Summaries of the Empirical Studies Included in *The New Classroom Instruction That Works*

Study	Summary	Strategies
Anand, P. G., & Ross, S. M. (1987). Using computer-assisted instruction to personalize arithmetic materials for elementary school children. *Journal of Educational Psychology, 79*(1), 72. https://www.doi.org/10.1037/0022-0663.79.1.72	Anand and Ross (1987) compared the effects of providing 5th and 6th grade students (n = 48) with three different versions of a computer-assisted lesson on division of fractions. In the first condition, personal information about the student (friends, interests, and hobbies) were incorporated into math problems. In the second condition, problems were presented with concrete (realistic, but still hypothetical) contexts. In the third condition, problems were presented in a traditional abstract format. Posttest outcomes in solving standard and transfer problems favored the personalized-context group over both the concrete representations group (improvement index = 31) and the abstract representations control group (improvement index = 44). Students in the personalized problems group also demonstrated higher motivation (i.e., task attitudes) than students in the other groups. Findings suggest the benefits of using personalized examples for motivation and meaningful learning of problem-solving procedures.	Cognitive interest cues
August, D., Branum-Martin, L., Cardenas-Hagan, E., & Francis, D. J. (2009). The impact of an instructional intervention on the science and language learning of middle grade English language learners. *Journal of Research on Educational Effectiveness*, *2*(4), 345–376. https://www.doi.org/10.1080/19345740903217623	August and colleagues (2009) compared the effectiveness of a multi-component intervention (Quality English and Science Teaching—QuEST) designed to improve the biological science knowledge and academic language of middle grades English language learners (n = 890) studying science in their second language versus traditional instruction in their district's regular curriculum. Instruction for students in the treatment condition was guided by instructional materials based on the BSCS 5E model of inquiry-based science learning and included (1) cues for cognitive interest; (2) direct instruction of 15 new academic (e.g., development, function) and discipline-specific vocabulary words (e.g., organism, cell) per week; (3) visual representations of learned concepts; (4) strategy instruction in word learning (e.g., drawing on cognate knowledge, root words, and base words); (5) paired, cooperative learning; and (6) hands-on, inquiry-based learning through lab experiments and writing assignments. After seven weeks of intervention, ELL students in the treatment group demonstrated greater science learning (improvement index = 11) and vocabulary knowledge (improvement index = 13) than ELL students in the control group. Researchers noted that if extrapolated to a full year of learning, these gains would be substantial for both vocabulary (improvement index = 27) and science learning (improvement index = 34).	Cognitive interest cues Vocabulary instruction Strategy instruction and modeling Visualizations and concrete examples Guided investigations
Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child development*, *78*(1), 246–263. https://www.doi.org/10.1111/j.1467-8624.2007.00995.x	Through a series of eight 25-minute lessons, Blackwell and colleagues (2007) taught a randomly selected group of mostly nonwhite (52% African American and 45% Latinx) 7th grade students who were previously low achieving in mathematics that they could grow their intelligence and abilities through effort. Class readings, discussions, and activities impressed upon students that, like muscles, brains grow stronger with frequent use, and they could control this as learners. By the end of the semester, students in the treatment group not only exhibited greater growth mindset but also reversed previous declines in grades in mathematics, achieving significantly higher grades (improvement index = 28) than control-group students who spent the eight sessions learning about the science of memory.	Student goal setting and monitoring

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Study	Summary	Strategies
Bottge, B. A., Heinrichs, M., Mehta, Z. D., & Hung, Y. H. (2002). Weighing the benefits of anchored math instruction for students with disabilities in general education classes. *The Journal of Special Education, 35*(4), 186–200. https://www.doi.org/10.1177/002246690203500401	Bottge and colleagues (2002) compared the effects of “enhanced anchored instruction” vs. traditional instruction in the problem-solving performance of 42 7th grade students in two classes, including 8 students with learning disabilities. Students in the treatment group engaged first watched a video that featured three students attempting to calculate the costs and sales tax of lumber and materials needed to build a skateboard ramp and pooling money to buy the materials and offsetting their costs with found materials. Students in the control group were taught an eight-step process for solving word problems of similar complexity (e.g., calculating the dimensions and costs of wallpaper). No immediate effects were found for the enhanced anchored instruction on tests of comprehension and word-problem solving ability; however, students in the anchored instruction group scored significantly higher than the control group on two later performance assessments measuring their ability to watch a similar video and develop a solution method (improvement index = 29 for Class 1 and 26 for Class 2) and to apply classroom learning to parse and solve a complex, real-life problems (improvement index = 34 for Class 1 and 21 for Class 2). Overall, the findings suggest that framing learning as complex, real-life problems supports students’ ability to master both content and complex problem-solving skills.	Cognitive interest cues Visualizations and concrete examples Structured problem solving
Bottge, B. A., Ma, X., Gassaway, L., Toland, M. D., Butler, M., & Cho, S. J. (2014). Effects of blended instructional models on math performance. *Exceptional Children*, *80*(4), 423–437. https://www.doi.org/10.1177/0014402914527240	Bottge and colleagues (2014) examined the effects of a pull-out program for students with learning disabilities (n = 335) that combined enhanced anchored instruction with direct instruction for solving math problems. Specifically, students in the treatment condition engaged in five units (90-plus days) of math instruction that integrated computer-based interactive lessons, math manipulatives (e.g., fraction strips) to help students visualize abstract concepts, videos to anchor math formulas to real-life situations, and hands-on learning activities projects to develop their understanding of, and ability to use, math formulas and computations to solve complex problems (e.g., calculating the correct slope for a ramp to achieve a specified velocity for a model car). Students randomly assigned to business-as-usual instruction engaged in learning similar content through teacher-led class lectures, class discussions, textbook readings, and independent problem solving. At the end of five units of study, students receiving enhanced anchored instruction significantly outperformed those in business-as-usual classrooms on posttests measures of students’ fraction computations (improvement index = 26) and problem-solving skills (improvement index = 15), demonstrating the benefits of engaging students in more in-depth, interest-provoking, complex, hands-on, real-world problems to help them understand both the how and why of what they are learning.	Cognitive interest cues Visualizations and concrete examples Strategy instruction and modeling Structured problem solving

Study	Summary	Strategies
Bottge, B. A., Toland, M. D., Gassaway, L., Butler, M., Choo, S., Griffen, A. K., & Ma, X. (2015). Impact of enhanced anchored instruction in inclusive math classrooms. *Exceptional Children, 81*(2), 158–175. https://www.doi.org/10.1177/0014402914551742	Bottge and colleagues (2015) demonstrated that providing high school students with "enhanced anchored instruction"—computer-based videos and hands-on activities designed to stimulate student interest in math—significantly improved both their interest in and learning of mathematics. For example, one unit began with a video of three friends attempting to build a skateboard ramp on a budget, which required them to make measurements, convert feet to inches, calculate sales taxes, and solve other complex math problems. Another unit started with a video that featured two girls attempting to predict where on a ramp to release model cars to successfully navigate five tricks—loops, flips, and the like. Meanwhile, students in the business-as-usual control group learned similar concepts through traditional methods such as reviewing previous lessons and solving word problems. In the end, students with and without learning disabilities in the enhanced anchored instruction group significantly outperformed their matched peers in the control group on a basic skills test (improvement index = 11 and 23, for students with and without disabilities, respectively) and a more complex problem-solving test (improvement index = 18 and 15, respectively).	Cognitive interest cues Structured problem solving
Brown, B. A., Ryoo, K., & Rodriguez, J. (2010). Pathway towards fluency: Using 'disaggregate instruction' to promote science literacy. *International Journal of Science Education, 32*(11), 1465–1493. https://www.doi.org/10.1080/09500690903117921	Brown and colleagues (2010) examined the effects of "disaggregate instruction" for teaching science concepts to 5th grade students (n = 49) in a diverse, low-SES school. Both treatment and control groups of students engaged in a science unit on photosynthesis. Treatment group instruction scaffolded students' development and use of academic vocabulary by initially building conceptual understanding through an inquiry-based approach that employed students' own everyday language to grasp concepts prior to introducing and building academic vocabulary. Control group students were taught scientific concepts and academic vocabulary concurrently. Comparative analysis of learning gains between pre- and post-tests understanding demonstrated significant effects for the treatment condition (improvement index = 32) of scaffolding academic vocabulary by building conceptual understand first through everyday language.	Vocabulary instruction
Bulgren, J. A., Deshler, D. D., Schumaker, J. B., & Lenz, B. K. (2000). The use and effectiveness of analogical instruction in diverse secondary content classrooms. *Journal of Educational Psychology, 92*(3), 426–441. https://www.doi.org/10.1037/0022-0663.92.3.426	Bulgren and colleagues (2000) examined the effects of using analogies to help students connect new concepts to prior knowledge (e.g., connecting warm-blooded animals' ability to regulate body temperature to temperature control systems in modern building) when engaged in science learning. The study sample included 83 students of varied prior achievement in science taught in eight high school classrooms in three midwestern high schools. Students in the randomly assigned treatment group were taught with scripted lessons and a structured process (i.e., an anchoring table and routine) to connect the familiar concept of military structure to the biological concept of the pyramid of numbers (e.g., the number of living things is greater at the bottom of the food pyramid than the top) and a story of a lemonade stand to understand the concept of commensalism (e.g., relationships between living creatures in which one benefits without benefiting or harming another). Students in the control group received traditional instruction on these topics. On a posttest of conceptual knowledge, students in the treatment conditions demonstrated significantly greater understanding of the pyramid of numbers (improvement index = 23) and commensualism (improvement index = 34).	Visualizations and concrete examples

Study	Summary	Strategies
Cardelle-Elawar, M. (1990). Effects of feedback tailored to bilingual students' mathematics needs on verbal problem solving. *The Elementary School Journal, 91*(2), 165–175. https://www.doi.org/10.1086/461644	Cardelle-Elawar (1990) studied the effects of teaching preservice teachers to provide individually tailored feedback to low-performing bilingual 6th grade students (*n* = 80) while they engaged in initial application of new math problem-solving methods. The treatment reflected a metacognitive approach to mathematics problem solving that emphasized four processes: translation (understanding English sentences and facts in order to make a mental representation of the problem), integration (combining statements into a coherent representation), planning and monitoring (focusing on how to solve the problem by breaking it into subproblems and developing a sequence for solving the problem), and solution execution (applying procedures and rules to accurately and efficiently carry out the calculations to solve the problem). Control group students received business-as-usual instruction (lectures followed by solving problems on the board without student involvement and correct answer feedback instead of guiding students to find answers or tailoring feedback to their learning needs). Posttests results of mathematics problem-solving ability showed significant treatment effects after six hours of feedback for both males (improvement index = 50) and females (improvement index = 49). Results suggest descriptive feedback (versus providing students with correct answers) helps students think through problem-solving processes can benefit bilingual students.	Guided initial application with formative feedback
Carlo, M. S., August, D., McLaughlin, B., Snow, C. E., Dressler, C., Lippman, D. N., Lively, T. J., & White, C. E. (2004). Closing the gap: Addressing the vocabulary needs of English- language learners in bilingual and mainstream classrooms. *Reading Research Quarterly, 39*(2), 188–215. https://www.doi.org/10.1598/RRQ.39.2.3	Carlo and colleagues (2004) examined the effects providing 5th grade students that included English-language learners and English-only speakers (*n* = 254) with direct instruction in word analysis and vocabulary learning strategies. Over a 15-week period, students in the treatment condition were given 30–45 minutes of instruction four days per week in 12–14 target words per week along with strategies for using context clues, morphology (i.e., different forms of words such as election, elect, electing), and cognates (i.e., words similar in Spanish and English such as *frigid* and *frio*) to infer word meaning and connotations. Spanish speakers in the treatment group were also given preview text in Spanish prior to whole-group lessons. Students in the control group received business-as-usual instruction. After the intervention, which included whole-class instruction and cooperative learning in heterogenous groups, treatment group students demonstrated greater word mastery (improvement index = 13) in equal degrees among ELL and English-only students with less dramatic improvements in reading comprehension (improvement index = 3). Results, however, varied considerably across schools and classrooms, which suggests that schoolwide supports for teacher professional learning and change are critical.	Vocabulary instruction Strategy instruction and modeling Peer-assisted consolidation of learning

Study	Summary	Strategies
Carpenter, S. K., Pashler, H., & Cepeda, N. J. (2009). Using tests to enhance 8th grade students' retention of U.S. history facts. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition, 23*(6), 760–771. https://www.doi.org/10.1002/acp.1507	Carpenter and colleagues (2009) examined the effects of quizzing 8th grade students on their retention of U.S. history facts. For the study, students were divided into two groups: (1) an immediate review group, which studied and were quizzed on content from the history course one week after the end of the course; and (2) a delayed review group which studied and were quizzed on course content 16 weeks after the end of the course. Both groups received a study packet that contained 15 items with both questions and answers (e.g., *Who assassinated Abraham Lincoln? John Wilkes Booth*) that students were encouraged to study (reviewing both questions and answers), and 15 questions without answers which served as retrieval practice/quizzing to remember items. A full school year (36 weeks) later, students were retested on course content with a 45-item test that included 30 questions from the study packets and 15 items that they had not reviewed. Overall, students appeared to retain only about 10 percent of what they had learned (scoring less than 3 of 30 possible points on items they had not reviewed) yet demonstrated significantly greater retention on items reviewed via retrieval practice. Findings demonstrate significant effects for retrieval practice over review (improvement index = 13) and even greater effects for retrieval practice over no review at all (improvement index = 23). Few differences in performance emerged between items students studied and those they did not review at all.	Retrieval practice (quizzing to remember)
Clariana, R. B., & Koul, R. (2006). The effects of different forms of feedback on fuzzy and verbatim memory of science principles. *British Journal of Educational Psychology, 76*(2), 259–270. https://www.doi.org/10.1348/000709905X39134	Clariana and Koul (2006) compared the effects of providing high school students (*n* = 82) with three different forms of feedback to high-level questions (e.g., analytical, inference, application) embedded in science workbooks: (1) delayed feedback (providing correct answers to questions at the end of the workbook), (2) knowledge of correct response immediate feedback (providing "scratch-off" answers to reveal correct answers to multiple-choice questions), and (3) multiple-try immediate feedback ("scratch off" answers with "try again" messages next to incorrect answers), and two control conditions, (4) questions without feedback, and (5) text only. Five days later, students were tested using items that repeated new learning content verbatim as well as items that paraphrased original content. On verbatim items, treatment effects (compared to the text-only control group) were as follows: delayed feedback (improvement index = 32), immediate feedback (improvement index = 24), multiple-try immediate feedback (improvement index = 7), questions without feedback (improvement index = 16). On paraphrased items, treatment effects (compared to the text-only control group) were as follows: delayed feedback (improvement index = 8), immediate feedback (improvement index = 7), multiple-try immediate feedback (improvement index = 24) questions without feedback (improvement index = 7). Researchers observed that memory often consists of multiple mental connections (a "fuzzy-trace"); thus, multiple attempts to retrieve learning and receive feedback appear to support learning when recall prompts are similarly open-ended or "fuzzy" and less effective when prompted for more simplistic and precise verbatim recall. Delayed feedback appeared to most effective on verbatim measures of learning. Findings suggest that providing students with immediate, nondirective feedback supports deeper learning and ability to transfer learning to novel (nonverbatim) problems.	High-level questions and student explanations

Study	Summary	Strategies
Collins, J. L., Lee, J., Fox, J. D., & Madigan, T. P. (2017). Bringing together reading and writing: An experimental study of writing intensive reading comprehension in low-performing urban elementary schools. *Reading Research Quarterly, 52*(3), 311–332. https://www.doi.org/10.1002/rrq.175	Collins and colleagues (2017) examined effects of a multiyear assisted writing intervention on reading comprehension of 4th and 5th grade students (*n* = 1,062) in low-performing urban schools. Students in the treatment condition received a curricular intervention called Writing Intensive Reading Comprehension, which scaffolded student writing with interactive "thinksheets" and graphic organizers designed to help students extract pertinent information from text, and then engaged in sustained and focused writing exercises designed to construct meaning of reading material. The intervention itself was designed to go beyond simple summary writing exercises and instead engage students in extended writing exercises designed to support their cognitive processing of new learning (i.e., connecting ideas, comparing and contrasting concepts, developing and defending arguments). Students in the control group read the same texts but did not use thinksheets or extended writing exercises to make sense of learning and instead relied on short-answer writing prompts and tests to assess student learning. After two years of intervention, 4th grade students in the treatment group slightly outperformed those in the traditional instruction control group (improvement index =5) with more significant outcomes for 5th grade students (improvement index = 19). Findings also revealed greater effects for special education and low-income students in the experimental group. Effects varied according to length of exposure to the intervention and teachers' fidelity of implementation, which demonstrates the need to support students with consistent, high-quality instruction and scaffolded support for using extended, cognitively challenging writing exercises to support learning comprehension.	Cognitive writing
Connor, C. M., Marrison, F. J., Fishman, B., Crowe, E. C., Otaiba, S. A., & Schatschneider, C. (2013). A longitudinal cluster-randomized controlled study on the accumulating effects of individualized literacy instruction on students' reading from first through third grade. *Psychological Science, 24*(8), 1408–1419. https://www.doi.org/10.1177/0956797612472204	Connor and colleagues (2013) examined the long-term effects of the Individualizing Student Instruction intervention—a software-based intervention that tracks students' vocabulary and reading skills and provides teachers with recommend amounts of individual reading instruction for each student—on student reading outcomes from 1st through 3rd grade for a student population (*n* = 357 for the longitudinal sample) of which more than 45 percent were living in poverty. Students were randomly assigned to teachers who received intensive professional development and coaching to deliver targeted reading instruction to individuals and small groups of students using evidence-based reading practices (e.g., emphasizing decoding for younger students and reading comprehension for older students). Instruction was supported with student assessment and progress monitoring software or a control condition intervention that focused on mathematics. By the end of 3rd grade, students receiving individualized reading instruction for all three grades demonstrated better letter-word recognition (improvement index = 16) and reading comprehension (improvement index = 17) than those who received fewer years of individualized support. Effects faded with each reduction in years of individualized support; in fact, students receiving just one year of individualized support in 1st grade demonstrated no better outcomes than control-group students, which suggests that individualized support in 1st grade is necessary but not sufficient for better long-term outcomes. Findings suggest that policies that support teacher professional learning evidence-based reading instruction can yield better student reading outcomes.	Targeted supports (scaffolded practice)

Study	Summary	Strategies
Connor, C. M., Morrison, F. J., Schatschneider, C., Toste, J. R., Lundblom, E., Crowe, E. C., & Fishman, B. (2011). Effective classroom instruction: Implications of child characteristics by reading instruction interactions on first graders' word reading achievement. *Journal of Research on Educational Effectiveness, 4*(3), 173–207. https://www.doi.org/10.1080/19345747.2010.510179	Connor and colleagues (2011) studied the effects of the Individualizing Student Instruction (ISI), a software-based intervention that tracks students' vocabulary and reading skills and provides teachers with recommend amounts of individual reading instruction for each student, on the reading outcomes of first-grade students (n=396). Students receiving the ISI intervention, which helped teachers to target whole-class and individual student instruction based on student needs for more code-focused and/or meaning focused instruction, demonstrated significantly greater reading skill gains by spring (improvement index = 19), the equivalent to two months of learning, than students in control classrooms whose teachers implemented the same reading curriculum (Open Court) through whole-class instruction only. Even greater effects emerged for students whose initial reading scores fell below the 25th percentile (improvement index = 22) and with weaker initial vocabulary scores (improvement index = 20). Furthermore, effects were significantly higher for students whose teachers closely matched instruction to recommended guidance from the system (improvement index = 48), which suggests targeting instruction precisely to student needs can significantly improve their outcomes.	Targeted support (scaffolded practice)
Cordova, D. I., & Lepper, M. R. (1996). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology, 88*(4), 715. https://www.doi.org/10.1037/0022-0663.88.4.715	Cordova and Lepper (1996) examined the effects of three different approaches to presenting learning material to elementary students (*n* = 70) to increase their intrinsic motivation to engage in mathematics learning—contextualization (i.e., framing learning in a simple "fantasy" context such as using mathematics to navigate a spaceship), personalization (i.e., inserting children's names and personal details into the "fantasy" context), and choice (i.e., giving students control over instructionally elements of the fantasy such as what icon would represent them on the game board). Students in the four treatment conditions (fantasy, fantasy + choice, fantasy + personalization, fantasy + personalization + choice) demonstrated greater motivation (i.e., willingness to stay after class to continue the game) than students in the control group who engaged in a similar game without the "fantasy" frame (improvement index = 5 to 46). Moreover, students in all four treatment conditions significantly outperformed those in the control group on postintervention measures of related mathematics learning, with the greatest effects for fantasy + personalization + choice (improvement index = 49) and the smallest effects for fantasy alone (improvement index = 22). Personalization itself appeared to have a significant effect on learning, with students in the fantasy + personalization demonstrating significantly greater outcomes (improvement index = 37) than those in the fantasy-only group. Findings indicate powerful learning benefits of increasing the intrinsic appeal of learning for students.	Cognitive interest cues

Study	Summary	Strategies
Coyne, M. D., McCoach, D. B., Ware, S., Austin, C. R., Loftus-Rattan, S. M., & Baker, D. L. (2019). Racing against the vocabulary gap: Matthew effects in early vocabulary instruction and intervention. *Exceptional Children, 85*(2), 163–179.	Coyne and colleagues (2019) compared the effects of supplementing 20 minutes of daily whole-class (Tier 1) vocabulary instruction using the Elements of Reading Vocabulary Program with a small-group (Tier 2) vocabulary intervention delivered by paraprofessionals, reading teachers, and other professionals in 30-minute sessions four days per week to kindergarten students at risk for language and learning difficulties (n = 825). Comparison groups included at-risk (n = 781) and not-at-risk students (n = 741) receiving Tier-1 instruction only. After 22 weeks of intervention, at-risk students receiving Tier 2 supports demonstrated significantly gains over at-risk students receiving Tier 1 instruction only in target words (improvement index = 36) and listening comprehension (improvement index = 16) and performed as well as or better than not-at-risk students on these measures. Thus, the treatment, in effect, counteracted the "Matthew effects" of capable readers making more rapid gains in vocabulary knowledge and reading skills than less capable ones.	Targeted support (scaffolded practice)
Doabler, C. T., Clarke, B., Kosty, D. B., Kurtz-Nelson, E., Fien, H., Smolkowski, K., & Baker, S. K. (2016). Testing the efficacy of a tier 2 mathematics intervention: A conceptual replication study. *Exceptional Children*, *83*(1), 92–110. https://www.doi.org/10.1177/0014402916660084	In a replication study, Doabler and colleagues (2016) examined the effects of the ROOTS Tier 2 intervention for a diverse population of kindergarten students (n = 316) experiencing math difficulties (i.e., performing at or below the 35th percentile on standardized measures of math learning). Students were randomly assigned to the ROOTS treatment group received 50 lessons of small group (2–5 students per group) instruction delivered by district interventionists. The ROOTS program itself emphasizes explicit direct instruction (including teacher modeling, guided practice with feedback, and visualizations) to develop procedural fluency and conceptual understanding in whole-number concepts and skills. Students in the control group received primarily teacher-led instruction (92% of the time) that included direct instruction, modeling, visualizations, guided practice and feedback in similar knowledge and skills using programs rated highly in the What Works Clearinghouse, and engaged in small-group and individualized learning, but without the structure of the ROOTS approach. However, students in the control group were less likely to engage in independent and written math practice or receive scaffolded instruction than those in the treatment group. On postintervention measures of early math ability, students in the treatment group demonstrated significantly greater gains (improvement index = 12) than those in the control group.	Targeted supports (scaffolded practice)

Study	Summary	Strategies
Dombek, J., Crowe, E. C., Spencer, M., Tighe, E. L., Coffinger, S., Zargar, E., Wood, T., & Petscher, Y. (2017). Acquiring science and social studies knowledge in kindergarten through fourth grade: Conceptualization, design, implementation, and efficacy testing of Content-Area Literacy Instruction (CALI). *Journal of Educational Psychology, 109*(3), 301-320. https://www.doi.org/10.1037/edu0000128	Dombek and colleagues (2017) examined the effects of providing content-area literacy instruction (CALI) as an individualized instructional program for kindergartners through 4th grade students (*n* = 418) to build science and social studies knowledge. For four days per week over three weeks, students in the treatment condition engaged in 30 minutes of learning during their literacy block that included one day of concept lessons (cueing cognitive interest by connecting learning to students' lives), three to four days of clarifying lessons (e.g., reading about science and social studies), three to four days of research lessons (e.g., conducting science experiments or using primary sources such as photographs, journals and letters to learn about social studies), and three to four days of apply lessons (e.g., making connections through projects such as posters and writing in response to open-ended questions). The intervention also engaged students in conducting simple science experiments that required them to collect and analyze data, and having frequent opportunities to talk about, read, and experience social studies and science texts and content. Students in the control group engaged in regular classroom instruction which tended to focus on literacy, but not social studies or science, during the literacy block. Posttest results demonstrated positive effects for the CALI intervention in improving student knowledge in social studies (improvement index = 49) and science (improvement index = 48), with some evidence of improving oral and reading comprehension skills as well (improvement index = 5).	Cognitive interest cues Cognitive writing Guided investigations
Dyson, N., Jordan, N. C., Beliakoff, A., & Hassinger-Das, B. (2015). A kindergarten number-sense intervention with contrasting practice conditions for low-achieving children. *Journal for Research in Mathematics Education, 46*(3), 331–370. https://www.doi.org/10.5951/jresematheduc.46.3.0331	Dyson and colleagues (2015) compared the effects of three different practice conditions for teaching basic number skills to low-achieving, low-income kindergartners (*n* = 126). Over the course of 24 half-hour small-group sessions, all students received the same number sense intervention aimed at developing their fluency with numbers (counting, number recognition), number relations (bigger and smaller, before and after), and number operations (breaking numbers into smaller sets or combining them into larger ones). Students in the treatment groups were randomly assigned to two different game-based practice conditions: one focused on number-list practice (e.g., using a spinner to advance tokens on a number line), and the second focused on number-fact practice (e.g., speeded practice with simple +1, -1, +0 flash cards). On immediate posttests of number fluency, students in the number-fact retrieval practice group demonstrated more than twice the gains (improvement index = 29) as the number-list (improvement index = 13) in comparison to the business-as-usual control group. Moreover, students in the number-fact (retrieval) practice condition significantly outperformed those in the number-list practice condition on a delayed posttest of fluency (improvement index = 19 vs. 5), with even more significant effect sizes observed in math fluency for number-fact retrieval practice among English-learner students (improvement index = 28). Gains for English-learner students were only evident in the number-fact practice condition. Findings suggest that targeted instruction with speeded but meaningful retrieval practice of facts appears to be optimal for students with serious learning delays.	Retrieval practice (quizzing to remember) Guided initial application with formative feedback Targeted support (scaffolded practice)

Study	Summary	Strategies
Friedman, L. B., Margolin, J., Swanlund, A., Dhillon, S., Liu, F. (2017). *Enhancing middle school science lessons with playground activities: A study of the impact of playground physics.* American Institutes of Research. https://files.eric.ed.gov/fulltext/ED574773.pdf	Friedman and colleagues (2017) studied the effects of Playground Physics, a technology-based application and curriculum designed to support middle school students' science engagement and learning of force, energy, and motion. Students in the treatment condition engaged in formal and informal inquiry-based learning activities during the regular school day. Specifically, the Playground Physics curriculum provided a series of structured lessons that formally presented physics concepts followed by a science investigation that guided students through the processes designing and conducting an experiment using the Playground Physics app to record and review videos of each other engaging in playground-type play and then reviewing videos through three different "lenses" designed to highlight the principles of motion, force (Newton's Third Law), and energy. Students entered calibration information about mass, height and distance to trace the path of a person or object across a screen, creating dots that became data points to generate graphical displays of distance travelled, speed, force, or energy. Comparisons of pre- and posttest measures of physics knowledge revealed students in the treatment group demonstrated significant gains students over the business-as-usual control group (improvement index = 15).	Guided investigations
Fuchs, L. S., Fuchs, D., Craddock, C., Hollenbeck, K. N., Hamlett, C. L., & Schatschneider, C. (2008). Effects of small-group tutoring with and without validated classroom instruction on at-risk students' math problem solving: Are two tiers of prevention better than one? *Journal of Educational Psychology, 100*(3), 491. https://www.doi.org/10.1037/0022-0663.100.3.491	Fuchs and colleagues (2008) compared the effects of tutoring 3rd grade students (*n* = 243) at risk for failure in mathematics with the "hot math" approach to schema-broadening instruction (SBI; i.e., teaching students to recognize the type of problem they are solving, parse critical vs. superficial information, identify appropriate problem-solution methods, and learn to transfer solution methods to novel problems) versus only delivering whole-class instruction (e.g., worked examples, guided group practice, and independent practice). Within each group, students at risk for poor math problem solving outcomes were assigned to a tutoring group or a no-tutoring group. Tutoring sessions lasted 20–30 minutes and focused on SBI, with tutors modeling solution methods, targeting the most difficult concepts, incorporating manipulatives, helping students to develop self-regulated learning strategies (e.g., setting goals and using self-talk to stay on task), and providing real-time formative feedback and encouragement during guided practice sessions. After 16 weeks, tutored students receiving SBI in their regular classrooms significantly out-performed those receiving conventional instruction (improvement index = 41). Tutored students, however, outperformed non-tutored students, regardless of whether they received SBI (improvement index = 38) or conventional instruction (improvement index = 37). Also, students receiving SBI in the regular classroom significantly outperformed those receiving traditional instruction (improvement index = 44). In sum, the small-group tutoring in SBI proved to be the far more significant variable in the study, which suggests intensive preventative tutoring delivered by well-trained professionals that aims to develop students' cognitive and self-regulation skills (including listening carefully, following directions, paying attention, and working hard) can improve the performance of at-risk students.	Guided initial application with formative feedback Targeted support (scaffolded practice) Structured problem solving

Study	Summary	Strategies
Fuchs, L. S., Fuchs, D., Finelli, R., Courey, S. J., & Hamlett, C. L. (2004). Expanding schema-based transfer instruction to help third graders solve real-life mathematical problems. *American Educational Research Journal, 41*(2), 419–445. https://www.doi.org/10.3102/00028312041002419	Fuchs and colleagues (2004) examined the effects of schema-based transfer instruction (SBTI) for 3rd -grade students (*n* = 351) engaged in solving four types of complex, real-world math problems: calculating total costs of “shopping list” problems, halving problems, using division to calculate how many bundles need for a total amount with “buying bag” problems, and interpreting complex graphs. Students in the treatment condition received explicit instruction to help them develop schemas for solving novel real-world math problems—that is, identifying what type of problem they are solving regardless of surface details and what strategies are needed to solve it. A second treatment condition engaged in an expanded version of SBTI that exposed students to even more complex real-world problems that combined problem types (e.g., multiplication and addition) and inserted more irrelevant and superficial details into problem cover stories in an effort to help students better recognize the underlying schema of the problems and thus, see them as solvable. Teachers were assigned randomly to 16-week control, SBTI, or expanded SBTI conditions. On posttest measures approximating real-life problem solving, the expanded SBTI group outperformed the SBTI group (improvement index = 36), which in turn, outperformed the control group (improvement index = 30). Accordingly, the expanded SBTI significantly outperformed the control group (improvement index = 47). Findings demonstrate the benefits of providing students with direct instruction in how to sort through superficial surface details in order to identify underlying similarities in problem types and providing students with interleaving practice opportunities to develop and broaden their schema.	Structured problem solving
Fuchs, L. S., Fuchs, D., Karns, K., Hamlett, C. L., Katzaroff, M., & Dutka, S. (1997). Effects of task-focused goals on low-achieving students with and without learning disabilities. *American Educational Research Journal, 34*(3), 513–543. https://www.doi.org/10.3102/00028312034003513	Fuchs and colleagues (1997) studied the effects of integrating task-focused goals, peer-assisted learning, and individualized performance feedback on math achievement for low-achieving Grade 2–4 students with disabilities. The first treatment group set short-term, task-specific goals for making progress toward mastery while receiving weekly progress feedback and engaging in peer-assisted learning. To isolate the impact of goal setting, a second treatment group received weekly feedback on progress and engaged in peer-assisted learning but did not set task-focused goals. After 26 weeks, previously low-achieving students who both set task goals and received weekly feedback demonstrated significantly higher performance than low-achieving students who only received weekly feedback (improvement index = 16). The intervention, however, did not improve achievement of students with learning disabilities.	Student goal setting and monitoring

Study	Summary	Strategies
Fuchs, L. S., Fuchs, D., Prentice, K., Burch, M., Hamlett, C. L., Owen, R., & Schroeter, K. (2003). Enhancing third-grade students' mathematical problem solving with self-regulated learning strategies. *Journal of Educational Psychology, 95*(2), 306. https://www.doi.org/10.1037/0022-0663.95.2.306	Fuchs and colleagues (2003) compared the effects of integrating goal setting, self-evaluation, and schema-based instruction (SBI; i.e., teaching students how to transfer solution methods from one problem to another). Over a 16-week period, students in the first treatment group evaluated their work using an answer key, charted their daily progress, and set personal goals to beat their own previous high scores or achieve perfect scores. Meanwhile, students in the second treatment group engaged in only SBI without goal setting or self-evaluation, and a control group received conventional classroom instruction. Students who set goals and self-evaluated progress outperformed those who received SBI only on immediate and near-term measures of their ability to transfer solution methods to similar problems (improvement index = 17 and 22, respectively). These effects, however, diminished when students were given real-world problems requiring more complex transfer of problem-solving methods (improvement index = 1).	Student goal setting and monitoring
Fuchs, L. S., Geary, D. C., Compton, D. L., Fuchs, D., Schatschneider, C., Hamlett, C. L., DeSelms, J., Seethaler, P. M., Wilson, J., Craddock, C. F., Bryant, J. D., Luther, K., & Changas, P. (2013). Effects of first-grade number knowledge tutoring with contrasting forms of practice. *Journal of Educational Psychology, 105*(1), 58–77. https://www.doi.org/10.1037/a0030127	Fuchs and colleagues (2013) investigated contrasting forms of practice while providing number knowledge tutoring for at-risk first-grade students (*n* = 591). Tutoring consisted of three, 30-minute sessions three times per week for 16 weeks. The major emphasis of each tutoring session (25 of 30 minutes) was direct instruction of number knowledge. For the remaining five minutes, students were randomly assigned to one of two treatment conditions. The first group participated in non-speeded (guided) practice designed to reinforce relations and principles addressed in number knowledge tutoring, and the second engaged in speeded (retrieval) practice designed to promote quick responding and use of efficient counting procedures to generate as many correct responses as possible. Both tutoring groups received immediate, corrective progress feedback. Students in these groups were compared to a control group, which received no tutoring. The two tutoring conditions produced stronger learning than non-tutoring control students on several post-treatment measures. Students in the speeded (retrieval) practice group outperformed those in the control group in math fact fluency (improvement index = 21), complex calculations (improvement index = 26), number knowledge (improvement index = 11), and word problems (improvement index = 9). Students in the non-speeded, conceptual-guidance (guided practice) group also outperformed those in the control group, but with generally smaller effect sizes in math fact fluency (improvement index = 23), complex calculations (improvement index = 19), number knowledge (improvement index = 8) and slightly larger gains in world problems (improvement index = 11). The effect size for speeded practice versus non-speeded practice on math facts was substantial (improvement index = 20), which suggest that small-group tutoring with speeded, retrieval practice combined with immediate progress feedback promotes at-risk students' fluency with simple math facts—while also developing more complex computational and word problem skills.	Guided initial application with formative feedback Retrieval practice (quizzing to remember) Targeted supports (scaffolded practice)

Study	Summary	Strategies
Fuchs, L. S., Malone, A. S., Schumacher, R. F., Namkung, J., Hamlett, C. L., Jordan, N. C., Siegler, R. S., Gersten, R., & Changas, P. (2016). Supported self-explaining during fraction intervention. *Journal of Educational Psychology, 108*(4), 493. https://www.doi.org/10.1037/edu0000073	Fuchs and colleagues (2016) studied the effects of teaching at-risk 4th graders to provide explanations for their mathematics work. Researchers randomly assigned students (*n* = 212) to three conditions: a control group and two intervention groups that engaged students in 36, 35-minute learning sessions with identical instruction in all but 7 minutes of each session, during which students were either taught to provide high-quality explanations for their solutions to fraction problems or to simply solve fraction word problems. Results favored students in the self-explanation condition on posttest measures of both their accuracy in computing magnitudes (improvement index = 42), explanations of math solutions (improvement index = 42) and calculating fractions (improvement index = 48). On word problems, children in the word-problem group slightly outperformed those in the self-explanations group (improvement index = 5).	High-level questions and student explanations
Fuchs, L. S., Powell, S. R., Seethaler, P. M., Cirino, P. T., Fletcher, J. M., Fuchs, D., & Hamlett, C. L. (2010). The effects of strategic counting instruction, with and without deliberate practice, on number combination skill among students with mathematics difficulties. *Learning and Individual Differences, 20*(2), 89–100. https://www.doi.org/10.1016/j.lindif.2009.09.003	Fuchs and colleagues (2010) studied the effects of strategic counting instruction, with and without deliberate practice, on number combination skills for 3rd grade students with mathematics difficulties. Students (*n* = 150) were randomly assigned to control (no tutoring) or one of two treatment conditions which both used the same validated word-problem tutoring protocol (i.e., Pirate Math). Students in both tutoring conditions received 48, 20- to 30-minute highly scripted tutoring sessions that focused on foundational skills essential for solving word problems (e.g., algorithms for solving double-digit addition and subtraction problems and checking one's own work while solving problems). In the first treatment group, students engaged in timed retrieval practice with immediate progress feedback—yet tutors did not review a key strategy (number combination) nor prompt students to use it to correct errors. The second (deliberate practice) treatment group engaged in timed retrieval practice but also engaged in 168–252 minutes of additional practice during which they were guided to review errors and use number combination skills to arrive at correct answers. Results showed positive effects for both speeded practice and deliberate practice tutoring conditions over nontutored students in posttests of procedural calculation skills (improvement index = 8 and 23, respectively). Students in the deliberate practice group significantly outperformed those in the non-deliberate practice group (improvement index = 9). Findings demonstrate both the benefits of retrieval practice—as well as deliberate practice—including feedback that encourages students to engage in self-reflection on outcomes and correct errors.	Guided initial application with formative feedback Targeted supports (scaffolded practice)

Study	Summary	Strategies
Fuchs, L. S., Powell, S. R., Seethaler, P. M., Cirino, P. T., Fletcher, J. M., Fuchs, D., Hamlett, C. L., & Zumeta, R. O. (2009). Remediating number combination and word problem deficits among students with mathematics difficulties: A randomized control trial. *Journal of Educational Psychology, 101*(3), 561–576. https://www.doi.org/10.1037/a0014701	Fuchs and colleagues (2009) studied the effects of remedial tutoring for 3rd graders with mathematics difficulty to determine the extent to which tutoring might have more benefits for students with mathematics difficulty alone vs. mathematics plus reading difficulty. Students (n = 133) demonstrating varying degrees of mathematics difficulty were randomly assigned to three conditions for three sessions per week over the course of 16 weeks. Students in the control group learned through worked examples, guided group practice, and independent practice. Students in the first treatment group engaged in the same whole-group instruction, but also received small-group tutoring focused on automatic retrieval of simple addition and subtraction math facts through a computerized program (i.e., Math Flash); tutors also gave students immediate feedback as well as guidance reminding them to solve problems through one of two methods: "know it or count it up." Students in the second treatment condition engaged in tutoring on word problems, but instead of focusing on speeded retrieval practice, tutors focused on building foundational skills for solving word problems, including practice with math facts as well as learning a three-step process for solving word problems and using simple algebraic equations (i.e., Pirate Math); tutors supported guided practice with these processes—for example, helping students sort word problems by problem type. Postintervention tests indicate that compared to the control group, the Math Flash condition enhanced fluency with math facts (improvement index = 21) with some transfer to procedural computation (improvement index = 11) but no transfer to algebra or word problems. Compared to the control group, students engaged in guided practice through the Pirate Math treatment demonstrated enhanced word-problem skills (improvement index = 29), fluency with math facts (improvement index = 23), procedural computation (improvement index = 20), and simple algebra (improvement index = 14). Word-problem tutoring had similarly beneficial effects for students with math disabilities as well as reading disabilities.	Guided initial application with formative feedback Targeted supports (scaffolded practice) Retrieval practice (quizzing to remember)
Fuchs, L. S., Schumacher, R. F., Long, J., Namkung, J., Hamlett, C. L., Cirino, P. T., Jordan, N. C., Siegler, R., Gersten, R., & Changas, P. (2013). Improving at-risk learners' understanding of fractions. *Journal of Educational Psychology, 105*(3), 683–700. https://www.doi.org/10.1037/a0032446	Fuchs and colleagues (2013) studied the effects of engaging at-risk 4th grade students (n = 259) in small-group (3:1 ratio), highly scripted tutoring of 36 lessons (Fraction Challenge) that aimed to develop students' conceptual understanding of fractions while developing their automaticity foundational skills and self-regulation abilities. The intervention integrated several strategies, including using number lines, circles, and manipulatives to help students visualize fractions; direct instruction of academic vocabulary (e.g., denominator, unit); strategy instruction (e.g., chunking and segmenting strategies for comparing fractions); and guided initial application and retrieval practice to develop automaticity. Efforts to support procedural automaticity were delayed after students had developed conceptual understanding of fractions. Students in the control group received whole-class instruction following a popular math textbook that covered similar content as the small-group tutoring condition but emphasized procedural competence over conceptual understanding. Results showed students receiving small-group tutoring outperformed those receiving whole-class instruction (improvement index = 24).	Vocabulary instruction Strategy instruction and modeling Visualizations and concrete examples Retrieval practice Targeted supports (scaffolded practice)

Study	Summary	Strategies
Fuchs, L. S., Schumacher, R. F., Sterba, S. K., Long, J., Namkung, J., Malone, A., Hamlett, C. L., Jordan, N. C., Gersten, R., Siegler, R. S., & Changas, P. (2014). Does working memory moderate the effects of fraction intervention? An aptitude-treatment Interaction. *Journal of Educational Psychology, 106*(2), 499–514. https://www.doi.org/10.1037/a0034341	Fuchs and colleagues (2014) examined the effects of two interventions designed to improve fraction knowledge of at-risk 4th graders (*n* = 243) against a business-as-usual control group, which focused on part-whole understanding, estimation, and word problems. Interventions each lasted 12 weeks, during which students were provided small-group (3:1) instruction three times per week focused on measurement interpretation of fractions (e.g., arranging fractions from least to greatest, estimating where fractions fit on a number line). Only 5 min of each 30-min sessions differed: One condition engaged students in speeded retrieval practice activities to build fluency with each of four measurement interpretation topics; in the other, students explained their reasoning with the aid of manipulatives to consolidate their understanding on the same four topics. Both intervention conditions outperformed the control group on multiple measures of fractions knowledge. Effects size for the speeded retrieval fluency condition over controls ranged from (improvement index = 23 to 37) and from (improvement index = 24 to 37) for self-explanation. Results revealed that students with very weak working memory learned better with conceptual activities but children with more adequate (but still low) working memory learned better with fluency activities.	High-level questions and student explanations Retrieval practice (quizzing to remember) Targeted support (scaffolded practice)
Fuchs, L. S., Seethaler, P. M., Sterba, S. K., Craddock, C., Fuchs, D., Compton, D. L., Geary, D. C., & Changas, P. (2021). Closing the word-problem achievement gap in first grade: Schema-based word-problem intervention with embedded language comprehension instruction. *Journal of Educational Psychology, 113*(1), 86–103. https://www.doi.org/10.1037/edu0000467	Fuchs and colleagues (2021) studied the effects of a schema-based word-problem intervention to assess whether embedding language comprehension instruction into schema-based instruction (SBI) would improve outcomes and whether a number knowledge intervention—without explicit instruction in word problem solving—would be sufficient to address word-problem solving deficits of at-risk 1st grade students (*n* = 391). Researchers randomly assigned students to four conditions: 1. Schema-based instruction (e.g., teaching students to RUN through a problem, Read it, Underline key words, Name the problem type) with embedded language comprehension instruction (i.e., direct instruction of academic vocabulary terms such as “more,” “fewer than,” “cost,” “because”), 2. Schema-based instruction without language comprehension instruction, 3. Number-knowledge instruction, and 4. Business-as-usual control. Each treatment condition comprised 45, 30-minute sessions. Postintervention measures of word-problem solving, adjusted for classroom and school effects, found that students receiving combined language comprehension and SBI significantly outperformed the control group (improvement index = 46), with a significantly larger effect than SBI alone (improvement index = 36). Although the number knowledge intervention group improved arithmetic skill over the control group (improvement index = 22), it did not significantly outperform the control group on word problems (improvement index = 4), which suggests arithmetic skill does not transfer to word-problem solving and thus demonstrates the value of providing students with SBI to solve word problems.	Vocabulary instruction Structured problem solving

Study	Summary	Strategies
Glaser, C., & Brunstein, J. C. (2007). Improving fourth-grade students' composition skills: Effects of strategy instruction and self-regulation procedures. *Journal of Educational Psychology, 99*(2), 297. https://www.doi.org/10.1037/0022-0663.99.2.297	Glaser and Brunstein (2007) compared the effects of adding self-regulation procedures (i.e., criterion and goal setting with self-monitoring of strategic planning, writing performance, and revision activities) to writing composition strategy versus receiving strategy instruction alone versus a control group receiving traditional didactic instruction on writing. After five weeks, students in the goal-setting group wrote better stories and demonstrated significantly greater knowledge of writing strategies (improvement index = 26 and 20), respectively, than students in the strategy-instruction alone group, which itself significantly outperformed the control group, yet demonstrated a "wash out" effect with performance deteriorating the back to pretest levels on a maintenance test administered five weeks later.	Student goal setting and monitoring
Graham, S., MacArthur, C., & Schwartz, S. (1995). Effects of goal setting and procedural facilitation on the revising behavior and writing performance of students with writing and learning problems. *Journal of Educational Psychology, 87*(2), 230. https://www.doi.org/10.1037/0022-0663.87.2.230	Graham and colleagues (1995) compared outcomes for three randomly assigned groups of Grade 5 and 6 students with learning disabilities after turning in a first draft of a writing assignment. The first group set a general goal to revise their papers to make them better; the second group set a focused goal to add at least three things to make their papers better; the third group set a focused goal and guidance for brainstorming and selecting new details to enhance their papers. Students in the second and third groups with focused goals made significantly more substantive changes to their papers and wrote higher quality second drafts than students provided general goals (improvement index = 27 and 29, respectively). Additional guidance for adding details did not result in higher quality papers among the third group. Findings demonstrate benefits of helping students, especially those with learning disabilities, set targeted goals for improvement.	Student goal setting and monitoring
Guthrie, J. T., Wigfield, A., Barbosa, P., Perencevich, K. C., Taboada, A., Davis, M. H., Scafiddi, N. T., & Tonks, S. (2004). Increasing reading comprehension and engagement through concept-oriented reading instruction. *Journal of Educational Psychology, 96*(3), 403–423. https://www.doi.org/10.1037/0022-0663.96.3.403	Guthrie and colleagues (2004) examined the effects of concept-oriented reading instruction (CORI), an instructional framework that integrates five motivational practices with six cognitive strategies, with a racially diverse group of 3rd graders during science instruction. The motivational strategies include setting mastery goals, providing students with choice in reading texts to enhance cognitive interest, engaging them in hands-on learning experiences (e.g., dissecting owl pellets), providing students with interesting texts related to hands-on learning, and supporting student collaboration to clarify and consolidate understandings. The cognitive strategies include the following "strategy instruction" techniques: activating background knowledge, high-level questions, summarizing, graphic organizers, and direct instruction of text structure. A first experiment with 3rd grade students (*n* = 361) found that students receiving the full motivation and cognitive strategies (CORI) intervention outperformed those receiving strategy instruction only on a posttest measure of reading comprehension (improvement index = 25). A second experiment with another group of 3rd graders (*n* = 491) compared the effects of CORI vs. strategy instruction vs. a control group receiving traditional instruction. It found students receiving CORI demonstrated significant gains in reading comprehension over those receiving strategy instruction only (improvement index = 26) and even larger gains over those receiving traditional instruction (improvement index = 42). Students receiving strategy instruction also significantly outperformed those receive traditional instruction (improvement index = 26).	Cognitive interest cues Student goal setting and monitoring Strategy instruction and modeling Visualizations and concrete examples High-level questions and student explanations Peer-supported consolidation Guided investigations

Study	Summary	Strategies
Guthrie, J. T., Wigfield, A., Humenick, N. M., Perencevich, K. C., Taboada, A., & Barbosa, P. (2006). Influences of stimulating tasks on reading motivation and comprehension. *The Journal of Educational Research, 99*(4), 232–246. https://www.doi.org/10.3200/JOER.99.4.232-246	Guthrie and colleagues (2006) conducted a "natural experiment" with 98 students in four classrooms at a low-income urban elementary school. They compared the outcomes of students who were learning the same science content, reading the same texts, and receiving the same amount of science instruction—with a key difference: in two of the classrooms, teachers stimulated high levels of student interest by engaging students in more hands-on learning activities and observations, posing more high-level science questions, and encouraging students to generate and test more hypotheses. Although students did not differ significantly demographically and demonstrated similar pretest levels of reading comprehension, after 12 weeks those in high-stimulation classrooms demonstrated significantly higher reading comprehension than those in low-stimulation classrooms (improvement index = 26).	Cognitive interest cues High-level questions and student explanations Guided investigations
Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology, 102*(4), 880–895. https://www.doi.org/10.1037/a0019506	Hulleman and colleagues (2010) randomly assigned college undergraduate students taking a required undergraduate psychology course into two conditions at the midpoint of the semester: one group wrote short essays connecting what they were learning to their personal lives; another group continued with business as usual. By the end of the semester, students in personal connections group not only demonstrated greater interest in the course (improvement index = 25) but also earned higher grades—an effect that was particularly pronounced for students who initially expressed low prior interest or performance in the course (improvement index = 10).	Cognitive interest cues
Ives, B. (2007). Graphic organizers applied to secondary algebra instruction for students with learning disorders. *Learning Disabilities Research & Practice*, *22*(2), 110–118. https://www.doi.org/10.1111/j.1540-5826.2007.00235.x	In an experiment involving 6th through 12th grade students diagnosed with learning disabilities, Ives (2007) compared the effects of supporting mathematics strategy instruction with graphic organizers versus strategy instruction alone. Over the course of four lessons, students in the treatment group (n = 14) were given direct instruction in solving linear equations along with a graphic organizer that guided them in eliminating variables while solving equations; students in the control group (n = 16) were given similar direct instruction without the aid of a graphic organizer. Students in the graphic organizer group outperformed the control group on researcher-created posttests of concept knowledge (improvement index = 42) and equation solving (improvement index = 20).	Visualizations and concrete examples

Study	Summary	Strategies
Jitendra, A. K., Dupuis, D. N., Rodriguez, M. C., Zaslofsky, A. F., Slater, S., Cozine-Corroy, K., & Church, C. (2013). A randomized controlled trial of the impact of schema-based instruction on mathematical outcomes for third-grade students with mathematics difficulties. *The Elementary School Journal, 114*(2), 252–276. https://www.doi.org/10.1086/673199	Jitendra and colleagues (2013) compared the effects of delivering supplemental schema-based instruction through a small-group (two to four students each) tutoring intervention versus a business-as-usual control group on the math outcomes of 3rd grade students at risk for mathematics difficulties (*n* = 109). A total of 54, 30-minute tutoring sessions over 12 weeks provided direct instruction a four-step FOPS problem-solving heuristic (Find the problem, Organize information in the problem using a schematic diagram, Plan to solve the problem, Solve the problem). Students learned to recognize the underlying mathematical structure of additive problems (e.g., change, group, compare) in order to identify problems based on structural features (part-part-whole) of a problem rather than surface features (e.g., the problem's cover story). Using visual representations (schematic diagrams) served to reduce cognitive load for students by helping them to organize and summarize information, making concrete abstract representations. Students were also given metacognitive instruction, including monitoring their own use of strategies and evaluating outcomes. Students in the control condition also received 54 sessions of small-group tutoring aligned with regular classroom lessons and basic computational skills. After 12 weeks of intervention, immediate posttest outcomes on word-problem solving significantly favored (improvement index = 18) students in the strategy-based instruction group over the control group who received small-group business-as-usual tutoring in the district's mathematics curriculum, including guidance when students struggled with key concepts or skills. Similar positive effects were also found on a district-administered immediate posttest of general math outcomes (improvement index = 13). Benefits of strategy-based instruction extended to students in both high and low at-risk subgroups but were not sustained on a word-problem solving retention test administered eight weeks later. Too much time may have elapsed between the intervention and the delayed test and/or students may have needed a longer intervention to practice and internalize the problem-solving procedures they were learning.	Visualizations and concrete examples Structured problem solving
Jitendra, A. K., Star, J. R., Rodriguez, M., Lindell, M., & Someki, F. (2011). Improving students' proportional thinking using schema-based instruction. *Learning and Instruction, 21*(6), 731–745. https://www.doi.org/10.1016/j.learninstruc.2011.04.002	Jitendra and colleagues (2011) investigated the effectiveness of classroom-based schema-based instruction (SBI) to teach 7th grade students (*n* = 436) how to comprehend and solve proportion problems involving ratios/rates, scale drawings, and percentages. Students in the SBI treatment condition received a total of 29, 50-minute lessons in recognizing the underlying mathematical structure of problems, translating them into a schematic diagram, following a four-step procedure (FOPS) to support and monitor problem solving, and using alternative solution strategies based on the problem. On posttests of problem-solving skills, students in the treatment condition outperformed those in a business-as-usual control group (improvement index = 27) after accounting for pretests and other characteristics (gender, ethnicity). However, effects diminished (improvement index = 19) on a delayed posttest a month later and virtually no effects were found on a transfer test that engaged students in novel and challenging content positive. One possible explanation for these findings is that the curriculum sequence following the intervention reflected distinctly different content, including geometric measures, measurement and area, and surface volume and probability, which may have interfered with prior learning.	Visualizations and concrete examples Structured problem solving

Study	Summary	Strategies
Jitendra, A. K., Star, J. R., Starosta, K., Leh, J. M., Sood, S., Caskie, G., Hughes, C. L., & Mack, T. R. (2009). Improving seventh grade students' learning of ratio and proportion: The role of schema-based instruction. *Contemporary Educational Psychology, 34*(3), 250–264. https://www.doi.org/10.1016/j.cedpsych.2009.06.001	Jitendra and colleagues (2009) examined the effectiveness of providing tutoring in schema-based instruction (SBI) in meeting the diverse needs of mixed-ability 7th grade students (*n* = 148) by teaching them to identify the mathematical structure of problems, access related problem-strategies, and follow a process for self-monitoring problem solving. Over 10 days, students received the same classroom instruction on several topics (e.g., ratios, rates, scale drawings). Classroom activities included students working independently on a review problem followed by whole-class review, teachers using worked-out examples to introduce key concepts/skills, and assigning practice homework. Students were then randomly assigned to two conditions: in the SBI condition, a researcher-designed unit with scripted lessons replaced regular instruction on ratios and proportions. Students learned to recognize problem types (e.g., a ratio or proportion problem), map details of the problem onto a schematic diagram, and solve problems using the four-step FOPS strategy (Find the problem, Organize information in the problem using a schematic diagram, Plan to solve the problem, Solve the problem). Students were encouraged to use "think-alouds" to monitor their problem-solving (e.g., "Did I read and retell the problem to understand what is given and what must be solved?") Students in the control group received regular textbook-based instruction on rations and proportions that included several worked-out examples to scaffold problem solving. On immediate and delayed (four months later) posttest measures of problem-solving, students in the SBI treatment outperformed students in control classes on a problem-solving measure (improvement index = 17, 21).	Visualizations and concrete examples High-level questions and student explanations Structured problem solving
Justice, L. M., Meier, J., & Walpole, S. (2005). Learning new words from storybooks: An efficacy study with at-risk kindergartners. *Language, Speech & Hearing Services in Schools, 36*(1), 17–32. https://www.doi.org/10.1044/0161-1461(2005/003)	Justice and colleagues (2005) compared the effects of elaborated versus nonelaborated interactions with novel vocabulary words while reading storybooks to at-risk kindergarten students in diverse, low-income schools (*n* = 57). Children in both treatment and control groups engaged in 20 small-group (three to six students) storybook reading sessions during which they were exposed to 60 novel words across 10 storybooks. Researchers randomly selected 30 of these words for elaboration; for students in the treatment condition, adult readers (graduate assistants) were directed to pause after each word to define it (e.g., "A *marsh* is a very wet place where there are wetlands covered with grasses") and use it in a new sentence (e.g., "We took a boat through the *marsh* and we saw lots of birds and alligators."). Children in the control group were exposed to nonelaborated words only through repeated exposure (each book was read four times to students). Posttest results showed that elaboration had significant effects on students' word knowledge (improvement index = 39) compared to repeated exposure to new words without elaboration (improvement index = 20). The benefits of elaboration were particularly pronounced for students with prior low vocabulary scores (improvement index = 41). Students with high levels of prior vocabulary knowledge were more likely to learn new words through incidental, nonelaborated exposure (improvement index = 30) whereas students with low prior vocabulary knowledge were unlikely to acquire novel words through repeated exposure without elaboration (improvement index = 4).	Vocabulary instruction

Study	Summary	Strategies
Kalyuga, S., Chandler, P., & Sweller, J. (2001). Learner experience and efficiency of instructional guidance. *Educational Psychology, 21*(1), 5–23. https://www.doi.org/10.1080/01443410124681	Kalyuga and colleagues (2001) conducted a series of experiments to compare the effects of providing mechanical trade apprentices with worked examples to develop procedural knowledge versus less-directive exploratory learning. In an initial experiment with novice learners (*n* = 17), worked examples provide significant but relatively small benefits for simple tasks (i.e., determining the circumference of a circle using a chart; improvement index = 18). A second experiment that varied the level of task difficulty—from simple problems with few (less than 10) possible options to complex tasks with more than 100 options to explore—found limited benefits for using worked examples to learn simple tasks (improvement index = 5) but significant benefits for learning complex tasks (improvement index = 24), likely because, as additional measures suggested, worked examples eased the cognitive load for learning. However, as participants became more experienced through subsequent training sessions, the benefits of worked examples diminished, with participants learning through exploration demonstrating higher performance than those in the worked examples group (improvement index = 15).	Visualizations and concrete examples
Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science, 331*(6018), 772–775. https://www.doi.org/10.1126/science.1199327	Karpicke and Blunt (2011) compared the effects of retrieval practice (i.e., frequent quizzing) versus elaborative studying (i.e., students constructing concept maps of content they were learning) for college students studying science texts. In a first experiment with undergraduate students (*n* = 80), students studied a science text under one of four conditions: 1. Study-once—studying the text during a single study period; 2. Repeated study—studying the same text in four consecutive study periods; 3. Elaborative concept mapping–studying the text in a single study period and then constructing a concept map; or 4. Retrieval practice—studying the text during an initial study period and then recalling as much information as possible on a free recall test, before re-studying the text and recalling information again. On a posttest a week later, students in retrieval practice condition outperformed all others, including the control study-once condition (improvement index = 25) and elaborative studying group (improvement index = 17)—gains equivalent to a 50 percent improvement in long-term retention. A second, similar experiment with the same four treatment groups of students (*n* = 120) engaged in reading authentic science texts with enumeration structures (e.g., lists of muscle tissues or sequences of events), resulted in even higher effect sizes for retrieval practice versus elaborative studying on posttest measures (improvement index = 36), even on test items requiring students to construct concept maps (improvement index = 35). Eight-four percent (101 of 120) students performed better on the final test after practicing retrieval practice than when practicing elaborative studying. Researchers concluded that retrieval practice is likely superior to elaborative studying/concept mapping because free recall requires students to actively engage in constructing a retrieval structure for new knowledge in their minds, thus developing more retrieval cues than elaborative studying alone.	Retrieval practice (quizzing to remember)

Study	Summary	Strategies
Karpicke, J. D., & Smith, M. A. (2012). Separate mnemonic effects of retrieval practice and elaborative encoding. *Journal of Memory and Language, 67*(1), 17–29. https://www.doi.org/10.1016/j.jml.2012.02.004	Karpicke and Smith (2012) conducted four experiments with college students (*n* = 90) to examine if retrieval practice enhances learning by inducing elaborative encoding. In each experiment, subjects learned 30 uncommon English words paired with one-word definitions (e.g., *antiar* = poison). Students studied the words in one of three learning conditions: 1. Dropping words from further practice once they could recall them, 2. Repeatedly studying all words on the list, or 3. Engaging in retrieval practice with all words. Half of the students were also instructed to create a mental image of the meaning using a sound-alike word (e.g., an ant drinking poison), thereby creating six total learning conditions. In Experiment 1, students in the repeated retrieval condition demonstrated better retention of new words than students in the repeated study group (improvement index = 11) and significantly better outcomes than dropping items (improvement index = 20). These results were replicated across additional experiments. Results also showed that elaborative studying improved initial encoding, but repeated use of the elaboration produced no measurable gains in long-term learning after successful retrieval.	Retrieval practice (quizzing to remember)
Kim, J. S., Hemphill, L., Troyer, M., Thomson, J. M., Jones, S. M., LaRusso, M. D., & Donovan, S. (2017). Engaging struggling adolescent readers to improve reading skills. *Reading Research Quarterly, 52*(3), 357–382. https://www.doi.org/10.1002/rrq.171	Kim and colleagues (2017) examined the effects of a year-long integrated approach to improving reading outcomes for struggling readers (*n* = 402) in grades 6–8, called Strategic Adolescent Reading Intervention (STARI). The intervention was designed to provide students with cognitively complex, personally relevant, and accessible fiction and nonfiction texts, with brief (15 minutes per day) direct instruction in the basic reading skills of decoding, fluency, and morphological analysis (e.g., recognizing adjectival suffixes). The intervention also engaged students in peer-learning activities (i.e., reciprocal teaching, partner reading, and class debate). Findings suggest that students randomly assigned to instruction with the STARI model demonstrated increased engagement in reading (improvement index = 31) and small but still statistically significant improvements in recognition (improvement = 8), morphological awareness (improvement index = 7), and efficiency in basic reading comprehension (improvement index = 8). Positive, but less statistically significant, outcomes were found for sentence processing, vocabulary, and reading comprehension.	Cognitive interest cues Strategy instruction and modeling Peer-assisted consolidation of learning

Study	Summary	Strategies
Kim, J. S., Olson, C. B., Scarcella, R., Kramer, J., Pearson, M., van Dyk, D., Collins, P., & Land, R. E. (2011). A randomized experiment of a cognitive strategies approach to text-based analytical writing for mainstreamed Latino English language learners in grades 6 to 12. *Journal of Research on Educational Effectiveness, 4*(3), 231–263. https://www.doi.org/10.1080/19345747.2010.523513	Kim and colleagues (2011) examined the effects of a cognitive strategies approach to teaching text-based analytical writing for mainstreamed middle and high school Latino English language learners (ELLs; $n = 1393$). English teachers were randomly assigned to a business-as-usual control group or to the Pathway Project professional development intervention, which trained teachers to use a pretest on-demand writing assessment to improve text-based analytical writing instruction. Professional development for the intervention group focused on using a cognitive strategies approach with students, including providing students with a mental toolkit for planning and evaluating their writing (i.e., planning and goal setting, asking questions and making predictions, identifying the gist, using graphic organizers, studying exemplary and nonexemplary essays to self-assess). Professional development for the control group focused on data analysis, helping students to improve their summarizing skills while reading, and using the textbook teacher's guide. Posttest results revealed significant effects for the treatment group on a written-test writing skills (improvement index = 14) but less significant effects on a standardized, multiple-choice achievement test of language arts skills (e.g., word analysis, fluency, vocabulary, reading comprehension, and literary analysis; improvement index = 2).	Strategy instruction and modeling Cognitive writing
King, A. (1991). Effects of training in strategic questioning on children's problem-solving performance. *Journal of Educational Psychology, 83*(3), 307. https://www.doi.org/10.1037/0022-0663.83.3.307	King (1991) examined the effects of three different conditions for 5th grade students ($n = 46$) working in pairs to solve computer-assisted problems. The first group (guided questions) engaged with partners in a questioning-answering dialogue, using strategic questions (e.g., "What is our plan?" "What do we know about the problem so far?" "Do we need a different strategy?") to guide their cognitive and metacognitive thinking while solving logic and spatial reasoning problems (e.g., identifying the proper sequence for a machine to create a product). The second group (unguided questioning) was simply instructed to ask and answer questions with their partners during problem solving. The third group (control) also worked in pairs to solve the problems but received no training or instructions in questioning. On posttest of problem-solving abilities administered after three weeks of twice-weekly, 45-minute learning sessions, guided questioners outperformed unguided questioners (improvement index = 40) and controls (improvement index = 34). Results suggest guiding student thinking with cognitive and metacognitive questions may promote their problem-solving skills.	High-level questions and student explanations

Study	Summary	Strategies
Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and metacognitive training. *American Educational Research Journal, 40*(1), 281–310. https://www.doi.org/10.3102/00028312040001281	Kramarski and colleagues (2003) compared the effects of four different approaches to mathematics instruction with 8th grade students (*n* = 384): 1. Cooperative learning with metacognitive questions, 2. Individual learning with metacognitive questions, 3. Cooperative learning without questions, and 4. Individual learning without questions. In the first condition, teams of four students worked together through a series of comprehension questions, strategic questions, and connection questions. In the second condition, students worked individually through the same metacognition questions. In the third condition, students were encouraged to work in groups but without the aid of the metacognitive questions. On posttest measures of graph interpretation, students in the cooperative learning + metacognitive questions group outperformed all others, including those working independently (improvement index = 28), working in groups without metacognitive guidance (improvement index = 25) and those working through metacognitive questions independently (improvement index = 16). No significant differences emerged for cooperative learning over independent learning without the benefit of metacognitive questions (improvement index = 1), which suggest cooperative is most effective when enhanced with structured opportunities for engaging in metacognitive processing of new learning.	High-level questions and student explanations Peer-assisted consolidation of learning
Lesaux, N. K., Kieffer, M. J., Kelley, J. G., & Harris, J. R. (2014). Effects of academic vocabulary instruction for linguistically diverse adolescents: Evidence from a randomized field Trial. *American Educational Research Journal, 51*(6), 1159–1194. https://www.doi.org/10.3102/0002831214532165	Lesaux and colleagues (2014) examined the effectiveness of an academic vocabulary intervention designed to improve language and literacy skills of linguistically diverse 6th grade students in 14 urban middle schools (*n* = 3,551). Students in the treatment group received 20 weeks of daily (45 minutes/day) instruction carved out of the regular 90-minute block of ELA instruction to build student knowledge of 70 high-utility words drawn from the *Time for Kids* magazine by teaching them definitions, encouraging them to apply words in novel contexts, and use them in their own writing. After the intervention, students in the treatment group demonstrated greater academic word mastery (improvement index = 16) but less significant effects for reading comprehension (improvement index = 2) or writing (improvement index = 8). However, effects on word mastery were greater for students whose primary home language is not English (improvement index = 19) and students with low preintervention vocabulary (improvement index = 20), which suggests vocabulary instruction has particular benefits for English learners and those with academic vocabulary deficits.	Vocabulary instruction
Limpo, T., & Alves, R. A. (2014). Implicit theories of writing and their impact on students' response to a SRSD intervention. *British Journal of Educational Psychology*, *84*(4), 571–590. https://www.doi.org/10.1111/bjep.12042	Limpo and Alves (2014) tested the impact of 12 weekly lessons (each 90-minutes long) that used self-regulated strategy development to help 213 5th and 6th grade students in Portugal set and monitor progress goals while receiving direct instruction in the writing process (state what you believe, give three or more reasons, explain each reason, wrap it up). Compared to a control group of students who received traditional instruction (i.e., grammar instruction and independent writing time with little support) but did not engage in goal setting and self-monitoring or receive strategy instruction, students in the treatment group wrote longer (improvement index = 36) and higher quality essays (improvement index = 26) on a post-test of their writing abilities.	Student goal setting and monitoring Strategy instruction and modeling

Study	Summary	Strategies
Lorch, R. F., Lorch, E. P., Calderhead, W. J., Dunlap, E. E., Hodell, E. C., & Freer, B. D. (2010). Learning the control of variables strategy in higher and lower achieving classrooms: Contributions of explicit instruction and experimentation. *Journal of Educational Psychology, 102*(1), 90–101. https://www.doi.org/10.1037/a0017972	Lorch and colleagues (2010) examined the effects of providing 4th grade students (*n* = 460) with explicit instruction in the control of variables strategy for designing experiments in three different treatment conditions. The strategy defines the procedure for designing experiments, including manipulating variables while holding other variables constant. Students were randomly assigned to three conditions: 1. Explicit instruction on control of variables through an interactive whole-class lecture, 2. Experimentation in small groups of three to five, designing and running trials and adjusting the slope and surface of ramps to vary the speed and distance of balls rolling down (or up) them, and 3. Both explicit instruction and experimentation. Postintervention assessments of students' ability to distinguish valid from invalid experimental comparisons demonstrated learning gains for all three groups with variances among the groups. The explicit instruction group outperformed the experimentation group (improvement index = 16). However, the instruction and experimentation group outperformed both the instruction-only group (improvement index = 12) and the experiment-only group (improvement index = 27). These gains were sustained on a five-month delayed tests. Students showed no gains in learning from the experimentation-only condition.	Guided investigations
Lynch, S., Taymans, J., Watson, W. A., Ochsendorf, R. J., Pyke, C., & Szesze, M. J. (2007). Effectiveness of a highly rated science curriculum unit for students with disabilities in general education classrooms. *Exceptional Children, 73*(2), 202–223. https://www.doi.org/10.1177/001440290707300205	Lynch and colleagues (2007) compared the effects of a 6- to 10-week guided inquiry middle school science curriculum (Chemistry that Applies) versus a traditional curriculum (Prentice Hall Science) with 8th grade students (*n* = 2,282) including many with learning disabilities (*n* = 202) in a large, diverse public school system. The intervention reflected a conceptual change theory approach to learning—introducing students to concepts and phenomena that contradict their preconceived notions (a cognitive interest cue) prior to providing them with opportunities to make sense of conflicting ideas, reflect on their prior knowledge, and discuss their ideas with other students. The unit balanced student self-direction with teacher direction with a predictable sequence of learning activities, starting with a prompt to encourage students to reflect on prior knowledge, a key question (e.g., "How do your predictions compare to the actual changes in the weights of substances?"), designing a plan to test predictions, collecting data, and a "think and write" exercise posing questions for organizing and interpreting data. After the unit of study, students with and without disabilities in the treatment group significantly outperformed those in the comparison group (improvement index = 10 for both groups).	Cognitive interest cues Guided investigations

Study	Summary	Strategies
Mayfield, K. H., & Chase, P. N. (2002). The effects of cumulative practice on mathematics problem solving. *Journal of Applied Behavior Analysis, 35*(2), 105–123. https://www.doi.org/10.1901/jaba.2002.35-105	Mayfield and Chase (2002) compared three different methods of teaching five basic algebra rules to college students (*n* = 33). Students in all three treatment conditions received the same instruction and 50-question review sessions. However, students in the first treatment condition engaged in interleaved cumulative practice, answering questions that covered a mix of the rules learned prior to each review session. Students in the second condition engaged in delayed review, answering questions on a previously trained rule. Students in the third condition engaged in massed practice, answering 50 extra questions on the rule they had just learned. After 26 learning and practice sessions, the interleaved cumulative practice group outscored the massed practice group measures of application (improvement index = 47) and general algebra skills (improvement index = 35) and also outperformed the delayed review group on both measures (improvement index = 8 and 34, respectively). In addition, the interleaved practice group solved the problem-solving items significantly faster than the other groups, demonstrating the cumulative benefits of interleaving practice.	Interleaved, spaced practice
McDougall, D., & Granby, C. (1996). How expectation of questioning method affects undergraduates' preparation for class. *The Journal of Experimental Education, 65*(1), 43–54. https://www.doi.org/10.1080/00220973.1996.9943462	McDougall and Granby (1996) studied the effects of an instructor telling a randomly selected group of students in a college-level statistics course that they would be called upon at random to answer questions during class. Compared with a control group of students who expected their instructor to use voluntary responses only, students in the treatment group read more assigned pages before class (improvement index = 30), spent more time preparing for class (improvement index = 38), and recalled more information from assigned readings (improvement index = 36). Results suggest that random "cold-calling" of students can increase class preparation, retention, and recall of new learning.	High-level questions and student explanations
McKeown, M. G., Crosson, A. C., Moore, D. W., & Beck, I. L. (2018). Word knowledge and comprehension effects of an academic vocabulary intervention for middle school students. *American Educational Research Journal*, *55*(3), 572–616. https://www.doi.org/10.3102/0002831217744181	McKeown and colleagues (2018) examined the effects of an intervention designed to teach cross-curricular academic vocabulary words to students in Grade 6 (*n* = 105) and 7 (*n* = 87) in order to improve word knowledge and reading comprehension. Students receiving the treatment, RAVE (robust academic vocabulary encounters), learned word definitions and connotations, were exposed to these in multiple contexts (e.g., how the word "expose" can be used in relation to radiation, art, culture), learned denotations and connotations of words, used words in multiple sentence constructions, and learned Latin roots of words (e.g., *fin* in "finit"e) and morphemes that can alter word meanings (e.g., un-, -ed). Results demonstrated positive effects of the treatment on 6th grade students' word knowledge (improvement index = 26) and reading comprehension (improvement index = 35), as well as 7th grade students' word knowledge (improvement index = 25) and reading comprehension (improvement index =15). However, the relatively small sample size within a single school hinders generalizability of findings.	Vocabulary instruction

Study	Summary	Strategies
McNeil, N. M., Fyfe, E. R., Petersen, L. A., Dunwiddie, A. E., & Brletic-Shipley, H. (2011). Benefits of Practicing 4 = 2 + 2: Nontraditional problem formats facilitate children's understanding of mathematical equivalence. *Child Development, 82*(5), 1620–1633. https://www.doi.org/10.1111/j.1467-8624.2011.01622.x	McNeil and colleagues (2011) examined whether practice with arithmetic problems presented in a nontraditional problem format would improve understanding of mathematical equivalence. Third grade students (*n* = 90) were randomly assigned to one of three conditions: 1. Use a traditional problem-solving format, in which problems are presented with operations on left side (e.g., 9 + 8 = 17); 2. Use a nontraditional problem format that inverts the expected order (e.g., 17 = 9 +8); or 3. No additional practice problems. Students who practiced with problems presented in a nontraditional format demonstrated significantly better posttest equation solving than students in the traditional practice group (improvement index = 28) and no extra practice group (improvement index = 22). These findings suggest that minor changes in how in students encounter practice problems can yield substantial improvements in their understanding of key concepts.	Interleaved, spaced practice
Midgette, E., Haria, P., & MacArthur, C. (2008). The effects of content and audience awareness goals for revision on the persuasive essays of fifth- and eighth-grade students. *Reading & Writing, 21*(1), 131–151. https://www.doi.org/10.1007/s11145-007-9067-9	Midgette and colleagues (2008) examined the effect of three different types of goal-setting strategies for 5th and 8th grade students writing persuasive essays. After completing an initial draft of their essays, the first group was given a general goal to "make any changes that you think would improve the essay." The second group was given a content specific goal to "add more reasons and evidence" to their essays. The third group was given a content and audience awareness goal to consider who might disagree with their opinion, the reasons they would give for their opinions, and the counterarguments they should include in their essays. Students in the third group wrote significantly more persuasive final essays than students in the content goal group (improvement index = 19), who in turn outperformed students in the general goal group (improvement index = 18). No spillover effect was evident in other elements of student writing (e.g., tone, use of strong verbs), which suggests that students may require an array of specific goals to help them engage in complex learning processes such as persuasive writing.	Student goal setting and monitoring
Morisano, D., Hirsh, J. B., Peterson, J. B., Pihl, R. O., & Shore, B. M. (2010). Setting, elaborating, and reflecting on personal goals improves academic performance. *Journal of Applied Psychology, 95*(2), 255. https://www.doi.org/10.1037/a0018478	Morisano and colleagues (2010) tested a goal-setting program for academically struggling university students (i.e., GPA of 3.0 or lower). Slightly more than half of the students (*n* = 45) were randomly chosen to engage in a 2.5-hour web-based, intensive goal-setting program that guided them through a series of steps to visualize their ideal future, identify areas of interest they want to learn more about, extract specific goals to realize their desired state, identify steps to take to achieve their goals, and clarify their commitment to each goal. Meanwhile, a control group (*n* = 40) engaged in online program of similar length, taking a series of psychology surveys and writing about positive past experiences. After four months, participants in the goal group demonstrated statistically significantly improvements in their GPAs (rising from 2.25 to 2.91), whereas the control group demonstrated no statistically significant changes in their GPAs (increasingly only slightly from 2.26 vs. 2.46). In sum, the 2.5-hour goal setting activity had a statistically significant positive effect on student outcomes (improvement index = 26).	Student goal setting and monitoring

Study	Summary	Strategies
Mwangi, W., & Sweller, J. (1998). Learning to solve compare word problems: The effect of example format and generating self-explanations. *Cognition and Instruction, 16*(2), 173–199. https://www.doi.org/10.1207/s1532690xci1602_2	Mwangi and Seller (1998) conducted a series of three experiments to examine the effects of two different approaches for providing students with worked examples to solve two-step math word problems. The first experiment with 3rd grade students (*n* = 18) randomly assigned students to two groups: one that was provided with worked-out examples of word problems to support new learning and one that solved the same problems without worked-out examples. No significant findings (improvement index = 0) emerged from this initial experiment. Researchers hypothesized that the placement of the worked-out examples at the end of word problems may have placed too much cognitive demand on students, who had to split their attention between the word problem and worked example to understand both. So, in a second experiment with 3rd graders (*n* = 27), Mwangi and Seller compared the effects of providing students with worked examples in an integrated format that showed how to solve each step of the problem versus a split-source format that only provided the entire equation at the end of the problem. In this study, the children provided integrated worked examples outperformed those presented with split-source examples (improvement index = 44). In a third experiment (*n* = 48), the researchers added another element of instruction to the worked examples, requiring some students to provide self-explanations of their solution methods to examine if thinking aloud would support even greater information processing for students. No significant effects for self-explanations were found.	Visualizations and concrete examples
Nelson, J. R., Vadasy, P. F., & Sanders, E. A. (2011). Efficacy of a tier 2 supplemental root word vocabulary and decoding intervention with kindergarten Spanish-speaking English learners. *Journal of Literacy Research, 43*(2), 184–211. https://www.doi.org/10.1177/1086296X11403088	Nelson and colleagues (2011) studied the efficacy of Tier 2 supplemental intervention to develop root word vocabulary and reinforce decoding skills for kindergarten Spanish-speaking English learners (ELs). Over the span of 20 weeks, children in both treatment and control groups received 20 minutes of daily small-group supplemental instruction in one new word per day from paraeducator tutors who taught students high-frequency, decodable words, offered child-friendly definitions of words with pictures, and used the words in child-friendly sentences. Vocabulary instruction was, however, more explicit for the treatment group (*n* = 93), with predictable and sequenced phonics-based instruction following a standardized protocol that focused on word blending, word meaning, fast reading of short passages to reinforce decoding skills, sentence completion, word-meaning matching to reinforce meaning, and “say a sentence” practice to reinforce student understanding of target words. Students in the control group, meanwhile, engaged in a less structured Tier 2 intervention—a modified form of interactive book-reading—to support their vocabulary development. At posttest, treatment students significantly outperformed control group students (*n* = 92) on proximal (i.e., closely linked to the instructional focus of the intervention) measures of root word vocabulary (improvement index = 35) and word reading (improvement index = 25). The treatment group, however, did not significantly outperform the controls on a distal measure (i.e., not linked directly to the instructional focus of the intervention) measure of reading vocabulary (improvement index = 15).	Strategy instruction and modeling Targeted supports (scaffolded practice)

Study	Summary	Strategies
Olson, C. B., Kim, J. S., Scarcella, R., Kramer, J., Pearson, M., van Dyk, D. A., Collins, P., & Land, R. E. (2012). Enhancing the interpretive reading and analytical writing of mainstreamed English Learners in secondary school: Results from a randomized field trial using a cognitive strategies approach. *American Educational Research Journal*, *49*(2), 323–355. https://www.doi.org/10.3102/0002831212439434	Olson and colleagues (2012) studied the effects of the Pathways project, a cognitive strategies approach to teaching interpretive reading and analytical writing for mainstreamed English learners in grades 6 through 11 (*n* = 1,671). Students in the treatment group were provided direct instruction (modeling, scaffolding, guided and independent practice) to help them develop a "toolkit" of mental or cognitive strategies for reading and writing, including setting goals, tapping prior knowledge, asking questions and making predictions, identifying main ideas, visualizing, self-monitoring, reading text closely, thinking aloud while reading, revising one's own thinking, and self-assessing. At the end of a full academic year of instruction, students in the treatment group significantly out-performed those in the control group in an on-demand writing assessment (improvement index = 25) but demonstrated less significant gains (improvement index = 3) in reading comprehension.	Student goal setting and monitoring Strategy instruction and modeling High-level questions and student explanations Cognitive writing
Olson, C. B., Matuchniak, T., Chung, H. Q., Stumpf, R., & Farkas, G. (2017). Reducing achievement gaps in academic writing for Latinos and English Learners in grades 7-12. *Journal of Educational Psychology, 109*(1), 1–21. https://www.doi.org/10.1037/edu0000095	Olson and colleagues (2017) tested the effects of the Pathways project, a cognitive strategies approach to teaching writing, to Grade 7–12 students (*n* = 1,817 in full sample) in a large, urban, low-SES district where 98 percent of the students were Latino and 88 percent mainstreamed English learners (ELs) with intermediate levels of fluency. Students in the treatment group were provided direct instruction (modeling, scaffolding, guided and independent practice) to help them develop a "toolkit" of mental or cognitive strategies for reading and writing, including setting goals, tapping prior knowledge, asking questions and making predictions, identifying main ideas, visualizing, self-monitoring, reading text closely, thinking aloud while reading, revising one's own thinking, and self-assessing. Over the course of two years students in the treatment group demonstrated moderately higher writing outcomes in year one (improvement index = 18) and significantly higher outcomes Year 2 (improvement index = 23) than those in the control group. Students in the treatment group were also significantly more likely to pass their state's high school exit exam in both years.	Student goal setting and monitoring Strategy instruction and modeling High-level questions and student explanations Cognitive writing
Outhwaite, L. A., Faulder, M., Gulliford, A., & Pitchford, N. J. (2019). Raising early achievement in math with interactive apps: A randomized control trial. *Journal of Educational Psychology, 111*(2), 284–298. https://www.doi.org/10.1037/edu0000286	Outhwaite and colleagues (2019) studied the effects of an interactive math app designed to provide 4- and 5-year-old students (*n* = 389) with visually rich, direct instruction and play-based retrieval practice with immediate progress feedback to support independent mastery of basic math facts and problem-solving skills. Two treatment groups were designed to answer the research question of whether children would make more progress when the app was implemented in addition to regular classroom learning or as a substitute for small-group learning. After 12 weeks of intervention, both treatment groups outperformed the control group on a standardized measure of math ability (improvement index = 12 and 8, respectively). Results suggest that the apps supported effective independent learning and practice by integrating visually appealing retrieval practice with immediate progress feedback.	Visualizations and concrete examples Retrieval practice (quizzing to remember)

Study	Summary	Strategies
Page-Voth, V., & Graham, S. (1999). Effects of goal setting and strategy use on the writing performance and self-efficacy of students with writing and learning problems. *Journal of Educational Psychology*, *91*(2), 230. https://www.doi.org/10.1037/0022-0663.91.2.230	Page-Voth and Graham (1999) compared the effects of encouraging 7th and 8th grade students with learning disabilities (*n* = 30) to set specific, individualized goals for improving their persuasive writing (e.g., to increase the number of reasons supporting their premise, increase the number of counter-arguments they refute) while also receiving a six-step strategy for writing (e.g., read the essay topic carefully, brainstorm ideas, review draft against goals) versus a comparison group that received the same strategy instruction but did not set specific goals when revising their papers. The treatment group wrote significantly higher quality (improvement index = 45) and longer (improvement index = 41) essays than those in the comparison group.	Student goal setting and monitoring
Peng, P., & Fuchs, D. (2017). A randomized control trial of working memory training with and without strategy instruction: Effects on young children's working memory and comprehension. *Journal of Learning Disabilities, 50*(1), 62–80. https://www.doi.org/10.1177/0022219415594609	Peng and Fuchs (2017) compared the effects of two different approaches to developing the verbal working memories and listening comprehension of first graders. Students (*n* = 58) were randomly assigned to three groups: 1. A group that engaged in working memory practice with strategy instruction, 2. A group that engaged in working memory practice without strategy instruction, and 3. A business-as-usual control group. All students in the treatment conditions received 35 minutes of 1:1 verbal working memory training for 10 consecutive school days for a total of 5.8 hours of additional support. During these sessions, students engaged in complex tasks designed to improve their verbal working memories (e.g., counting figures and recalling sums afterward; solving simple math problems and recalling answers in order; recalling picture cards in order; identifying a person, place, or thing based on multiple clues). Students in the strategy instruction condition were explicitly taught a strategy to aid working memory (e.g., rehearsing numbers or words to be remembered aloud). Compared to the control group, both treatment conditions showed significant effects for listening recall and listening passage comprehension (strategy instruction group improvement index = 18 and 24, respectively; practice-only group improvement index = 7 and 24, respectively). Findings suggest that brief but intensive direct instruction in strategies to enhance working memory may strengthen the working memories and listening comprehension of young children at risk by helping them learn how to mentally rehearse new information as they hear it.	Strategy instruction and modeling

Study	Summary	Strategies
Powell, S. R., Driver, M. K., & Julian, T. E. (2015). The effect of tutoring with nonstandard equations for students with mathematics difficulty. *Journal of Learning Disabilities, 48*(5), 523–534. https://www.doi.org/10.1177/0022219413512613	Powell and colleagues (2015) compared the effects of providing 2nd grade students with mathematics difficulties (*n* = 51) two different forms of small-group tutoring—standard equations tutoring and practice and a mix of standard and interleaving practice with nonstandard equation tutoring—with a no-tutoring control group. Both treatment conditions provided students with four weeks of tutoring for 10 to 15 minutes per day, three days per week. Students in the standard condition were quizzed on simple addition equations using numerical and pictorial flash cards and used math manipulatives and balance scales to develop addition fluency. In each lesson, students only practiced with standard equations (e.g., 2 + 3 = 5). Students in the nonstandard tutoring condition engaged in similar learning opportunities with the addition of interleaved nonstandard equations (e.g., 8 = 3 + __) to overcome the common student misconception of the equal sign as an operational symbol (e.g., “do something” or “the answer comes next”) instead of relational symbol indicating balance on two sides of an equation—a misinterpretation that often contributes to difficulties solving equations and word problems. On posttests, students in the combined tutoring condition fared better than the standard tutoring group in addition fluency (improvement index = 8) and open equations (e.g., 3 + __ = 8) (improvement index = 24) than the standard equation group and significantly outperformed control group students on both measures (improvement index = 14 and 47, respectively). Results indicate that exposure to interleaving practice with nonstandard equations positively influence student understanding of the equal sign as well as mathematics proficiency.	Interleaved, spaced practice
Powell, S. R., Fuchs, L. S., Fuchs, D., Cirino, P. T., & Fletcher, J. M. (2009). Effects of fact retrieval tutoring on third-grade students with math difficulties with and without reading difficulties. *Learning Disabilities Research and Practice, 24*(1), 1–11. https://www.doi.org/10.1111/j.1540-5826.2008.01272.x	Powell and colleagues (2009) studied the effects of fact retrieval tutoring for third-grade students (*n* = 139) with learning difficulties in math as well as reading. Students were randomly assigned to three treatment conditions or a no-tutoring control group. Students in the three treatment conditions all engaged in computer-based learning of math facts and practice using flash cards but received different forms of guidance and feedback from trained tutors: 1. Primarily corrective feedback (i.e., right and wrong answers) with facts to review as homework assignments; 2. Corrective feedback and review assignments, but also use of manipulatives to visualize addition and subtraction and explicit instruction showing how facts relate to one another (e.g., 7 + 5 = 12 and 12 – 7 = 5); and 3. Procedural computation/estimation instruction (e.g., showing the steps for two-digit addition and learning how to round up to the nearest 10 in double-digit addition). Tutoring spanned 45 sessions over 15 weeks for 15 to 25 minutes per session. Compared to students in the control group, students in the first two retrieval conditions performed best (improvement index = 19 and 20, respectively). Students in the third (procedural computation/estimation) treatment group performed little better than the control group (improvement index = 6), perhaps because in this condition students worked math facts without time constraints which may have diminished the benefits of retrieval practice. None of the tutoring interventions improved outcomes for the subset of students with learning difficulties in both math and reading.	Guided initial application with formative feedback Retrieval practice (quizzing to remember)

Study	Summary	Strategies
Pullen, P. C., Tuckwiller, E. D., Konold, T. R., Maynard, K. L., & Coyne, M. D. (2010). A tiered intervention model for early vocabulary instruction: The effects of tiered instruction for young students at risk for reading disability. *Learning Disabilities Research & Practice, 25*(3), 110–123. https://www.doi.org/10.1111/j.1540-5826.2010.00309.x	Pullen and colleagues (2010) examined the efficacy of a tiered intervention for vocabulary instruction based on shared storybook reading for 1st graders of whom 98 were identified as at risk for reading disability based on low levels of vocabulary. All students in the study (*n* = 224) received Tier 1 instruction in shared storybook reading from a regular classroom teacher on Days 1 and 3 (e.g., Monday, Wednesday) of instruction followed by whole-class vocabulary activities (e.g., reviewing new words, calling on students to define words). Students in the treatment group (*n* = 49) received 20 minutes of additional small-group (four to five students) instruction on the following days (e.g., Tuesday, Thursday) that included review of target words and additional opportunities for students to interact with and use them individually and as a group. Students in the treatment group demonstrated significant gains on measures of target vocabulary knowledge on receptive measures (e.g., "point to *veranda*") (improvement index =14) expressive measures (e.g., "define *veranda*") (improvement index = 19) and contextual measures (e.g., When is a time that you would be *quivering*?"; improvement index = 24).	Targeted supports (scaffolded practice)
Rawson, K. A., & Dunlosky, J. (2011). Optimizing schedules of retrieval practice for durable and efficient learning: How much is enough? *Journal of Experimental Psychology: General, 140*(3), 283. https://www.doi.org/10.1037/a0023956	Rawson and Dunlosky (2011) examined the effects of retrieval practice (quizzing) on the performance of college students (*n* = 335) who were randomly assigned to one of five groups that engaged in various amounts of retrieval practice sessions (from one to five) spread over time (from 1 to 31 days). On posttests administered one month after initial learning, results showed a significant effect for all practice sessions if items were initially mastered three times versus once in the initial practice session (improvement index = 11). The following effect sizes were found for subsequent practice sessions over a single session: two versus one (improvement index = 21), three versus two (improvement index = 14), four versus three (improvement index = 10), five versus four (improvement index = 10). Three learning sessions, in fact, appeared to create the optimal learning gains over just one practice session (improvement index = 33) with diminishing returns emerging for the fourth and fifth practice sessions. Relearning items only once demanded a total of 6.3 minutes of practice time per item. A second relearning session added another 0.7 minutes of practice time per item but yielded a 35 percent improvement in performance. Three relearning sessions (vs. one) added only another 2.7 minutes of practice time per item but yielded a 62 percent improvement in performance. Four and five relearning sessions (vs. one) added 3.4 or 4.8 minutes, respectively, of additional practice time per item but with diminishing incremental benefit to retention. These findings suggest the most efficient approach to practice is the 3x3 schedule (practicing to three correct recalls during the initial session followed by three subsequent learning sessions).	Retrieval practice (quizzing to remember)

Study	Summary	Strategies
Rittle-Johnson, B., & Star, J. R. (2007). Does comparing solution methods facilitate conceptual and procedural knowledge? An experimental study on learning to solve equations. *Journal of Educational Psychology, 99*(3), 561. https://www.doi.org/10.1037/0022-0663.99.3.561	Rittle-Johnson and Star (2007) examined the effects of students work in pairs to engage in comparing and contrasting alternative solutions methods versus reflecting on the same solution methods for 7th grade students (n = 70) learning to solve algebra equations. During a two-day intervention, students worked in pairs in both groups to learn algebra equation methods using worked examples and practice problems. One group of student pairs (n = 18) studied worked examples that showed side-by-side comparisons of two different methods for solving a problem while student pairs in a second group (n = 17) studied worked examples of different solution methods provided sequentially (one after the other). At posttest, students who studied side-by-side examples of worked problems demonstrated greater gains in problem solving abilities (improvement index = 20) and flexibility in employing different solution methods than those in the sequential group (improvement index = 15). Both groups demonstrated similar gains in conceptual knowledge with slightly higher, but not statistically significant, outcomes for the sequential group (improvement index = 6). These findings suggest students benefit from comparing and contrasting solution methods to develop problem-solving skills.	Visualizations and concrete examples
Rohrer, D., Dedrick, R. F., & Burgess, K. (2014). The benefit of interleaved mathematics practice is not limited to superficially similar kinds of problems. *Psychonomic Bulletin & Review, 21*(5), 1323–1330. https://www.doi.org/10.3758/s13423-014-0588-3	Rohrer and colleagues (2014) compared the effects of interleaved vs. blocked mathematics practice problems for 7th grade students (n =140). Over a nine-week period, students in the treatment group received different kinds of practice problems interleaved, which required them to first identify the problem type and then select the appropriate strategy. Students in the control group received more traditional practice assignments—a block problems that reflect the strategy they had just learned, which meant they already knew which strategy to use before solving the problem. On an unannounced posttest administered two weeks after the intervention, students in the treatment group significantly outperformed those in the blocked practice group (improvement index = 35). Results suggest interleaving improves learning by improving students' ability not only to discern between different kinds of problems but also to connect problem types with their corresponding strategy.	Interleaved, spaced practice
Rohrer, D., Dedrick, R. F., Hartwig, M. K., & Cheung, C. N. (2020). A randomized controlled trial of interleaved mathematics practice. *Journal of Educational Psychology, 112*(1), 40. https://www.doi.org/10.1037/edu0000367	Rohrer and colleagues (2020) compared the effects of interleaved practice (i.e., arranging mathematics practice opportunities so that no two consecutive problems required the same strategy) versus traditional practice assignments (i.e., a block of problems devoted to the same skill or concept assignments) for seventh grade students (n = 54). After four months, students in the interleaved practice group significantly outscored the blocked practice group (improvement index = 30). Teachers could implement the intervention without training, which suggest interleaved mathematics practice is both effective and feasible.	Interleaved, spaced practice

Study	Summary	Strategies
Roschelle, J., Feng, M., Murphy, R. F., & Mason, C. A. (2016). Online mathematics homework increases student achievement. *AERA Open, 2*(4), 1–12. https://www.doi.org/10.1177/2332858416673968	Roschelle and colleagues (2016) studied the effects of providing 7th grade students (*n* = 2,850) with an online tool (ASSISTments) that gave students timely feedback and hints on multistep math problems. In addition to immediate hints and answers, the online tool supported students guided initial application of new learning by providing them with extensive guidance on how to solve problems as well as "skill builder" exercises that provide students with repeated practice on problems until they achieved mastery (e.g., a streak of three correct answers on similar problems) and opportunities to engage in spaced practice to build retention of new skills. Results showed that compared to a control group of students that engaged in traditional (delayed feedback) homework assignments, the intervention had small, but statistically significant impact on student scores on an end-of-the-year standardized mathematics assessment (improvement index = 7) with slightly larger effects for below-average students (improvement index = 11).	Guided initial application with formative feedback Interleaved, spaced practice
Roschelle, J., Shechtman, N., Tatar, D., Hegedus, S., Hopkins, B., Empson, S., Knudsen, J., & Gallagher, L. P. (2010). Integration of technology, curriculum, and professional development for advancing middle school mathematics: Three large-scale studies. *American Educational Research Journal, 47*(4), 833–878. https://www.doi.org/10.3102/0002831210367426	In a series of three large-scale studies, Roschelle and colleagues (2010) studied the effects of a two- to three-week mathematics program for 6th, 7th, and 8th grade students (the SimCalc Project), which integrated interactive technology, text-based curriculum, and teacher professional learning. Students in the treatment groups (*n* = 825, 510, and 303, respectively) learned the mathematics of change and variation through visually enhanced instruction (i.e., computer animations paired with words) that were anchored in familiar everyday experiences (e.g., runners in a race) with learning cycles that asked them to make predictions, compare their predictions with mathematical reality, and explain the differences between their predictions and reality. Across all three experiments, students in the treatment groups demonstrated significantly greater grains in learning advanced mathematics (improvement index = 24, 19, 21, respectively) than those in the control group, who received business-as-usual instruction. These findings demonstrate the benefits of using interactive, multimedia visualizations of learning and student explanations of learning to enhance learning outcomes, especially with advanced mathematics.	Visualizations and concrete examples High-level questions and student explanations

Study	Summary	Strategies
Saddler, B., & Graham, S. (2005). The effects of peer-assisted sentence-combining instruction on the writing performance of more and less skilled young writers. *Journal of Educational Psychology*, *97*(1), 43–54. https://www.doi.org/10.1037/0022-0663.97.1.43	Saddler and Graham (2005) examined the effects of integrating three instructional strategies to develop the writing skills of 4th grade students (*n* = 44): 1. Direct instruction in the basic writing strategy of sentence combining (i.e., showing students how to construct complex sentences from two or more basic ones), 2. Peer-assisted learning (pairing a stronger writer with a weaker one to practice the target skill with students alternatively coaching one another), and 3. Giving students opportunities to apply the strategy during independent practice while writing a paper with their partner and revising their writing. Students in the comparison group received direct instruction in grammar and worked in pairs to practice using more descriptive nouns, verbs, and modifiers in their writing. After receiving 30, 25-minute lessons over 10 weeks of instruction, students in the sentence combining treatment group were significantly more capable of revising essays to improve their quality (improvement index = 24) than those in the grammar instruction control group. Researchers concluded that direct instruction in sentence combining paired with peer-assisted practice and coaching likely made the process of writing more habitual and less effortful for students, freeing up their mental bandwidth to focus on more complex writing processes, thus improving the quality of their essays.	Strategy instruction and modeling Peer-assisted consolidation of learning
Sawyer, R., Graham, S., & Harris, K. (1992). Direct teaching strategy instruction with explicit self-regulation: Effects on the composition skills and self-efficacy of students with learning disabilities. *Journal of Educational Psychology, 84*, 340–352. https://www.doi.org/10.1037/0022-0663.84.3.340	Sawyer and colleagues (1992) compared the effects of four approaches to teaching writing to students with learning disabilities in 5th and 6th grade (*n* =43): 1. Direct instruction in writing strategies; 2. Direct instruction in writing strategies plus guidance in self-instruction, collaborative practice, and independent practice with feedback; 3. Full self-regulated strategy development (SRSD; the previous strategies plus goal setting and self-monitoring), and 4. Business-as-usual instruction (control group). On a posttest of writing skill, students who had engaged in full SRSD with goal setting and self-monitoring outperformed the self-instruction without goal setting and self-monitoring group (improvement index = 30) and direct instruction only group (improvement index = 47).	Student goal setting and monitoring
Scheiter, K., Gerjets, P., & Schuh, J. (2010). The acquisition of problem-solving skills in mathematics: How animations can aid understanding of structural problem features and solution procedures. *Instructional Science, 38*(5), 487–502. https://www.doi.org/10.1007/s11251-009-9114-9	Scheiter and colleagues (2010) studied the effects of a brief (two-hour) intervention to augment algebraic concepts with computer-based animations among a small sample (*n* = 32) of 9th grade students. Students in the treatment group received hybrid instruction that included animations based on the "concreteness fading" concept—dynamic visualizations of problems were gradually replaced with algebraic formulas—along with worked-out examples of problem solutions; students in the control group were taught with text-based worked-out examples only. Students in the hybrid group demonstrated superior ability to transfer problem-solving skills to similar problems (improvement index = 37) and unrelated problems (improvement index = 37) than those in the control group.	Visualizations and concrete examples

Study	Summary	Strategies
Schunk, D. H., & Swartz, C. W. (1991, April 3–7). *Process goals and progress feedback: Effects on children's self-efficacy and skills* [Paper presentation]. American Educational Research Association Annual Meeting, Chicago, IL, United States. https://files.eric.ed.gov/fulltext/ED330713.pdf	Schunk and Swartz (1991) examined the effects of goal setting and progress feedback on self-efficacy and writing achievement for 5th graders (*n* = 60). Prior to writing four different types of paragraphs (descriptive, informative, narrative, descriptive narrative), all students received modeling/strategy instruction and guided practice in writing, but were randomly assigned to one of four conditions: 1. Setting product goals (e.g., writing a good paragraph), 2. Setting process goals (e.g., learning the process for writing a good paragraph), 3. Setting process goals and receiving regular progress feedback, or 4. Setting a general goal (e.g., "try to do your best"). On a posttest of writing skill, students in the goal-plus-feedback group significantly outperformed the "try-your-best" goal control group (improvement index = 50) as well as the goal-only group (improvement index = 22). Even without feedback, students who set process goals outperformed those who set product goals (improvement index = 44). These findings suggest integrating strategy instruction with mastery goals and progress feedback can have significant benefits for students.	Student goal setting and monitoring
Schunk, D. H., & Swartz, C. W. (1993). Goals and progress feedback: Effects on self-efficacy and writing achievement. *Contemporary Educational Psychology, 18*(3), 337–354. https://www.doi.org/10.1006/ceps.1993.1024	Schunk and Swartz (1993) compared the writing performance of 40 mostly nonwhite 4th graders who received similar writing strategy instruction but in four different treatment conditions during 45-minute learning sessions delivered over 20 days. The first two groups were repeatedly given process goals (e.g., to "learn how to use these steps to write a descriptive paragraph") One of these groups also received progress feedback three to four times each lesson. A third group were given goals that emphasized the product of learning over the process (e.g., setting a goal to simply "write a descriptive paragraph") A fourth (control) group was given vague goals to "try to do your best." Although students initially demonstrated similar writing abilities, after six weeks of intervention those who set process goals and received immediate progress feedback scored significantly higher on a "maintenance" test of writing skills than those with process goals alone (improvement index = 33), product goals (improvement index = 39), and vague goals (improvement index = 50).	Student goal setting and monitoring

Study	Summary	Strategies
Scruggs, T. E., Mastropieri, M. A., & Sullivan, G. S. (1994). Promoting relational thinking: Elaborative interrogation for students with mild disabilities. *Exceptional Children, 60*(5), 450–457. https://www.doi.org/10.1177/001440299406000507	Scruggs and colleagues (1994) examined the effectiveness of using "elaborative interrogation" techniques to facilitate the content acquisition of 4th and 5th grade students (n = 36) with mild disabilities. Students were randomly selected to engage in three conditions—control, experimenter-provided explanation, and student-generated explanation—while learning facts about well-known animals (e.g., "the porcupine moves slowly," "the camel has a double row of eyelashes for each eye"). In the control condition, adults presented facts to students who engaged in drill-and-practice to learn them. In the experimenter-provided explanation condition, an adult provided students with an explanation for the fact (e.g., "the camel lives in the desert where the sand blows"). In the student-generated explanation condition, adults asked students to offer an explanation (e.g., "Why would it make sense that the anteater has longer claws on its front feet?"). On delayed posttest measures of recall of facts and explanations, the student-generated explanation group significantly outperformed both the control group (improvement index = 44 and 46, respectively) and also the experimenter-provided explanations group on both measures (improvement index = 30 and 4, respectively). Researchers hypothesized that self-explanations support learning by engaging students in connecting new learning with prior knowledge, but not that these findings should not be construed to suggest that indirect techniques such as self-explanations should be used to replace direct instruction; rather these techniques should supplement other strategies by helping students to process new learning.	High-level questions and student explanations
Silverman, R., & Hines, S. (2009). The effects of multimedia-enhanced instruction on the vocabulary of English-language learners and non-English-language learners in pre-kindergarten through second grade. *Journal of Educational Psychology, 101*(2), 305–314. https://www.doi.org/10.1037/a0014217	Silverman and Hines (2009) compared the effects of providing two different forms of science academic vocabulary instruction to pre-K–grade 2 students: multimedia and nonmultimedia traditional instruction. Over the course of 12 weeks of instruction (45 minutes per day, 3 days per week) students in both groups—which included both English-language learners (ELL) and non-English learners (n = 85 overall)—were taught the same 100 academic vocabulary words using the same science texts and scripted curriculum. Students in the treatment group were shown short video clips to illustrate each word whereas students in the control engaged in teacher-led discussion and review of vocabulary terms. No significant results emerged for non-ELLs, but ELL students taught new vocabulary via visual representations demonstrated significantly greater knowledge of new words than peers in the control group (improvement index = 33) and general vocabulary knowledge (improvement index = 34).	Visualizations and concrete examples
Star, J. R., & Rittle-Johnson, B. (2009). It pays to compare: An experimental study on computational estimation. *Journal of Experimental Child Psychology, 102*(4), 408–426. https://www.doi.org/10.1016/j.jecp.2008.11.004	Star and Rittle-Johnson (2009) compared the effects of two different approaches to using worked-out examples to teach fifth grade students (n = 157) multiple approaches to problem solving in mathematics. Students in the compare condition studied two different approaches to solving the same problem of computational estimation presented side-by-side (e.g., round one number in a multiplication problem vs. rounding both numbers). Students in the sequential condition studied the same two worked examples sequentially. Results slightly favored students in compare condition on a posttest of problem-solving skills (improvement index = 11) though these effects faded on a subsequent retention test of the same skills (improvement index = 6).	Visualizations and concrete examples

Study	Summary	Strategies
Stevens, R. J. (2003). Student team reading and writing: A cooperative learning approach to middle school literacy instruction. *Educational Research and Evaluation*, *9*(2), 137–160. https://www.doi.org/10.1076/edre.9.2.137.14212	Stevens (2003) tested the effects of an intervention (student team reading and writing) designed to improve reading and writing skills of early adolescents (*n* = 3,916 for overall sample) in urban, high-poverty middle schools by integrating five key components: 1. Motivating learners with high-interest, cognitively challenging texts from high-quality authors (e.g., Langston Hughes, Pearl S. Buck, Isaac Asimov), 2. Providing direct instruction in reading comprehension strategies (e.g., word mastery, comprehension monitoring, and summarizing), 3. Delivering direct instruction in the writing process (i.e., planning, drafting, revising, editing, finalizing) and key concepts of writing (e.g., improving descriptions, getting readers' attention), 4. Engaging students in frequent writing on topics meaningful to them, and 5. Creating cooperative (and competitive) learning teams of heterogenous abilities and pairing students with reading and learning partners. After a full-year implementation of the model, students in the randomly assigned treatment group significantly outperformed those in the business-as-usual control group on measures of reading vocabulary (improvement index = 13), reading comprehension (improvement index = 10), and language expression (improvement index = 15).	Cognitive interest cues Strategy instruction and modeling Peer-assisted consolidation of learning Cognitive writing
Swanson, H. L., Lussier, C., & Orosco, M. (2013). Effects of cognitive strategy interventions and cognitive moderators on word problem solving in children at risk for problem solving difficulties. *Learning Disabilities Research & Practice*, *28*(4), 170–183. https://www.doi.org/10.1111/ldrp.12019	Swanson and colleagues (2013) compared the effects of three randomly assigned treatment conditions for elementary school students (*n* = 120) with math difficulties (below the 25th percentile on norm-referenced achievement tests) to a no-treatment control condition. In each treatment condition, small groups of students received 20 scripted, 30-minute lessons over the course of eight weeks. Each lesson began with five minutes of direct instruction in a rule or strategy for solving problems. Students in the first treatment condition learned a step-by-step process for solving word problems (e.g., find the question sentence and underline it, circle the numbers) and identifying the correct operation to solve them. Students in the second condition were provided a visual-schematic diagram and shown how to use diagrams to visualize and solve problems (e.g., using boxes to identify the parts of a whole). Students in the third condition received step-by-step instruction and the visual diagram treatments. Researchers found significant effects for visual-schematic instruction on postintervention measures of problem solving (improvement index = 22) and smaller effects for combining step-by-step and visual-schematic instruction (improvement index = 14). One explanation for the limited effects of cognitive strategies for students with math disabilities is the cognitive demands the step-by-step guidance may have placed on students whereas the visual techniques allowed them to map numbers from the text onto a visual aid and thus focus on more relevant elements of the problem.	Visualizations and concrete examples

Study	Summary	Strategies
Tajika, H., Nakatsu, N., Nozaki, H., Neumann, E., & Maruno, S. (2007). Effects of self-explanation as a metacognitive strategy for solving mathematical word problems *Japanese Psychological Research, 49*(3), 222–233. https://www.doi.org/10.1111/j.1468-5884.2007.00349.x	Tajika and colleagues (2007) examined the effects of teaching 6th graders (*n* = 79) to think aloud using self-explanation while studying worked-out examples and solving math word problems. Students received the same whole-class instruction on calculating ratios, but were randomly assigned to one of three groups: 1. A self-explanation group, which received multistep worked-out examples that they were instructed to explain aloud and confirm they understood; 2. A self-learning group, which received the same worked-out examples but were not instructed to think through them aloud; and 3. A control group, which received answers to the sample problems but not examples showing each step of the process. Afterward, students in the self-explanation group outperformed students in the self-learning group (improvement index = 32) and control group (improvement index = 38) on a test of their ability to solve similar word problems as well as a transfer test that measured their ability to extend learning to solve novel problems (improvement index = 22 and 28, respectively). Minimal effects were found for self-learning compared to controls on both measures, which suggests worked-out examples alone have limited effects without metacognitive reflection and learning.	High-level questions and student explanations
Terwel, J., van Oers, B., van Dijk, I., & van den Eeden, P. (2009). Are representations to be provided or generated in primary mathematics education? Effects on transfer. *Educational Research and Evaluation*, *15*(1), 25–44. https://www.doi.org/10.1080/13803610802481265	Terwel and colleagues (2009) compared the effects of providing 5th grade students (*n* = 239) with ready-made visual representations for learning the mathematical concept of percentage (control condition) or engaging them in co-creating their own (treatment condition). Students in the treatment condition were prompted to work in small groups to process learning, solve real-life problems, and develop their own visual representations of concepts based on teacher guidance. Students in the control condition, meanwhile, worked individually to apply teacher-provided visuals and graphs and then worked in groups to discuss their solutions with peers. After three weeks of instruction (one hour per day), students were given a researcher-developed test of knowledge related to concepts taught and a transfer test that required students to draw upon their learning to solve novel problems (e.g., applying understand of percentages to solve permillage problems). Students in the treatment group outperformed those in the control group on both tests of knowledge (improvement index = 16) and the transfer test (improvement index = 24), demonstrating the benefits of engaging students in developing their own models and visual representations of what they are learning, perhaps because doing so instills ownership of learning.	Visualizations and concrete examples

Study	Summary	Strategies
Tong, F., Irby, B. J., Lara-Alecio, R., Guerrero, C., Fan, Y., & Huerta, M. (2014). A randomized study of a literacy-integrated science intervention for low-socio-economic status middle school students: Findings from first-year implementation. *International Journal of Science Education*, *36*(12), 2083–2109. https://www.doi.org/10.1080/09500693.2014.883107	Tong and colleagues (2014) examined the effects of one-year reading/literacy-integrated science inquiry intervention on 5th-grade low-socioeconomic status (SES) African American and Hispanic students' achievement in science and English reading (*n* = 94 treatment students, 194 comparison students). Teachers in the treatment condition followed scripted lesson plans designed to engage students in inquiry-based science learning (following the BSCS 5E model of lesson design), provide direct instruction in academic and science vocabulary, frequent reading and writing exercises, including written summaries and an illustrated glossary of science terms, and peer-learning to process new learning and engage in hands-on exploration activities. Control group students, meanwhile, engaged in traditional classroom instruction focused on textbook readings, class lectures and worksheets. Students in the treatment group were significantly more likely than control group students to pass a districtwide curriculum-based science test (improvement index =43). Findings confirm that integrating literacy, including explicit vocabulary instruction, into inquiry-based science instruction can promote students' science and reading achievement, particularly for low-SES students.	Vocabulary instruction Peer-assisted consolidation of learning Guided investigations Cognitive writing
Townsend, D., & Collins, P. (2009). Academic vocabulary and middle school English learners: An intervention study. *Reading and Writing*, *22*(9), 993–1019. https://www.doi.org/10.1007/s11145-008-9141-y	Townsend and Collins (2009) studied the effectiveness of an academic vocabulary intervention for middle school (grades 6–8) English learner students *(n* = 37). Students in the treatment condition engaged in researcher-led teaching sessions that focused on teaching 60 key academic vocabulary words over a total of 20, 75-minute, afterschool sessions (4 days per week for 5 weeks). Lessons were aligned with state curriculum standards and included nonfiction social studies and science texts and provided multiple opportunities for students to process word meanings, personalize them, and encounter them in a variety of ways, including direct instruction, word games (modified versions of Taboo and Pictionary), and other activities such as short skits to illustrate the words. Students in the control condition attended an afterschool homework club. Treatment students showed significantly more growth in knowledge of academic vocabulary during treatment than control conditions (improvement index = 32) with even greater effects for students who made the least progress in English vocabulary in the absence of the intervention.	Vocabulary instruction
Tournaki, N. (2003). The differential effects of teaching addition through strategy instruction versus drill and practice to students with and without learning disabilities. *Journal of Learning Disabilities, 36*(5), 449–458.	Tournaki (2003) studied the effectiveness of providing 2nd grade students (n = 84) with direct instruction in the "minimal addend" strategy. Students randomly assigned to the treatment group were taught how to start with the larger of two digits when adding (e.g., 5 in 5 +3) and "count on" from there (e.g., 6, 7, 8). Compared to a control group that engaged in addition drill and practice, teaching this simple skill to students supported learning gains for all students (improvement index = 29), with even greater gains for students with identified learning disabilities (improvement index = 43).	Strategy instruction and modeling

Study	Summary	Strategies
Troia, G. A., & Graham, S. (2002). The effectiveness of a highly explicit, teacher-directed strategy instruction routine: Changing the writing performance of students with learning disabilities. *Journal of Learning Disabilities, 35*(4), 290–305. https://www.doi.org/10.1177/00222194020350040101	Troia and Graham (2002) examined the effectiveness of adding a highly explicit, teacher-directed instructional routine for planning (goal setting, brainstorming, organizing) to a four-step process for writing (drafting, revising, proofreading and editing, publishing) to a randomly selected group of Grade 4 and 5 students identified with special needs (n = 24). Compared to similar students who received process instruction only, students who received explicit direct instruction in planning strategies spent more time planning their writing (improvement index = 43) and wrote better narrative stories (improvement index = 34). These effects found to persist (and increase) a month later on a follow-up narrative writing assignment (improvement index = 48). Students in the treatment group, however, did not appear to transfer these planning strategies to a subsequent, different writing assignment (i.e., persuasive writing), which suggests that many students may require ongoing guidance in goal setting and other metacognitive strategies (e.g., in the form of checklists, rubrics, and mnemonic devices) to internalize and transfer these habits of mind to future learning opportunities.	Student goal setting and monitoring Strategy instruction and modeling
Vadasy, P. F., & Sanders, E. A. (2008). Code-oriented instruction for kindergarten students at risk for reading difficulties: A replication and comparison of instructional groupings. *Reading & Writing, 21*(9), 929–963. https://www.doi.org/10.1007/s11145-008-9119-9	Vadasy and Sanders (2008) examined the effects of phonics-based tutoring with guided practice for at-risk, urban kindergarten students (N = 76) in two different formats: individual instruction and instruction in dyads. Students were assigned to one of three conditions: individual tutoring (n = 22), tutoring in dyads (n = 32), or no tutoring (n = 22, classroom instruction only). Paraeducators provided 18 weeks of explicit instruction and guided practice opportunities in phonemic skills and the alphabetic code to students 30 minutes daily. Tutored students significantly outperformed nontutored students on posttest measures of phonological awareness (improvement index = 22), word reading accuracy (improvement index = 24), oral reading fluency (improvement index = 18), spelling (improvement index = 19), and comprehension (improvement index = 16) with no significant differences between the two tutored groups, suggesting code-oriented tutoring for pairs of students as a viable alternative to individual instruction.	Strategy instruction and modeling Guided initial application (scaffolded practice) Targeted supports (scaffolded practice)
Vadasy, P. F., & Sanders, E. A. (2010). Efficacy of supplemental phonics-based instruction for low-skilled kindergartners in the context of language minority status and classroom phonics instruction. *Journal of Educational Psychology, 102*(4), 786–803. https://www.doi.org/10.1037/a0019639	Vadasy and Sanders (2010) examined the effects of supplemental phonics instruction for low-skilled language minority (LM) kindergartners and non-LM kindergartners (n = 148). Students performing in the bottom half of their classroom language group (LM and non-LM) were randomly assigned either to individualized supplemental phonics-based instruction (treatment)—including letter-sound correspondence, phonemic decoding, spelling, and guided practice in oral reading—or to classroom instruction only (control) for 18 weeks. Tutoring sessions typically consisted of 20 minutes of explicit phonics instruction and 10 minutes of assisted oral reading practice in decodable texts. Tutors would listen as students read text and offer support as needed, including "echo reading": reading challenging lines to students who would repeat them afterward. Irrespective of language status, treatment students significantly outperformed controls at posttest in alphabetics, word reading, spelling, passage reading fluency, and comprehension (average improvement index = 30). Regular classroom instruction, however, significantly influenced the effects of supplemental learning with greater effects for spelling evident for students in lower phonics classrooms and greater effects on comprehension for students in higher phonics classrooms with the effects of classroom phonics time itself found to have a significant effect on phonological awareness and reading comprehension (improvement index = 10).	Strategy instruction and modeling Guided initial application (scaffolded practice) Targeted supports (scaffolded practice)

Study	Summary	Strategies
Vadasy, P. F., Sanders, E. A., & Logan Herrera, B. (2015). Efficacy of rich vocabulary instruction in fourth- and fifth-grade classrooms. *Journal of Research on Educational Effectiveness*, *8*(3), 325–365. https://www.doi.org/10.1080/19345747.2014.933495	Vadasy and colleagues (2015) conducted a multicohort cluster randomized trial to estimate the effects of rich vocabulary classroom instruction on vocabulary and reading comprehension for 4th and 5th grade students from 61 classrooms and 24 schools (*n* = 1,232). Students in the treatment condition received 30 minutes of instruction per day over 14 weeks in 140 vocabulary words featured in two grade-level novels. Instruction included providing definitions of words, examples of their use in sentences, synonym matching, encountering words in novels, and using them in writing exercises. After adjusting for pretest differences among students, significant treatment effects were found on proximal measures of word knowledge (improvement index = 49). Smaller effects were found a research-created test of comprehension (improvement index = 11). No significant effects were found, however, on distal, standardized measures of word knowledge (improvement index = 6) or reading comprehension (improvement index = 6). Classroom observations indicated, however, that treatment teachers increased instructional time on vocabulary at the expense of instructional time for comprehension, which suggests vocabulary instruction needs to be balanced with other instructional considerations.	Vocabulary instruction
Vaughn, S., Cirino, P. T., Linan-Thompson, S., Mathes, P. G., Carlson, C. D., Hagan, E. C., Pollard-Durodola, S. D., Fletcher, J. M., & Francis, D. J. (2006). Effectiveness of a Spanish intervention and an English intervention for English-language learners at risk for reading problems. *American Educational Research Journal, 43*(3), 449–487.	Vaughn and colleagues (2006) compared the effects of small-group reading interventions for first grade English-language learners at risk for reading problems (*N* = 171) who were provided regular classroom instruction and small-group tutoring in either Spanish (*n* = 80) or English (*n* = 91). Students in the treatment group received 75 to 107 hours of supplemental reading instruction (approximately 115 intervention sessions of 50 minutes each) from certified teachers who followed an explicit scope and sequence in phonemic awareness, phonics instruction, application of alphabetic knowledge in reading, and reading for meaning. Learning activities included word games, reading expository texts, guided practice (with ongoing and systematic feedback) in reading and writing, sounding out complex words, retelling and summarizing texts as well as direct instruction in vocabulary. For students in English-only classrooms, the treatment generated significant positive outcomes across several measures, including phonological awareness, letter-sound identification, decoding, and word reading (improvement index, on average = 16). For students in Spanish-only classrooms, results also favored treatment students across a variety of measures of phonological awareness, letter-sound and letter-word identification, verbal analogies, word reading fluency, and spelling (improvement index, on average = 17). Comparison students in both the Spanish and English groups made significant reading gains over the course of the study, possibly because both treatment and control groups were drawn from schools recognized for their successful performance; thus, teachers in both groups may have already been using evidence-based reading practices and providing supplemental instruction to students during regular classroom instruction.	Strategy instruction and modeling Guided initial application with formative feedback Targeted supports (scaffolded practice)

Study	Summary	Strategies
Vaughn, S., Martinez, L. R., Wanzek, J., Roberts, G., Swanson, E., & Fall, A. M. (2017). Improving content knowledge and comprehension for English language learners: Findings from a randomized control trial. *Journal of Educational Psychology*, *109*(1), 22–34. https://www.doi.org/10.1037/edu0000069	Vaughn and colleagues (2017) compared the outcomes of 8th grade students whose social studies teachers employed a variety of strategies to increase their student motivation and learnings versus a comparison group whose teachers taught the same content with a business-as-usual approach. One such strategy included providing a "comprehension canopy" to cue cognitive interest and activate prior knowledge. At the start of each lesson, teachers engaged students in a 10- to 15-minute routine that included an engaging video clip to provide students with a purpose for their learning, link it to their prior knowledge, and focus them on comparing and contrasting, cause and effect, or perspective taking. Teachers also provided modeling and direct instruction of reading comprehension strategies by guiding students through a critical reading routine that included modeling the use of self-evaluative comprehension questions during reading. As students moved through the unit, teachers repeated this 15-minute close-reading routine with each new text. Lessons also included instruction of essential vocabulary, regular comprehension checks, and team-based problem-solving activities. For example, students were asked to respond in groups to such questions as, "How did the colonial regions develop differently?" or "What might have happened to prevent the Revolutionary War?" Both English learners (ELs) and non-ELs who received the intervention significantly outperformed students in the control group on measures of content knowledge (improvement index = 16) and reading comprehension (improvement index = 8).	Cognitive interest cues Vocabulary instruction Strategy instruction and modeling Peer-assisted consolidation Structured problem solving
Wanzek, J., Vaughn, S., Kent, S. C., Swanson, E. A., Roberts, G., Haynes, M., Fall, A.-M., Stillman-Spisak, S. J., & Solis, M. (2014). The effects of team-based learning on social studies knowledge acquisition in high school. *Journal of Research on Educational Effectiveness, 7*(2), 183–204. https://www.doi.org/10.1080/19345747.2013.836765	Wanzek and colleagues (2014) examined the effects of team-based learning intervention for 11th grade social studies students. Students in treatment classes participated in three, 15-day units of instruction using team-based learning practices to engage in dialogue about course content, application of content to solve problems, and use evidence to support responses. Student teams were strategically designed as heterogenous, permanent teams of three to five students who worked together to achieve consensus on comprehension-check quiz questions through dialogue on their shared responses and collaborated on application activities designed to use new learning to address a problem (e.g., "Consider the top three priorities for the nation as it moves from isolationism to expansionism. Then, consider the most pivotal moments in each president's term and make recommendations as to whether the same or a different course of action is required."). Afterward, they engaged in a peer evaluation process, reflecting on the contributions of individual team members to the group's success. Posttest measures of content acquisition found a small but statistically significant effect on learning for students in the treatment group over those in the business-as-usual control group, which engaged in whole-class instruction and questioning and independent text reading and work (improvement index = 9). These benefits, however, were more pronounced for moderate- and high-performing students (improvement index = 29 and 16, respectively), whereas those with low pretest scores also scored low at posttest, demonstrating no significant growth in learning. One possible explanation for these differences is that that higher achieving students may have been better prepared to engage in critical thinking and reasoning about their learning, and thus, fared better with more student-directed learning opportunities than students with low prior knowledge and reading comprehension abilities, who may benefit from more direct instruction and scaffolding of content and reading skills.	Peer-assisted consolidation of learning

Study	Summary	Strategies
Wasik, B. A., & Bond, M. A. (2001). Beyond the pages of a book: Interactive book reading and language development in preschool classrooms. *Journal of Educational Psychology, 93*(2), 243. https://www.doi.org/10.1037/0022-0663.93.2.243	Wasik and Bond (2001) demonstrated the benefits of direct vocabulary instruction through interactive book reading—reading books to students to students and presenting them with concrete objects represented by the words and giving students opportunities to use book-related words. Overall, 127 low-income (95%), African American (94%) preschoolers enrolled in a Title 1 learning center in Baltimore, Maryland, participated in the study. Two teachers were randomly selected to provide their students (n = 61) with daily interactive book reading over a 15-week period. At the end of the intervention, students in the treatment group demonstrated significantly greater vocabulary development on both receptive measures (improvement index = 28) and expressive measures (improvement index = 35) than students in the control group.	Vocabulary instruction Visualizations and concrete examples
Williams, J. P., Nubla-Kung, A. M., Pollini, S., Stafford, K. B., Garcia, A., & Snyder, A. E. (2007). Teaching cause-effect text structure through social studies content to at-risk second graders. *Journal of Learning Disabilities*, *40*(2), 111–120. https://www.doi.org/10.1177/00222194070400020201	Williams and colleagues (2007) compared the effect of providing at-risk second graders (n = 243) with strategy instruction in how to read nonfiction social studies texts compared with content-only instruction. Randomly assigned treatment group students were explicitly taught the concept of cause and effect, shown how to use clue words (e.g., “because,” “therefore”) to identify cause-effect text structure, use graphic organizers to depict cause-and-effect relationships, and ask themselves causal comprehension questions (i.e., “What is the cause?” “What is the effect?” “What are the effects of having very little money for schools?”) to review and summarize text. Control group students were taught the same content and read the same texts without structure-strategy instruction, using, for example, an information web to summarize text. Both groups engaged in 22 lessons in all. Students in the treatment group demonstrated significantly greater comprehension of reading texts—namely the ability to understand cause-effect relationships—than those in the content-only control group (improvement index = 44).	Strategy instruction and modeling High-level questions and student explanations
Williams, J. P., Pollini, S., Nubla-Kung, A. M., Snyder, A. E., Garcia, A., Ordynans, J. G., & Atkins, J. G. (2014). An intervention to improve comprehension of cause/effect through expository text structure instruction. *Journal of Educational Psychology*, *106*(1), 1–17. https://www.doi.org/10.1037/a0033215	Williams and colleagues (2014) examined the effects of teaching “structure strategy instruction” to second-grade students at risk of failure (n = 197) engaged in reading nonfiction (social studies) reading texts. During 20 classroom lessons, students in the treatment condition received direct instruction in cause and effect, were taught to identify clue words signaling cause and effect statements (e.g., thus, because), used graphic organizers to depict cause-and-effect relationships in what they were reading, and responded to high-level questions reviewing cause and effect relationships in what they read. Students in the comparison condition read the same texts and received the same classroom instruction without the aid of direct instruction in cause-effect relationships and responded simply to content questions. Students in the treatment condition outperformed those in the control group on measures of comprehension (improvement index = 47).	Strategy instruction and modeling High-level questions and student explanations

Study	Summary	Strategies
Wood, C., Fitton, L., Petscher, Y., Rodriguez, E., Sunderman, G., & Lim, T. (2018). The effect of e-book vocabulary instruction on Spanish-English speaking children. *Journal of Speech, Language, and Hearing Research, 61*(8), 1945–1969. https://www.doi.org/10.1044/2018_JSLHR-L-17-0368	Wood and colleagues (2018) compared the effects of an intensive vocabulary intervention embedded within e-books versus reading only on the vocabulary skills of kindergarten and first grade Spanish-English speaking English learners (ELs) from low-socioeconomic status backgrounds (*n* = 288). Approximately 3 times per week for 10 to 20 weeks, students in the treatment group read e-books that supplemented vocabulary instruction in four target words per book through explanations in Spanish, word maps with visual representations of the words, nonexamples and morphology highlights (e.g., showing how "unbutton" and "buttoning" are variations of the target word "button"), and a final review of each targeted word. Children in control condition read and listened to the same e-books three times per week without supplemental vocabulary instruction. Afterward, students in treatment condition demonstrated significantly higher performance on a researcher-created test that required students to name the targets word in English they had learned in their e-books after being shown a picture representing the word (improvement index = 15) and smaller but still significant effects on a similar, but more general, standardized assessment of vocabulary (improvement index = 7). Findings suggest computer-assisted vocabulary instruction that provides first-language explanations, repetition, and highlighted morphology show promise in supporting word learning for early-grade ELs.	Vocabulary instruction
Woodward, J. (2006). Developing automaticity in multiplication facts: Integrating strategy instruction with timed practice drills. *Learning Disability Quarterly*, *29*(4), 269–289. https://www.doi.org/10.2307/30035554	Woodard (2006) compared the effects of combining direction instruction in rule-based facts with timed practice drills versus timed practice drills only for developing automaticity in math facts for 4th grade students (57 percent receiving free/reduced-price lunch; *n* = 58) of varying abilities, including 15 receiving special education services. During 20, 25-minute lessons over the course of four weeks, students in the strategy instruction group received direct instruction in rule-based facts (e.g., 0s, 1s, doubles, 5s, 9s, and 10s), derived facts (e.g., 6 x 7 = 6 x 6 + 6), and rounding up and rounding down strategies along with visual aids (e.g., skip-counting number lines, drawings of groped cubes) to illustrate the strategies. They also engaged in interleaved practice and review of previously learned facts. During the same number of lessons, students in the direct-instruction comparison group were taught math facts sequentially (from easiest to more difficult) without rule-based strategies, using recitation to memorize multiplication facts. Both groups engaged in timed practice drills which included spaced practice/review of previously practiced facts. Results showed both conditions supported the development of automaticity in students yet favored those engaged in both strategy instruction and interleaved timed practice drills in posttest measures of their ability to solve common multiplication facts (improvement index = 22).	Strategy instruction and modeling Interleaved, spaced independent practice

Study	Summary	Strategies
Xin, Y. P., Jitendra, A. K., & Deatline-Buchman, A. (2005). Effects of mathematical word problem-solving instruction on middle school students with learning problems. *The Journal of Special Education, 39*(3), 181–192. https://www.doi.org/10.1177/00224669050390030501	Xin and colleagues (2005) compared the effects of two problem-solving instructional approaches—schema-based instruction (SBI) and general strategy instruction (GSI)—on the mathematical word problem-solving performance of middle school students (n = 22) who had learning disabilities or were at risk for mathematics failure. Students in the SBI condition were taught the same process but also provided explicit instruction in identifying problem types (e.g., a compare problem) and using schema diagrams to represent the problem. In sum, students learned to identify the key problem features, map those features onto a diagram, and then transfer the diagram into an equation. Students in the GSI condition were also taught a four-step process for solving word problems: read to understand, develop a plan (which could include drawing a picture to represent the problem, make a model, write and equation, act it out), solve, and look back. Afterward, the SBI group significantly outperformed the GSI group on immediate and delayed post-tests as well as the transfer test (improvement index = 45, 49 and, 50, respectively). Results suggest that combining schema diagrams with strategy instruction, including identifying problem structure, may be particularly beneficial for students with learning disabilities because it helps them to differentiate relevant from irrelevant information, reduce burdens on working memory, and helps them to recognize underlying structures across problems.	Visualizations and concrete examples Structured problem solving
Zhou, N., & Yadav, A. (2017). Effects of multimedia story reading and questioning on preschoolers' vocabulary learning, story comprehension and reading engagement. *Educational Technology Research and Development, 65*(6), 1523–1545. https://www.doi.org/10.1007/s11423-017-9533-2	Zhou and Yadav (2017) studied the effects of four different approaches to teaching vocabulary and reading comprehension to kindergarten students (n = 72): multimedia story reading with open-ended processing questions, multimedia story reading without questions, story reading with open-ended processing questions, and story reading without questions. Students in all four conditions read the book *The Polar Bear Horizon*. Those in the first two conditions read the book independently on iPad devices using a read-aloud feature with concurrent animations and interactions that let students see and hear word labels by touching them. Those in the third and fourth groups listened to a researcher read a paper book version of the story that contained the same graphics and text without multimedia interactivity. In the first and third (questions) groups, researchers asked a series of questions that reflected increasing cognitive demand (moving from recalling facts and details) to simple reasoning, prediction, and evaluation. After reading the story twice over a two-week period, students were tested on knowledge of target vocabulary and story comprehension. Results demonstrated significant effects for questions over non-questions for both paper books (improvement index = 18) and multimedia (improvement index = 9). Less significant effects were found for multimedia except for students not asked questions (improvement index = 24). On the comprehension test, no significant effects were found for either multimedia or questions. Findings demonstrate the value of teacher questions and also suggest that interactive multimedia can supplement teacher-led instruction.	Visualizations and concrete examples High-level questions and student explanations