Literacy

Author(s) and Year	WWC Recommendation	Grade(s)	Subgroup(s)	Outcome Domain	Effect Size	Intervention Description
Elementary[12]						
Borman and Dowling[13]* 2009	▪ Awareness of the segments of sounds ▪ Decode, analyze, write, and recognize words	K	Predominantly minority	Word reading	0.30	Teachers implemented Superkids during 82-minute daily sessions all year with instruction on 13 letters, decoding, encoding, and blending sounds.
Little et al.*[14] 2012	▪ Awareness of the segments of sounds ▪ Decode, analyze, write, and recognize words	K	African American (30%) and Hispanic (21%)	Phonology and word reading	0.29	Early Reading Intervention with small-group instruction in letters and sounds, segmenting sounds, reading words, and reading sentences and storybooks.
Case et al.[15] 2010	▪ Connected text	1	50% African American students	Word reading	0.76	At-risk students received small-group instruction in phonics, sight-word recognition and vocabulary, and reading fluency and comprehension during 24 40-minute lessons over 11 weeks.
Gilbert et al.[16] 2013	▪ Awareness of the segments of sounds ▪ Decode, analyze, write, and recognize words ▪ Connected text	1	African American (47%), Hispanic (8%), and low-income (66% FRPL)	Word reading	0.09	" Small-group, multi-tiered supplemental tutoring program using a responsiveness-to-intervention (RTI) approach. Topics covered in the tutoring included letter–sound correspondence, sight words, phonemic awareness, decoding, and text reading."

[12] "Foundational Skills to Support Reading for Understanding Kindergarten Through 3rd Grade." What Works Clearinghouse, July 2016. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/wwc_foundationalreading_070516.pdf

[13] Borman, G.D., and N.M. Dowling. "Student and Teacher Outcomes of The Superkids Quasi-Experimental Study." *Journal of Education for Students Placed at Risk*, 14(3), 2009. https://eric.ed.gov/?id=EJ862877

[14] Little, M.E. et al. "A Comparison of Responsive Interventions on Kindergarteners' Early Reading Achievement." *Learning Disabilities Research & Practice*, 27(4), 2012. Accessed via EBSCOHost.

[15] Case et al. "Validation of a Supplemental Reading Intervention for First-Grade Children." *Journal of Learning Disabilities*, 2010, 43(5). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3070172/

[16] Gilbert, J.K. et al. "Efficacy of a First-Grade Responsiveness-to-Intervention Prevention Model for Struggling Readers." *Reading Research Quarterly*, April 2013. Accessed via EBSCOHost.

Author(s) and Year	WWC Recommendation	Grade(s)	Subgroup(s)	Outcome Domain	Effect Size	Intervention Description
Hagans and Good[17] 2013	▪ Awareness of the segments of sounds	1	Low SES (58% FRPL)	Phonology	1.36***	Students received small-group instruction on initial- and final-phoneme identity, segmenting and blending phonemes, and letter–sound correspondence during 80-100 minutes of weekly instruction over 12 weeks.
Wanzek and Vaughn*[18] 2008	▪ Awareness of the segments of sounds ▪ Decode, analyze, write, and recognize words	1	Majority Hispanic (72%) and low-income (90% FRPL)	Word reading	0.15	Daily small-group intervention sessions focused phonics and fluency activities.
Borman, Dowling, and Schneck[19] 2008	▪ Academic language skills ▪ Awareness of the segments of sounds ▪ Decode, analyze, write, and recognize words ▪ Connected text	1-3	Predominantly minority (77%) and low-income (71% FRPL)	Reading comprehension Vocabulary	0.23-0.26	Teachers implemented Open Court intervention in daily lessons for a full school year.
Denton et al.[20] 2013	▪ Connected text	2	Hispanic (57%) and African American (28%)	Word reading	0.49***	Tier 3 interventionists focused on phonological awareness, letter–sound correspondence, high-frequency words, oral reading fluency, and reading comprehension.

[17] Hagans, K. and R. Good. "Decreasing Reading Differences in Children from Disadvantaged Backgrounds: The Effects of an Early Literacy Intervention." *Contemporary School Psychology*, 17(1), 2013. Accessed via EBSCOHost.
[18] Wanzek, J. and S. Vaughn. "Response to Varying Amounts of Time in Reading Intervention for Students With Low Response to Intervention." *Journal of Learning Disabilities*, 41(2), 2008. Accessed via ProQuest.
[19] Borman, G.D., N.M. Dowling, and C. Schneck. "A Multisite Cluster Randomized Field Trial of Open Court Reading." *Educational Evaluation and Policy Analysis*, December 2008. Accessed via ProQuest.
[20] Denton, C.A. et al. "Effects of Tier 3 Intervention for Students With Persistent Reading Difficulties and Characteristics of Inadequate Responders." *Journal of Educational Psychology*, 105(3), April 2013. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4191908/

Author(s) and Year	WWC Recommendation	Grade(s)	Subgroup(s)	Outcome Domain	Effect Size	Intervention Description
Christ and Davie[21] 2009	▪ Connected text	3	African American (28%), Hispanic (23%) ELL (23%), and low-income (60% FRPL)	Reading comprehension	0.43***	Students participated in supplemental Read Naturally instruction including repeated reading, vocabulary, comprehension questions, and progress monitoring with feedback.
Secondary[22]						
Lesaux et al.[23] 2014	▪ Integrate reading and writing	6	Majority (70%) from home where English is not the primary language	Overall writing quality	0.10	Academic vocabulary instruction via short texts in individual and small-group settings.
Gallagher, Woodworth, and Arshan[24] 2015	▪ Use formative assessments	7-9	FRPL eligible students (two-thirds)	Audience, organization, and use of evidence	0.16-0.20	Teachers delivered instruction on argument writing and used formative assessments to monitor students' progress.
Olson et al.[25] 2017	▪ Explicitly teach writing strategies ▪ Integrate reading and writing ▪ Use formative assessments	7-12	Mainstreamed Latino English learners	Overall writing quality	0.46	Teachers received PD to implement cognitive strategies for reading and writing.
Olson and Land[26] 2008	▪ Explicitly teach writing strategies ▪ Integrate reading and writing ▪ Use formative assessments	9-12	Majority mainstreamed English learners	Overall writing quality	0.71	Teachers received PD to implement cognitive strategies for reading and writing.

[21] Christ, T.J. and J. Davie. "Empirical Evaluation of Read Naturally Effects: A Randomized Control Trial (RCT)." May 7, 2009. https://www.readnaturally.com/userfiles/ckfiles/files/UofMnReadNaturallyStudy.pdf

[22] "Teaching Secondary Students to Write Effectively." What Works Clearinghouse, November 2016, pp. 70-79. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/wwc_secondary_writing_110116.pdf

[23] Lesaux, N.K. et al. "Effects of Academic Vocabulary Instruction for Linguistically Diverse Adolescents: Evidence from a Randomized Field Trial." *American Educational Research Journal*, December 2014. http://journals.sagepub.com/doi/pdf/10.3102/0002831214532165

[24] Gallagher, H.A., K.R. Woodworth, and N.L. Arshan. "Impact of the National Writing Project's College-Ready Writers Program on Teachers and Students." SRI International, 2015. https://www.sri.com/sites/default/files/publications/sri-crwp-research-brief_nov-2015-final.pdf

[25] Olson C.B. et al. "Reducing Achievement Gaps in Academic Writing for Latinos and English Learners in Grades 7-12." *Journal of Educational Psychology*, January 2017. http://psycnet.apa.org/index.cfm?fa=buy.optionToBuy&uid=2016-21264-001

[26] Olson, C.B. and R. Land. "Taking a Reading/Writing Intervention for Secondary English Language Learners on the Road: Lessons Learned from the Pathway Project." *Research in the Teaching of English*, February, 2008. Accessed via ProQuest.

Author(s) and Year	WWC Recommendation	Grade(s)	Subgroup(s)	Outcome Domain	Effect Size	Intervention Description
Fong et al.[27] 2015	▪ Integrate reading and writing	12	Intervention group included African American (5%) and Hispanic (46%) students	Overall writing quality	0.13**	The Expository Reading and Writing Course (ERWC) used scaffolding to teach students to read, comprehend, and write about different texts.

Source: What Works Clearinghouse and individual publications
*Study meets WWC criteria with reservations
**"The study did not report the information necessary for the WWC to calculate effect sizes, and the presented effect sizes are as reported in the study."
*** Statistically significant ($p \leq 0.05$)

[27] Fong, A.B. et al. "Evaluation of the Expository Reading and Writing Course." WestEd, July 2015. http://files.eric.ed.gov/fulltext/ED559522.pdf

INTERVENTION PROGRAMS

As described above, WWC Practice Guides recommend differentiated and/or targeted instruction for struggling readers, English learners, and other at-risk students as an instructional approach to improve literacy achievement. Therefore, this subsection highlights several intervention programs that have produced evidence of effectiveness in these small-group instructional settings.

Hanover reviewed the participant characteristics of the evidence used to support the effectiveness of each intervention program and selected only those programs with evidence of effectiveness serving underrepresented students such as minorities. English learners, and low-income students. Ultimately, four interventions met these qualifications: Failure Free Reading, Fast ForWord, Lexia Reading, and Read 180. Figure 1.3 on the following page summarizes the WWC's findings for these interventions, some of which have multiple entries. Brief profiles of each intervention follow, focusing on describing the intervention and summarizing key empirical studies of the efficacy of each program.

Figure 1.3: WWC Intervention Summary Reviews

Intervention	Subset	Grade Level(s)	Improvement Index*	Effectiveness Rating**	Extent of Evidence***
Beginning Reading					
Failure Free Reading[28]	Alphabetics	3	--	No discernible	Small
	Comprehension	3	10	Potentially positive	Small
	Reading fluency	3	10	No discernible	Small
Lexia Reading[29]	Alphabetics	K-1	11	Potentially positive	Small
	Comprehension	K	11	Potentially positive	Small
	Reading achievement	1	--	No discernible	Small
	Reading fluency	K-1	--	No discernible	Small
Adolescent Literacy					
Fast ForWord[30]	Alphabetics	K-10	--	No discernible	Small
	Comprehension	4-10	8	Potentially positive	Medium to large
	Literacy achievement	K-10	--	No discernible	Medium to large
	Reading fluency	7-10	17	Potentially positive	Small
READ 180[31]	Alphabetics	4-6	--	No discernible	Medium to large
	Comprehension	4-9	6	Positive	Medium to large
	Literacy achievement	4-10	4	Positive	Medium to large
	Reading fluency	4-6	4	Potentially positive	Medium to large
English Language Learners					
Fast ForWord[32]	English language development	K-5	31	Potentially positive	Small
	Reading achievement	1-6	--	No discernible effects	Small

Source: What Works Clearinghouse
Notes: BR=beginning reading; AL=adolescent literacy; SLD=students with learning disabilities
*The expected change in percentile rank for an average comparison group student if the student had received the intervention.
**A potentially positive rating indicates evidence that the intervention had a positive effect on outcomes with no overriding contrary evidence. A positive rating indicates strong evidence that intervention had a positive effect on outcomes.
***A small extent of evidence includes only one study, or one school, or findings based on a total sample size of less than 350 students and 14 classrooms (assuming 25 students in a class). A medium to large extent of evidence includes more than one study, more than one school, and findings based on a total sample of at least 350 students or 14 classrooms.

TEACHING PRACTICES

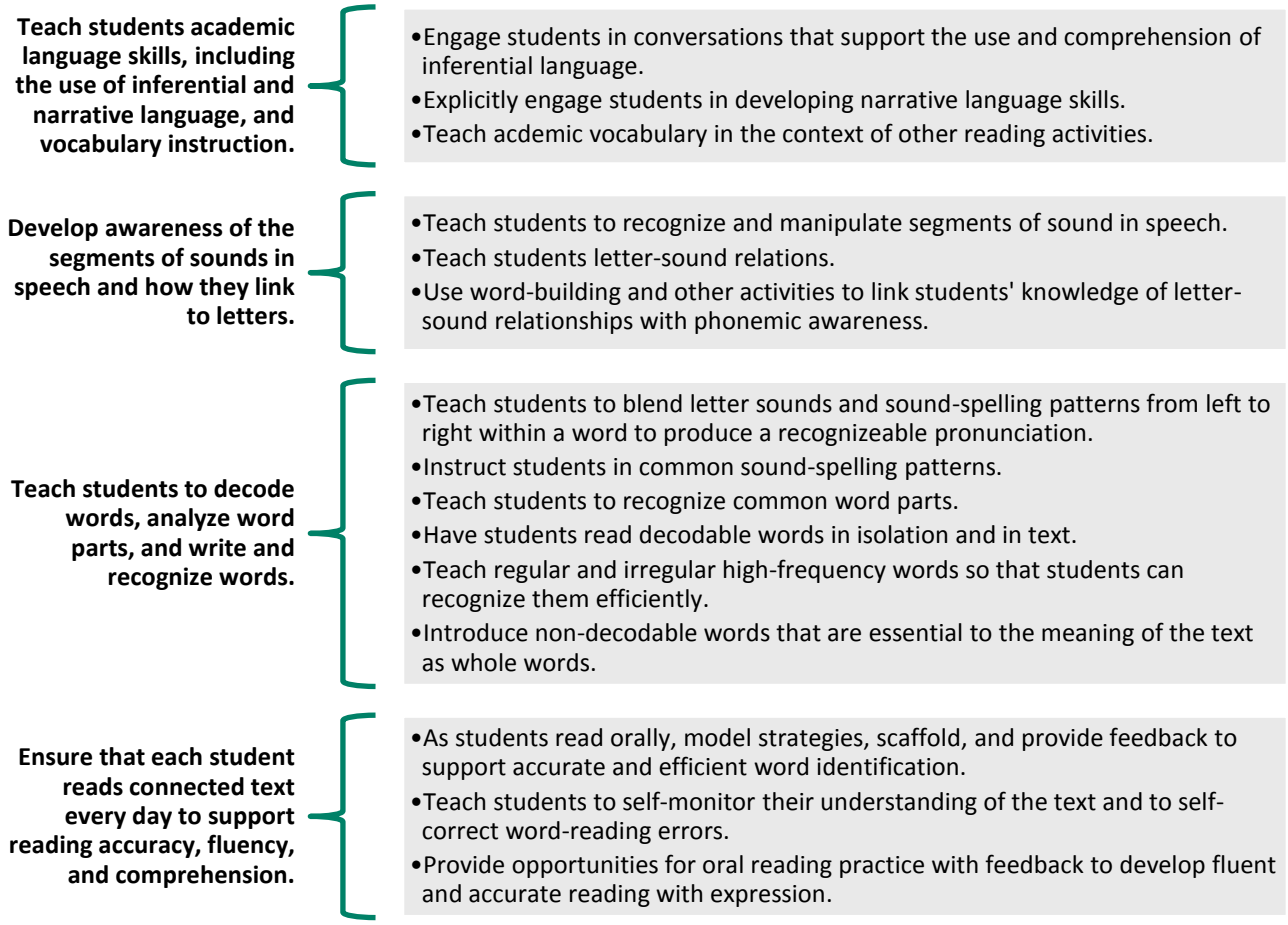
EXPLICIT INSTRUCTION

The WWC elaborates on the components of reading instruction that improve student achievement, particularly noting the extent of evidence supporting instruction that teaches

[28] "Failure Free Reading." What Works Clearinghouse, July 2, 2007. https://ies.ed.gov/ncee/wwc/Docs/InterventionReports/WWC_Failure_Free_070207.pdf
[29] "Lexia Reading." What Works Clearinghouse, June 2009. https://ies.ed.gov/ncee/wwc/Docs/InterventionReports/wwc_lexia_063009.pdf
[30] "Fast ForWord." What Works Clearinghouse, August 2010. https://ies.ed.gov/ncee/wwc/Docs/InterventionReports/wwc_fastfw_083110.pdf
[31] "READ 180." What Works Clearinghouse, November 2016, p. 1. https://ies.ed.gov/ncee/wwc/Docs/InterventionReports/wwc_read180_112916.pdf
[32] "Fast ForWord Language." What Works Clearinghouse, September 28, 2006. https://ies.ed.gov/ncee/wwc/Docs/InterventionReports/WWC_Fast_ForWord_092806.pdf

students about the segments of sounds as well as how to decode and analyze words in the early grades. Figure 1.4 summarizes the components of these recommendations.

Figure 1.4: Reading Comprehension Instructional Practices for Grades K-3



Source: What Works Clearinghouse[33]

Instructional Coaching

To bolster the effectiveness of ELA teaching practices, many identified studies promote the use of literacy coaching and dedicated professional development. These opportunities supplement general teacher education and certification work to impart targeted strategies to educators in reading and writing classrooms.

In one study, for instance, researchers examined the efficacy of a content-based coaching program in schools serving high populations of minority and English language learner students. The initiative trained literacy coaches at the district level to work with teachers in a cohesive manner, so that targeted instruction for at-risk students was consistent between

[33] Figure text reproduced verbatim from source: "Foundational Skills to Support Reading for Understanding Kindergarten Through 3rd Grade." What Works Clearinghouse, July 2016, p. 2. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/wwc_foundationalreading_070516.pdf

schools. The content-based coaches then traveled to schools and worked with teachers both in groups and individually to disseminate effective instructional practices for students at risk for literacy issues. Coaches worked with teachers to lead high-quality, text-based discussions, develop student supports, facilitate interactive text discussions, and apply a "learner-centered lens" in creating lesson plans. To effectively support teachers, the coaches met with educators in grade-level teams on a weekly basis. After three years of the content-based coaching program, schools found that student reading achievement had improved (with particularly high benefits for ELL students) and teachers were leading higher-quality classroom text discussions.

INTERVENTION PROGRAMS

FAILURE FREE READING

Failure Free Reading seeks to offer "new hope for non-readers" by teaching reading "without phonics" and using "a combination of teaching, text and technology."[34] It is advertised for use with "the very lowest-achieving students."[35] The company offers ten "solutions," or packages designed for specific needs, including:

- Elementary (K-5)
- Secondary (6-12)
- Verbal Master
- Life Skills
- ELL
- RTI
- Deaf Education
- Train and Try
- Elementary Single Level
- Life Skills Single Level[36]

Overall, results of both causal and correlational studies suggest that Failure Free Reading has a neutral to positive impact on multiple measures of literacy among young, struggling readers. Most significantly, the only study of Failure Free Reading with a control group design found that the intervention has a substantively (but not significantly) positive effect on reading comprehension; however, the intervention had no noticeable effect on phonemic decoding or word reading accuracy and fluency.[37]

Correlational studies without control groups typically found that Failure Free Reading has a significantly positive effect on the literacy growth of struggling readers in early elementary school. In a study of 39 students in special education programs, for example, Rankhorn found that students receiving 30 minutes of Failure Free Reading instruction five days a week for

[34] "About Us – Why Failure Free Reading?" Failure Free Reading. https://www.failurefreeonline.com/n/why-failure-free.php
[35] "Frequently Asked Questions (FAQ)." Failure Free Reading. https://www.failurefreeonline.com/n/faq.php
[36] "Solutions." Failure Free Reading. https://www.failurefreeonline.com/n/reading_solutions.php
[37] Torgeson, J. et al. "National Assessment of Title I Interim Report, Volume II: Closing the Reading Gap." Institute of Education Sciences at the U.S. Department of Education, February 2006. https://www.failurefreeonline.com/n/casestudies/ClosingTheReadingGap_vol2.pdf

approximately seven months saw statistically significant score improvements on all sub-tests of the Woodcock Johnson Tests of Achievement.[38]

LEXIA READING

Lexia Reading, a product of Lexia Learning, offers preschoolers through Grade 12 students opportunities to "build, intensify, and accelerate" reading skills. Available as an application for Apple and Android devices, this is a technology-based and student-driven intervention. It focuses on five essential reading skills aligned with the Common Core State Standards: phonological awareness, phonics, vocabulary, fluency, and comprehension.[39] The producer and independent reviews emphasize the importance of Lexia Reading's "immediate feedback" and scaffolding, which may include "simplifying the task by reducing choices, adjusting the complexity of language, altering the presentation and visual components of the task or providing embedded support."[40]

FAST FORWORD

Fast ForWord is a product of Scientific Learning Products, with PK-12 reading, elementary language, and middle/high school literacy variations available.[41] Each FFW product is a computer-based training program that helps students develop mastery and confidence at their own pace, designed to support a Response to Intervention approach.[42] "The keys to the success of the Fast ForWord program are," the authors of one study write, "diligent attendance by the students in the program and successful completion of the program's exercises."[43]

Results from classroom settings yield potentially promising results. Specifically, independent studies show that Fast ForWord helps students make gains in reading and phonics overall, but cannot demonstrate comparative value over other treatments nor gains as large as those claimed by the producer. For example, Borman, Benson, and Overman studied 141 Grade 2 and 274 Grade 7 students in eight Baltimore City Public Schools sites. Students in the treatment group were tasked with 90-100-minute daily training sessions for the administration period, which was a minimum of 20 school days. In this non-clinical setting, they found an "exemplary" fidelity of implementation at all levels of programming, but "few

[38] Rankhorn, B., G. England, and S. Collins. "Effects of the Failure Free Reading Program on Students with Severe Reading Disabilities." *Journal of Learning Disabilities*, 31:3, June 1998. p. 309. EBSCO.
[39] "Lexia Reading." Lexia Learning. http://lexialearning.com/product/lexia-reading
[40] Dawson, G., and D'Souza, S. "Behavioral Interventions to Remediate Learning Disorders: A Technical Report." The University of Auckland. March 23, 2015. p. 58. https://www.ldaustralia.org/client/documents/NZ%20brain%20changing%20interventions%20report%20e.g.%20Arrowsmith.pdf#page=58
[41] "Products." Scientific Learning Products. http://www.scilearn.com/products
[42] See, e.g., "Fast ForWord Language v2." Scientific Learning Products. http://www.scilearn.com/products/fast-forword/language-series/language
[43] Borman, G.D., Benson, J.G., and Overman, L. "A Randomized Field Trial of the Fast ForWord Language Computer-Based Training Program." *Educational Evaluation and Policy Analysis* 31, 1 (Mar 2009): pp. 94-95. ProQuest Education.

encouraging signs of academic benefits approaching those claimed by the program's developers."[44]

Gillam et al. used Fast ForWord Language (FFW-L) as one of four randomly-assigned treatments — to ensure all students were given support, there was no traditional control group receiving no treatment — among a group of 216 children ages 6-9 years with language impairments. They found that children "who received FFW-L did not fare better than children in other language interventions of equal intensity," with one exception. In a measure of phonological awareness, FFW-L and computer-adaptive language intervention demonstrated longer-held gains over the other two treatments.[45] Loeb et al. tested a subgroup of the Gillam et al. study including 103 children ages 6-9 years, again with multiple treatments, finding short-term and long-terms gains among all treatments. They argue that the program's "acoustically modified speech was not a necessary component for improving phonemic awareness."[46]

READ 180

READ 180 is a product of Scholastic,[47] described on the vendor website as "the leading blended learning solution for struggling readers in grades 4-12+."[48] The 90-minute instructional model includes whole-group instruction (20 minutes), small group rotations (20 minutes in each rotation; 60 minutes total), and whole-group wrap-up (10 minutes). The small-group rotations consist of direct instruction, instructional software, or independent reading. The program is multi-modal and includes computer software, texts, workbooks, audiobooks, and CDs, as well as direct instruction in reading skills.[49]

This intervention exhibits many best practices in reading intervention modeling, according to research. Slavin et al., for instance, reviewed 33 studies on reading interventions in a meta-analysis of best practice. They commented that cooperative learning was a common feature of the successful reading interventions: "These programs all rely on a form of cooperative learning in which students work in small groups to help one another master reading skills and in which the success of the team depends on the individual learning of each team member." In addition, this study observes that mixed-method models, such as READ 180 and Voyager

[44] Ibid., Op. cit., p. 99.
[45] Gillam, R.B., et al. "The Efficacy of Fast ForWord Language Intervention in School-Age Children With Language Impairment: A Randomized Controlled Trial." *Journal of Speech, Language, and Hearing Research* 51, 1 (Feb 2008): 97-119. ProQuest Education.
[46] Loeb, D.F., et al. "The Effects of Fast ForWord Language on the Phonemic Awareness and Reading Skills of School-Age Children With Language Impairments and Poor Reading Skills." *American Journal of Speech-Language Pathology* 18, 4 (Nov 2009): 376-287. ProQuest Education.
[47] Houghton Mifflin Harcourt is in the process of acquiring Scholastic's educational technology and services businesses, which would include technology-based products like READ 180. See: "Houghton Mifflin Harcourt to Acquire Scholastic's Educational Technology and Services Business for $575 Million." Houghton Mifflin Harcourt. April 24, 2015. http://www.hmhco.com/media-center/press-releases/2015/april/scholastic-acquisition
[48] "READ 180." Scholastic. http://teacher.scholastic.com/products/read180/#
[49] "A Model for Blended Instruction." Houghton Mifflin Harcourt. http://www.hmhco.com/products/read-180/read-180-experience/3-models-of-blended-learning.htm

Passport, demonstrate "good evidence of effectiveness." Mixed-method models combine large-group, small-group, computer-assisted, and individual instruction.[50]

However, other research suggests that READ 180 is not necessarily better than other programming. Kim et al., for example, examined the use of the program with a sample of 294 Grade 4-6 students, who were randomly assigned to a treatment group for 4 days of instruction per week over a period of 23 weeks. They tested this intervention against a "district after-school program." Kim et al. found "no significant impact" of READ 180 on "norm-referenced measures of word reading efficiency and reading comprehension and vocabulary" compared to the district program, but they modified the READ 180 program to a 60-minute rather than 90-minute timeframe and eliminated "teacher-directed whole-group lessons."[51]

[50] Slavin, R.E., et al. "Effective Reading Programs for Middle and High Schools: A Best-Evidence Synthesis." *Reading Research Quarterly* 43, 3 (Jul-Sep 2008): pp. 292, 309. ProQuest Education.

[51] Kim, J.S., et al. "A randomized experiment of a mixed-methods literacy intervention for struggling readers in grades 4-6: effects on word reading efficiency, reading comprehension and vocabulary, and oral reading fluency." *Reading and Writing* 23, 9 (Oct 2010): 1109-1129. ProQuest Education.

SECTION II: INSTRUCTIONAL STRATEGIES FOR MATHEMATICS

In this section, Hanover Research discusses instructional strategies for mathematics. Findings in this section come primarily from empirical analyses, and are supplemented by resources provided by national organizations. These strategies address considerations at various levels of schooling, such that primary- and secondary-level interventions are presented together. The section concludes with brief summaries of intervention programs that exhibit these instructional strategies.

SUMMARY ANALYSIS

TEACHING PRACTICES

WWC offers five practice guides related to math instruction, mainly focused on instructional strategies for elementary and middle school students. The guides include:

- Teaching Math to Young Children
- Assisting Struggling Students with Mathematics: Response to Intervention (RtI) for Elementary and Middle Schools
- Developing Effective Fractions Instruction for Kindergarten Through 8th Grade
- Improving Mathematical Problem Solving in Grades 4 Through 8
- Teaching Strategies for Improving Algebra Knowledge in Middle and High School Students

The figure on the following pages reviews the recommendations from each practice guide, including an indication of the strength of evidence for each recommendation (Figure 2.1). In total, WWC produced 26 recommendations, of which four recommendations are supported by a strong level of evidence. Notably, consistent recommendations across grade levels and student subgroups supported by a strong level of evidence include:

- Explicit and systematic instruction in problem solving and related thought processes
- Explicit instruction in world problems
- Teaching students to use visual representations

Most importantly, teaching students to use problem solving strategies and reflect on their thought process and reasoning are critical strategies for promoting higher-order math skills. For struggling students, WWC guidelines for RtI emphasize early screening and intervention, as well as explicit instruction that focuses on teaching problem-solving strategies, using visual representations, and spending a small but important amount of time each day building basic

skills and promoting "fluent retrieval of mathematics facts." Finally, the report notes that supporting at-risk student motivation by monitoring progress and praising or otherwise rewarding student efforts may also be important. While this recommendation is not supported by evidence as strong as the instructional strategies noted in the guide, these practices may be helpful in supporting student engagement in math, which has an indirect impact on achievement.

Figure 2.1: WWC Recommendations for Mathematics Instruction

Recommendation	Level of Evidence
Elementary and Middle School Students	
Math for Preschool, Prekindergarten, and Kindergarten[52]	
Teach number and operations using a developmental progression.	Moderate
Teach geometry, patterns, measurement, and data analysis using a developmental progression.	Minimal
Use progress monitoring to ensure that math instruction builds on what each child knows.	Minimal
Teach children to view and describe their world mathematically.	Minimal
Dedicate time each day to teaching math, and integrate math instruction throughout the school day.	Minimal
Fractions Instruction for Kindergarten Through Grade 8[53]	
Build on students' informal understanding of sharing and proportionality to develop initial fraction concepts.	Minimal
Help students recognize that fractions are numbers and that they expand the number system beyond whole numbers. Use number lines as a central representational tool in teaching this and other fraction concepts from the early grades onward.	Moderate
Help students understand why procedures for computations with fractions make sense.	Moderate
Develop students' conceptual understanding of strategies for solving ratio, rate, and proportion problems before exposing them to cross-multiplication as a procedure to use to solve such problems.	Moderate
Professional development programs should place a high priority on improving teachers' understanding of fractions and of how to teach them.	Minimal
Mathematical Problem Solving in Grades 4-8[54]	
Prepare problems and use them in whole-class instruction.	Minimal
Assist students in monitoring and reflecting on the problem-solving process.	Strong
Teach students how to use visual representations.	Strong
Expose students to multiple problem-solving strategies.	Moderate
Help students recognize and articulate mathematical concepts and notation.	Moderate
Mathematics Instruction for Struggling Students in an RtI Framework[55]	

[52] "Teaching Math to Young Children." What Works Clearinghouse, November 2013, p. 11. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/early_math_pg_111313.pdf
[53] "Developing Effective Fractions Instruction for Kindergarten Through 8th Grade." What Works Clearinghouse, September 2010, p. 11. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/fractions_pg_093010.pdf
[54] "Improving Mathematical Problem Solving in Grades 4 Through 8." What Works Clearinghouse, May 2012, p. 9. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/mps_pg_052212.pdf
[55] "Assisting Students Struggling with Mathematics: Response to Intervention (RtI) for Elementary and Middle Schools." What Works Clearinghouse, p. 6. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/rti_math_pg_042109.pdf

Recommendation	Level of Evidence
Screen all students to identify those at risk for potential mathematics difficulties and provide interventions to students identified as at risk.	Moderate
Instructional materials for students receiving interventions should focus intensely on in-depth treatment of whole numbers in kindergarten through grade 5 and on rational numbers in grades 4 through 8. These materials should be selected by committee.	Low
Instruction during the intervention should be explicit and systematic. This includes providing models of proficient problem solving, verbalization of thought processes, guided practice, corrective feedback, and frequent cumulative review.	Strong
Interventions should include instruction on solving word problems that is based on common underlying structures.	Strong
Intervention materials should include opportunities for students to work with visual representations of mathematical ideas and interventionists should be proficient in the use of visual representations of mathematical ideas.	Moderate
Interventions at all grade levels should devote about 10 minutes in each session to building fluent retrieval of basic arithmetic facts.	Moderate
Monitor the progress of students receiving supplemental instruction and other students who are at risk.	Low
Include motivational strategies in tier 2 and tier 3 interventions.	Low
Secondary School Students	
Algebra Instruction[56]	
Use solved problems to engage students in analyzing algebraic reasoning and strategies.	Minimal
Teach students to utilize the structure of algebraic representations.	Minimal
Teach students to intentionally choose from alternative algebraic strategies when solving problems.	Moderate

Figure 2.2 on the following pages display a summary of five empirical studies that examine the impact of instructional practices on promoting minority student achievement in mathematics. Specifically, these analyses address how teaching practices can influence positive outcomes and draw data from classroom-level interventions. Where provided, effect sizes (Cohen's d) are reported based either on the researchers' calculations or those derived by WWC. For each study, Hanover provides an overview of the sample, a description of the study methodology, and the observed results. It is important to note that the amount of research-based studies related to mathematics instruction is limited in comparison to literacy. Thus, the table includes relatively fewer studies, one of which was published in 2003.

[56] "Teaching Strategies for Improving Algebra Knowledge in Middle and High School Students." What Works Clearinghouse, April 2015, p. 3. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/wwc_algebra_040715.pdf

Figure 2.2: Summary of Selected Evidence for Instructional Strategies for Mathematics

Author(s) and Year	WWC Recommendation	Grade(s)	Subgroup(s)	Outcome Domain	Effect Size	Intervention Description
Fuchs et al.*[57] 2003	▪ Explicit instruction on solving word problems	3	▪ African American (49%) ▪ FRPL (45%)	Word problems	2.09**	Students received explicit instruction problem solving via teacher demonstrations, student verbalizations, guide practice, and cumulative review.
Jitendra et al.[58] 2009	▪ Problem solving process ▪ Use visual representations ▪ Strategies for solving ratio, rate, and proportion problems	7	▪ Hispanic (22%) ▪ African American (22%) ▪ FRPL (42%)	Word problems involving numbers and operations	0.08-0.38	Students received instruction in monitoring, reflection, and the use of visual representations (schematic drawing).
Jitendra et al.[59] 2010	▪ Problem solving process ▪ Use visual representations	7	▪ Hispanic (14%) ▪ African American (23%) ▪ FRPL (43%)	Word problems involving numbers and operations	-0.01-0.21**	Students received instruction in monitoring, reflection, and the use of visual representations (schematic drawing).

Source: What Works Clearinghouse and individual publications
*Study meets WWC criteria with reservations
** Statistically significant ($p \leq 0.05$)

[57] Fuchs et al. "Explicitly Teaching for Transfer: Effects on Third-Grade Students' Mathematical Problem Solving." *Journal of Educational Psychology*, 2009. https://eric.ed.gov/?id=EJ671094
[58] Jitendra, A.K. et al. "Improving Seventh Grade Students' Learning of Ratio and Proportion: The Role of Schema-Based Instruction." *Contemporary Educational Psychology*, 42(3), 2009. https://dash.harvard.edu/bitstream/handle/1/9767982/STAR%20CEP%20manuscript%20053009.pdf?sequence=1
[59] Jitendra, A.K. et al. "Improving Students' Proportional Thinking Using Schema-Based Instruction." *Learning and Instruction*, 21(6), December 2011. https://eric.ed.gov/?id=EJ936843

INTERVENTION PROGRAMS

As described above, WWC Practice Guides recommend differentiated and/or targeted instruction for struggling and other at-risk students as a pedagogical approach to improve mathematics achievement. Therefore, this subsection highlights several intervention programs that have produced evidence of effectiveness in these small-group instructional settings.

Hanover reviewed the participant characteristics of the evidence used to support the effectiveness of each intervention program and selected only those programs with evidence of effectiveness serving underrepresented students such as minorities, English learners, and low-income students. Ultimately, four interventions met these qualifications: Cognitive Tutor Algebra I, DreamBox Learning, Saxon Math, and I CAN Learn Pre-Algebra and Algebra. Figure 2.3 on the following page summarizes the WWC's findings for these interventions, some of which have multiple entries. Brief profiles of each intervention follow, focusing on describing the intervention and summarizing key empirical studies of the efficacy of each program.

Figure 2.3: WWC Intervention Summary Reviews

Intervention	Subset	Grade Level(s)	Improvement Index*	Effectiveness Rating**	Extent of Evidence***
DreamBox Learning[60]	▪ 87% Hispanic ▪ 88% FRPL ▪ 81% English learners	K-1	4	Potentially positive	Small
Saxon Math[61]	▪ 31% African American ▪ 24% Hispanic ▪ 50% FRPL	1-5	3	Potentially positive	Medium to large
I CAN Learn Pre-Algebra and Algebra[62]	▪ 39% African American ▪ 19% Hispanic ▪ 44% FRPL	8	7	Positive	Medium to large
Cognitive Tutor Algebra I[63]	▪ 34% African American ▪ 32% Hispanic ▪ 52% FRPL	8	4	Positive	Medium to large

Source: What Works Clearinghouse
**A potentially positive rating indicates evidence that intervention had a positive effect on outcomes with no overriding contrary evidence. A positive rating indicates strong evidence that intervention had a positive effect on outcomes. ***A small extent of evidence includes only one study, or one school, or findings based on a total sample size of less than 350 students and 14 classrooms (assuming 25 students in a class). A medium to large extent of evidence includes more than one study, more than one school, and findings based on a total sample of at least 350 students or 14 classrooms.

TEACHING PRACTICES

The following pages synthesize the strategies from the IES report and recommendations, a similar report produced in 2016 by the American Institutes for Research's National Center on Intensive Intervention (NCII), and additional literature on increasing the math achievement of struggling students. A summary of major instructional strategies emerging from these reports is provided in Figure 2.4.

[60] [1] "Intervention Evidence Snapshot: DreamBox Learning." What Works Clearinghouse. https://ies.ed.gov/ncee/wwc/EvidenceSnapshot/627 [2] "Intervention Report: DreamBox Learning." What Works Clearinghouse, December 2013, p. 1. https://ies.ed.gov/ncee/wwc/Docs/InterventionReports/wwc_dreambox_121013.pdf

[61] [1] "Intervention Evidence Snapshot: Saxon Math." What Works Clearinghouse. https://ies.ed.gov/ncee/wwc/EvidenceSnapshot/447 [2] "Intervention Report: Saxon Math." What Works Clearinghouse, May 2013. https://ies.ed.gov/ncee/wwc/Docs/InterventionReports/wwc_saxon_052913.pdf

[62] [1] "Intervention Evidence Snapshot: I CAN Learn Pre-Algebra and Algebra." What Works Clearinghouse. https://ies.ed.gov/ncee/wwc/EvidenceSnapshot/228 [2] "Intervention Report: I CAN Learn Pre-Algebra and Algebra." What Works Clearinghouse, March 2009. https://ies.ed.gov/ncee/wwc/Docs/InterventionReports/wwc_icanlearn_031009.pdf

[63] [1] "Intervention Evidence Snapshot: Cognitive Tutor Algebra I." What Works Clearinghouse. https://ies.ed.gov/ncee/wwc/EvidenceSnapshot/655 [2] "Intervention Report: Cognitive Tutor Algebra I." What Works Clearinghouse, June 2016. https://ies.ed.gov/ncee/wwc/Docs/InterventionReports/wwc_cognitivetutor_122116.pdf

Figure 2.4: Instructional Practices to Improve Math Achievement Among Underrepresented Students

- ✓ Higher order thinking skills and a focus on advanced instruction over basic skills
- ✓ Use of both direct instruction and "discovery learning"
- ✓ Project-based work and hands-on learning experiences
- ✓ Instruction that promotes student engagement
- ✓ Time on-task during math class

Source: Multiple

Most notably, studies suggest that effective math instruction focuses on higher order thinking skills and problem-solving over basic math skills, as well as teaching strategies associated with higher student engagement, such as project work and hands-on learning experiences. For example, Crosnoe et al. found that elementary school students performed better on math assessments when they had teachers who focused on "inference-based instruction" over instruction in basic skills. In the study, inference-based instruction included "a broad dimension of academic activities encompassing analysis, inference, and synthesis."[64]

However, while inference-based instruction is associated with higher achievement, some studies also found value in teaching math with a combination of explicit instruction in addition to "discovery" learning. For example, Star and Rittle-Johnson found positive results from small group instruction that encouraged Grade 7 students to come up with their own strategies to solve math problems, as well as instruction in which teachers explicitly taught problem-solving strategies and demonstrating multiple methods to solve math problems. The strongest effects were observed for student groups who experienced both direct instruction and were encouraged to identify their own strategies to solve math problems.[65]

Finally, at least one study identified "time on-task during math class" as a factor associated with improved achievement among African American students, indicating that appropriate scheduling for math instruction, in addition to teacher preparation and strong classroom management skills also play a role in ensuring appropriate instruction.

PRACTICES FOR ELL STUDENTS

Many studies that examined the achievement gap among minority students focused specifically on language minority students; in this case, Hanover focused on Hispanic ELL students whenever possible.

[64] Crosnoe, R. et al. "Instruction, Teacher–Student Relations, and Math Achievement Trajectories in Elementary School." American Psychological Association, *Journal of Educational Psycholo*gy, 102:2, 2010, pp. 407-417. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2908253/pdf/nihms191709.pdf

[65] Star, J.R. and Rittle-Johnson, B. "Flexibility in Problem-Solving: The Case of Equation Solving." *Learning and Instruction*, 18:6, 2008, pp. 565-579. http://www.sciencedirect.com/science/article/pii/S0959475207001120

Because ELL students are still mastering the English language, math word problems present a particular challenge. A 2010 survey published by the *Bilingual Research Journal* found that, across three middle schools in three states, teachers commonly reported believing that "mathematics should be easy for ELLs because it is a 'universal language.'"[66] However, this belief can be harmful for ELL students because of the need for math instruction to include elements of vocabulary and literacy instruction. For example, a recent study of Grade 4 student performance on the Massachusetts Comprehensive Assessment System (MCAS) found that ELL student scores were influenced by their lack of understanding of common words such as "certain, likely, unlikely, and impossible." These words are more likely to be understood by native English speakers, leaving ELL students at a clear disadvantage; even if the students possess the math skills and knowledge needed to solve the problem, they may not understand the use of certain vocabulary in context.[67]

At least one empirical study included in this analysis found that a large amount of teacher-directed, whole-class instruction had a negative impact on Hispanic ELL students, although these practices were beneficial to other student groups, such as Black, English-speaking students.[68] However, a 2008 study of ELL instruction in the content areas found that math instruction was "underresearched" compared to other subjects, largely due to the belief that math is less-dependent on language than, for example, science or history. In the study, researchers drew from a variety of sources, including studies of how ELL students learn math, case studies of ELL and bilingual classrooms, and expert guidance on instructional strategies.

WWC also offers a practitioner guide for ELL students: "Teaching Academic Content and Literacy to English Learners in Elementary and Middle School." The recommendations in this guide focus on strategies to support ELLs in both language acquisition and learning in the content areas, including math. Notably, the recommendations with the strongest evidence base involve teaching academic vocabulary words (such as math terms) and integrating English language instruction into content area instruction, including using visual representations, explicitly teaching academic vocabulary words in the content areas, and providing opportunities for students to read and write about subject areas (in this case math) to increase student exposure to and understanding of content-area terminology.[69]

This study's recommendations for teaching in math as a content area, as well as strategies that emerged from Hanover's review of the literature, are included in the figure below.

[66] Hansen-Thomas, H. "What do Mainstream Middle School Teachers Think About Their English Language Learners? A Tri-State Case Study." *Bilingual Research Journal*, 33:2, 2010. Accessed through: EBSCO Host.

[67] Martinello, M. "Language and the Performance of English-Language Learners in Math Word Problems." *Harvard Educational Review*, 78:2, 2008, p. 361. Accessed through: ProQuest.

[68] Chang, M. "Teacher Instructional Practices and Language Minority Students: A Longitudinal Model." *Journal of Educational Research*, November 1, 2008. Accessed through: EBSCO Host.

[69] "Teaching Academic Content and Literacy to English Learners in Elementary and Middle School." What Works Clearinghouse, April 2014. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/english_learners_pg_040114.pdf

Figure 2.5: Instructional Practices to Improve Math Achievement among ELL Students

- Use explicit instruction to support student learning
- Consistent use of "math terminology," with clear explanations
- Require students to participate in oral discussions in class, and to use precise math terminology
- Use discourse strategies such prompting students to clarifying their statements and/or explaining their reasoning; rephrase their statements in more formal math terms; and ask questions
- Reduce whole-class instructional activities

Source: Multiple[70]

EXPLICIT AND SYSTEMATIC INSTRUCTION

Research consistently finds that *explicit and systematic instruction* is highly effective for students struggling with math, and "provide[s] in-depth coverage of the most critical content areas of mathematics and reflect[s] current research on effective mathematics instruction."[71] According to the National Mathematics Advisory Panel's (NMAP) 2008 final report, explicit instruction aids in solving word problems, computation, and transferring known skills to novel situations – particularly for students with learning disabilities and low-achieving students.[72]

Explicit, systematic math instruction requires clearly teaching the steps involved in solving or understanding a problem or using a strategy.[73] Instruction can be direct and explicit regardless of the topic, and can take many forms. The NMAP defines explicit instruction as including the following requirements:[74]

- Teachers provide clear models for solving a problem type using an array of examples;
- Students receive extensive practice in use of newly learned strategies and skills;
- Students are provided with opportunities to think aloud (i.e., talk through the decisions they make and the steps they take); and

[70] [1] Janzen, J. "Teaching English Language Learners in the Content Areas." *Review of Educational Research*, 78:4, 2008, p. 1017-1021. Accessed through: ProQuest. [2] Calderón, M. "Effective Instruction for English Learners." Aiming High, Sonoma County Office of Education, 2006. https://www.scoe.org/docs/ah/AH_calderon.pdf

[71] Doabler, C.T. et al. "Enhancing Core Mathematics Instruction for Students at Risk for Mathematics Disabilities." *Teaching Exceptional Children*, 44:4, April 2012. p. 48. Accessed via ProQuest.

[72] Faulkner, L. et al. "The Final Report of the National Mathematics Advisory Panel." U.S. Department of Education, 2008. p. 48. https://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

[73] [1] "Principles for Designing Intervention in Mathematics." National Center on Intensive Intervention, 2016. pp. 3–4. http://www.intensiveintervention.org/sites/default/files/Princip_Effect_Math_508.pdf [2] Vaughn, S. et al. "Intensive Interventions for Students Struggling in Reading and Mathematics." Center on Instruction, 2012. p. 17. http://files.eric.ed.gov/fulltext/ED531907.pdf

[74] Bullet points quoted verbatim from: Faulkner et al., Op. cit., p. xxiii.

- Students are provided with extensive feedback.

Similar to the NMAP's findings, the WWC practice guide for assisting students struggling with mathematics finds strong evidence for the effectiveness of explicit and systematic mathematics instruction and includes the practice as a key recommendation for teaching students struggling with math. The figure at right notes recommendations from the IES regarding systematic math instruction, focusing on instructional materials, class structure, and review.[75]

COMPONENTS OF EXPLICIT SYSTEMATIC INSTRUCTION

- **Ensure that instructional materials are systematic and explicit. In particular, they should include numerous clear models of easy and difficult problems, with accompanying teacher think-alouds.**
- **Provide students with opportunities to solve problems in a group and communicate problem-solving strategies.**
- **Ensure that instructional materials include cumulative review in each session.**

Explicit instruction requires the instructor to clearly model how to apply a skill or solve a problem, offer step-by-step instruction, and provide students with time to practice.[76] When modeling the steps to solve a problem, the WWC recommends that teachers "think aloud" and share their thinking processes. Explaining the reasoning behind each step helps students to understand the underlying mathematics. To provide instruction that is also systematic, instructors "should gradually build proficiency by introducing concepts in a logical order and by providing students with numerous applications of each concept." [77] Additionally, each lesson should include cumulative review, which helps students practice previously taught concepts, remember what they learned, and make connections between math concepts. For example, when practicing fractions, students could also practice their multiplication and division skills.[78] These steps, as well as further essential components of explicit and systematic instruction, are presented in Figure 2.6 below.

[75] Bullet points quoted verbatim from: Gersten, Beckmann, et al., Op. cit., pp. 21–24.
[76] "Principles for Designing Intervention in Mathematics," Op. cit., pp. 3–4.
[77] Gersten, Beckmann, et al., Op. cit., pp. 21–24.
[78] Ibid.

Figure 2.6: Components of Explicit and Systematic Instruction

Source: National Center on Intensive Intervention[79]

Multiple meta-analyses of studies conducted in the past twenty years indicate that explicit direct instruction is effective for the general student body, students struggling to learn math, and students with demonstrated math difficulties. For example, a 2009 meta-analysis by Gersten et al. in *Review of Education Research* analyzed 11 studies of math interventions for low-achieving students and found that explicit instruction had an overall significant mean

[79] Figure content quoted verbatim with modification from: "Principles for Designing Intervention in Mathematics," Op. cit., pp. 3–4.

effect size of 1.22 on student math achievement.[80] Additionally, in a meta-analysis in *Remedial and Special Education*, researchers analyzed 58 studies of math interventions for elementary students with special needs, focusing on interventions dealing with preparatory math, basic skills, and problem-solving strategies. Interventions that provided direct instruction had a mean effect size of 1.13.[81]

VISUAL REPRESENTATIONS

Math instruction that uses concrete manipulatives and visual representations can help students who struggle with math, with a mean effect size of 0.47 as measured through a 2008 meta-analysis.[82] Students often struggle to grasp the abstract, conceptual nature of math, and thus providing students with concrete or visual examples facilitates connections and a deeper understanding.[83] The Center on Instruction (COI) recommends teaching students to visually represent information when solving a math problem, arguing that the systematic use of visuals positively affects the math outcomes of struggling students and students with disabilities by clarifying and simplifying problems.[84] The most common types of visual aides are drawings, number lines, diagrams, and graphs, while concrete manipulatives can include tiles, counting bears, money, and blocks.[85]

Empirical studies find that visual aids are more effective when used by *both* the teacher and the student, and that the most effective visuals address a specific problem type.[86] The WWC recommends using visual representations "extensively and consistently" and suggests interventionists "explicitly link visual representations with the standard symbolic representations used in mathematics."[87]

SOLVING WORD PROBLEMS

Students should learn to categorize the structures of word problem types and strategies for solving different problem types.[88] The WWC, which rates the evidence supporting word problem instruction as "strong" based on empirical review, recommends explicitly teaching

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[80] Gersten, R. et al. "Mathematics Instruction for Students with Learning Disabilities: A Meta-Analysis of Instructional Components." *Review of Educational Research*, 79:3, 2009. p. 1216. https://www.researchgate.net/profile/Russell_Gersten/publication/258182785_Mathematics_Instruction_for_Students_With_Learning_Disabilities_A_Meta-Analysis_of_Instructional_Components/links/00b49537d097c25025000000.pdf

[81] Kroesbergen, E.H. and J.E.H. van Luit. "Mathematics Interventions for Children with Special Educational Needs: A Meta-Analysis." *Remedial & Special Education*, 24:2, April 3, 2003. pp. 109–111. Accessed via EbscoHost.

[82] Jayanthi, M., R. Gersten, and S. Baker. "Mathematics Instruction for Students with Learning Disabilities or Difficulty Learning Mathematics." Center on Instruction, 2008. p. 8. http://www.centeroninstruction.org/files/Mathematics%20Instruction%20LD%20Guide%20for%20Teachers.pdf

[83] Gersten, Beckmann, et al., Op. cit., pp. 30–33.

[84] Jayanthi, Gersten, and Baker. Op. cit. p. 8.

[85] [1]"Principles for Designing Intervention in Mathematics." Op. cit. p. 5. [2] Barnett, J.E.H. and S. Cleary. "Review of Evidence-Based Mathematics Interventions for Students with Autism Spectrum Disorders." *Education and Training in Autism and Developmental Disabilities*, 50:2, June 2015. p. 174. Accessed via ProQuest.

[86] Jayanthi, Gersten, and Baker, Op. cit., p. 8.

[87] Gersten, Beckmann, et al., Op. cit., p. 31.

[88] Ibid., pp. 26–29.

students about the underlying structures of word problems with similar mathematical structures. Teachers should also help students to identify the relevant elements of the problem, such as numbers and vocabulary, and distinguish them from superficial elements of the problem, such as the problem's format (e.g., a story or advertisement). Once students are familiar with the underlying structure of word problem types and can identify relevant features, students can apply their knowledge of how to solve underlying structures of familiar problems to new, unfamiliar problems.

INTERVENTION PROGRAMS

DREAMBOX LEARNING

WWC found that DreamBox Learning has potentially positive effects on students' mathematics achievement based on one study that meets standards. The reviewed study included nearly 600 students in Grades K-1, including Hispanic (87 percent), low-income (88 percent), and English learner (81 percent) students in an urban setting in California.[89]

DreamBox Learning works is a supplemental program for students in grades K-5 delivered via an online platform. Based on curricular standards from the National Council of Teachers of Mathematics, the software allows students to progress at their own pace via online modules that feature math games and problem solving puzzles accompanied by virtual manipulatives. Notably, the adaptive software allows teachers and administrators to observe student progress in real time.[90]

SAXON MATH

WWC found that Saxon Math has potentially positive effects on students' mathematics achievement based on two studies that meet standards. The reviewed studies included over 2,300 students in Grades 1-5, including African American (31 percent), Hispanic (24 percent), and low-income (50 percent) students in rural, suburban, and urban settings throughout the United States.[91]

Unlike the other programs identified in this report, Saxon Math is a core curriculum based on an incremental approach to mathematics instruction. The instruction emphasizes "math conversations that engage students in learning, as well as continuous practice with hands-on activities, manipulatives, and paper-pencil methods."[92]

I CAN LEARN PRE-ALGEBRA AND ALGEBRA

WWC found that I CAN Learn Pre-Algebra and Algebra has positive effects on students' mathematics achievement based on four studies that meet standards. The reviewed studies included nearly 10,000 students in Grade 8, including African American (39 percent), Hispanic

[89] "Intervention Evidence Snapshot: DreamBox Learning," Op. cit.
[90] "Intervention Report: DreamBox Learning," Op. cit.
[91] "Intervention Evidence Snapshot: Saxon Math," Op. cit.
[92] "Intervention Report: Saxon Math," Op. cit.

(19 percent), and low-income (44 percent) students in urban settings.[93] The widely implemented intervention program is delivered online and accompanied by instructional video and multimedia lessons. The curricula are designed to be compatible with state, district, and school standards.[94]

COGNITIVE TUTOR ALGEBRA I

WWC found that Cognitive Tutor Algebra has positive effects on students' Algebra performance based on five studies that meet standards. The reviewed studies included nearly 7,000 students in Grade 8, including African American (34 percent), Hispanic (32 percent), and low-income (52 percent) students in rural, suburban, and urban settings.[95]

The intervention works as a supplement to standard mathematics instruction and includes both text- and software-based instruction. The intervention promotes problem skills and encourages students to articulate their problem-solving process with teachers and classmates. The program also "emphasize[s] connections between verbal, numeric, graphic, and algebraic representations."[96] Finally, the program features several instructional strategies supported by empirical research, "including real world problems, peer review of student work, step-by-step demonstrations on how to solve example problems, hands-on tools including manipulatives and technology, graphic representations of mathematical concepts, and classroom discussions and explanations about mathematical understandings and key concepts."[97]

[93] "Intervention Evidence Snapshot: I CAN Learn Pre-Algebra and Algebra," Op. cit.
[94] "Intervention Report: I CAN Learn Pre-Algebra and Algebra," Op. cit.
[95] "Intervention Evidence Snapshot: Cognitive Tutor Algebra I," Op. cit.
[96] "Intervention Report: Cognitive Tutor Algebra I," Op. cit.
[97] Ibid.

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