International Journal of the Whole Child
2025, VOL. 10, NO. 1

Tech Talk
Raising the Bar: Improving Mathematics Education to Equip Students for Success

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Abstract

This article explores the critical importance of mathematics education in fostering essential skills such as reasoning, problem-solving, and real-world numeracy. It examines concerning trends in U.S. mathematics performance through national and international assessments, including NAEP and TIMSS, exposing widening achievement gaps. Evidence-based strategies and curricular models—such as Singapore Math and the use of instructional coaching—that have demonstrated promise in improving outcomes, are discussed. Furthermore, it highlights the expanding role of educational technology and artificial intelligence in mathematics instruction, with practical recommendations and toolkits for educators. By integrating research-based practices, culturally responsive pedagogy, and innovative technologies, schools can better support all learners in developing mathematical proficiency vital for academic, personal, and professional success.

The Importance of Mathematics Education

Significant emphasis is placed on mathematics education, and rightly so, given its critical role in fostering reasoning, critical thinking, and problem-solving. Learning mathematical thinking and numeracy promotes these skills and should be vital to mathematics education. Mathematical thinking and doing math are not the same. Mathematical thinking is a cognitive process that requires the use of different types of problem-solving strategies, such as if-then thinking, decomposing, classifying, comparing, and generating ideas (Stacey, 2006; Thinking Maps, 2022). Proficiency in mathematical reasoning supports logical thinking, informed decision-making, active civic engagement, and enhancing workplace performance (Gates Foundation, 2022; Iris Center, 2025). Numeracy, on the other hand, refers to the ability to apply mathematical understanding in real-life contexts—whether at home, in the workplace, or within educational environments - and is essential for all individuals, not just those pursuing STEM careers

(National Numeracy, 2025a). Strong numeracy skills are crucial for everyday tasks such as budgeting, managing health, making household improvements, and administering medications. At the societal level, numeracy underpins key sectors including healthcare, economics, construction, and technology, and drives innovation and global advancement. Conversely, poor numeracy skills can have far-reaching consequences, including unemployment, lower wages, poor health, social issues, and even an increased risk of crime. Ultimately, numeracy equips individuals with the tools needed for interpreting, engaging, and navigating the complexities of the modern world (Iris Center, 2025; McNeil, Jordan, Viegut, & Ansari, 2025; National Numeracy, 2025b).

Mathematics Scores in the United States

Concerns persist regarding the state of mathematics achievement in U.S. public education. The National Assessment of Educational Progress (NAEP) produces "The Nation's Report Card," which assesses student performance in various subjects, including mathematics, every two years. These assessments are administered to representative samples of 4th and 8th-grade students nationwide, as well as to 12th-grade students in selected subjects (National Center for Education Statistics [NCES], 2025a). According to the most recent NAEP mathematics data (NCES, 2024a, 2024b), 39% of 4th-grade students scored at or below the *NAEP Proficient* level. This represents a three-point improvement from 2022, yet remains two points below 2019 levels. While scores among middle- and high-performing students improved, no significant changes were observed for lower-performing students. Among 8th-grade students, 28% achieved scores at or above the NAEP Proficient level, reflecting a two-point increase from 2022 but a six-point decline from 2019. Notably, scores rose for higher-performing students but declined for those in the lower performance brackets (The Nation's Report Card, 2023).

The Trends in International Mathematics and Science Study (TIMSS), administered every four years, assesses mathematics and science achievement among 4th- and 8th-grade students globally. The 2023 assessment marked the completion of TIMSS's eighth cycle. In that cycle, 63 education systems participated at the 4th-grade level and 45 at the 8th-grade level. Results from the 2023 mathematics assessment revealed a notable decline: 4th-grade students scored 18 points lower on average than in 2019, with the lowest scores at the 10th and 25th percentiles since TIMSS began in 1995. Similarly, 8th-grade students scored 27 points lower than their 2019 counterparts. In both grade levels, the achievement gap between students at the 10th and 90th percentiles was wider in 2023 than in the 2003, 2007, 2011, and 2015 cycles, indicating increased performance disparities (NCES, 2025c).

In the 2023 TIMSS assessment, the international average score in mathematics was 503 out of a possible 1000. Scores ranged from a low of 362 in South Africa to a high of 615 in Singapore. The United States scored 517, tying with Portugal. In comparative rankings, U.S. students outperformed those in 28 education systems, scored lower than those in 21 systems, and performed similarly to students in 13 systems at both the 4th- and 8th-grade levels in mathematics and science (NCES, 2025c). Male students scored higher on average across both subjects and grade levels than female students.

A particularly troubling trend is the growing achievement gap between students in the highest and lowest percentiles in mathematics. This disparity is also evident among 13-year-old students, especially in the racial achievement gap between Black and White students. The gap has widened from 25 points in 2020 to 33 points in 2022, and further to 42 points in 2023. These increases are most pronounced among lower-performing students, signaling a critical area for intervention and equity-focused educational strategies (NCES, 2025c; The Nation's Report Card, 2023).

Impacting Mathematics Scores

Given the concerning trends in mathematics achievement in the United States, it is critical to consider how teachers, schools, and districts can take meaningful steps to improve student outcomes. The IRIS Center at Vanderbilt University (2025) emphasizes two key actions: adopting standards-based curricula and implementing evidence-based instructional practices. When selecting curricula, it is essential to avoid an overreliance on rote computational procedures or surface-level content that lacks depth or connection to conceptual understanding. Educators should recognize that while standards and textbooks are important tools, they are not synonymous with curriculum; rather, they serve as components of a broader instructional framework. Mathematical concepts and procedures should be taught using approaches grounded in rigorous research and proven to be effective in improving student learning (IRIS Center, 2025).

According to EdReports (2024), a high-quality mathematics curriculum should be aligned with academic content standards and reflect the instructional shifts necessary to prepare students for college and careers. It should also integrate the Standards for Mathematical Practice (Common Core Standards, 2022) and demonstrate evidence of culturally responsive pedagogy (NCTM, 2025). These components must work in concert, supporting and reinforcing one another, rather than functioning in isolation. Trusted sources for evaluating and selecting effective mathematics curricula include the *What Works Clearinghouse* (Institute of Educational Statistics, 2025) and the *Best Evidence Encyclopedia* (2021), both of which provide research-based reviews of curricular materials (IRIS Center, 2024).

The Institute of Education Sciences' *What Works Clearinghouse* (2021) outlines six evidence-based recommendations for supporting students who struggle with mathematics, each accompanied by practical implementation strategies. These recommendations are as follows:

1. Provide systematic instruction during interventions to enhance students' conceptual understanding of mathematics.
2. Teach precise and concise mathematical language and support students in using this language to communicate their mathematical thinking effectively.
3. Employ a carefully selected set of concrete and semi-concrete representations to support students' understanding of mathematical concepts and procedures.
4. Use number lines to teach mathematical concepts and procedures, reinforce grade-level content, and prepare students for more advanced mathematics.
5. Deliver explicit instruction in solving word problems to deepen conceptual understanding and promote the application of mathematical ideas.

6. Incorporate timed activities regularly to help build fluency in mathematical skills.

These recommendations are supported by meta-analytic findings across twelve mathematical domains, including general mathematics achievement, algebraic reasoning, and whole number computation (Institute of Education Sciences, 2021, p. 14).

McNeil, Jordan, Viegut, and Ansari (2025), in their article *What the Science of Learning Teaches Us About Arithmetic Learning*, offer four research-based recommendations for improving mathematics instruction, particularly within early childhood education programs. Their suggestions, grounded in developmental cognitive science, include:

1. Integrate developmental cognitive science more fully into educator preparation programs.
2. Increase awareness of early mathematics milestones by embedding them into developmental assessment tools used by pediatricians and early childhood educators, and by promoting them through public awareness initiatives.
3. Foster understanding of the benefits of well-structured, time-limited retrieval practice for students who have already achieved a high level of accuracy. Emphasize that this form of practice is distinct from high-stakes, time-pressured testing.
4. Embed brief but regular "what-I-need" (WIN) time or tutoring sessions into students' weekly schedules to provide targeted instructional support.

These recommendations are accompanied by detailed rationales in the article, underscoring their importance for both instructional practice and policy development (McNeil et al., 2025, p. 13).

A curriculum that has had favorable math outcomes is the Singapore math method. As we have seen from TIMSS data over the past few decades, Singapore has been outscoring other nations in mathematics (Myers, 2024; NCES, 2024). What is so special about math in Singapore, and what is the Singapore math method? The Singapore math method was developed in the 1980s by Singapore's Ministry for Education for Singapore public schools and is familiar worldwide. Singapore math focuses on the how and why of math, promoting a deep conceptual understanding and math mastery, as well as a positive attitude towards math (Chong, 2016; O'Toole, 2020; Singapore Math, 2025). The 12 years of Singapore math curriculum spans from primary to pre-university and capitalizes on a spiral method where concepts and skills grow in increasing complexity. The Singapore Math Curriculum Framework is shaped like a pentagon that has on each of its five sides, attitudes (beliefs, interests, perseverance, and confidence), metacognition (thinking about one's thinking and engaging in self-regulation), process (reasoning, communication, heuristics, and application and modeling), concepts (numerical, algebraic, geometrical, statistical, probabilistic, and analytical), and finally skills (numerical calculation, algebraic manipulation, spatial visualization, data analysis, measurement, use of mathematical tools, and estimation) (IEA TIMSS & PIRLS, 2015; Singapore Math, 2025). The Singapore math method uses a progression from concrete to pictorial to abstract (CPA) or sometimes known as CRA (concrete to representations to abstract). It uses number bonds to show part-whole relationships between numbers, bar modeling to visualize fractions, percentages, and ratios, allowing for different ways to think about numbers, and mental math to help students develop number sense and think mathematically (Singapore Math, 2025). From the Singapore math method, Singapore Math® was developed in the late 1990s in the United

States based on the way math is taught in Singapore. The company has ready-made curriculum materials that can be purchased (Singapore Math, 2025).

Although not a new concept, the use of mathematics coaches and specialists has gained renewed attention as a strategy for improving student achievement in mathematics. In 2022, Alabama enacted the *Numeracy Act*, a comprehensive legislative initiative aimed at raising statewide mathematics performance. The act provides substantial resources, including intensive professional development for teachers and principals, the placement of math coaches in every K–5 classroom, access to high-quality instructional materials (such as math manipulatives), targeted interventions for students requiring additional support, and accountability measures to track progress and outcomes (Alabama STEM Council, 2024).

Similarly, in Tennessee, two counties—Putnam and Weakley—reported that middle school math scores in 2024 exceeded pre-pandemic levels. This improvement has been linked to several key strategies: the implementation of instructional coaching, increased instructional time in mathematics (two 45-minute sessions daily, referred to as "core" and "encore," in contrast to a traditional single 50-minute session), and the consistent use of data to guide instructional decision-making (Yoder, 2025).

How Can Edtech Be Used in Math Education?

Educational technology (edtech) has been a component of mathematics instruction since the 1980s—early examples include programs such as *Math Blaster* (Reyneke, 2024). The National Council of Teachers of Mathematics (NCTM) emphasized in its *Principles in Action Executive Summary* that technology should be purposefully integrated to support students in thinking and communicating mathematically (NCTM, 2014). Tannenbaum (2024), an elementary technology coach, advocates for using digital tools to help students visualize mathematical concepts, enhance engagement, and offer multimodal learning opportunities.

Research supports the effectiveness of technology in improving mathematics performance and increasing student interest in the subject (Bright, Welcome, & Arthur, 2024; Eyyam & Yaratan, 2014). The instructional benefits of physical manipulatives are well established, and virtual manipulatives have been a valuable edtech resource for more than two decades (Siller, 2024). Notably, virtual manipulatives for teaching fractions have demonstrated even greater efficacy than their physical counterparts in some studies (Rich, 2023). Additionally, edtech is being used to gamify learning, provide simulations, and offer interactive and collaborative learning tools (Bright, Welcome, & Arthur, 2024; Picha, 2018).

Artificial Intelligence in Math Education

Artificial Intelligence (AI) is increasingly transforming educational practices, and its integration into mathematics education is becoming more widespread. Educators are leveraging AI to streamline instructional and administrative tasks, including the development of lesson plans, behavior management strategies, and communications with families and communities (AI-Pro, 2024; DeFlitch, 2025; Hanson, 2024). Additionally, teachers are beginning to use AI to analyze

student performance data, identify trends through performance clustering, and generate progress monitoring reports (AI-Pro, 2024; Hanson, 2024).

In mathematics instruction specifically, AI is being used to design rich, engaging learning experiences that support the development of number sense, encourage exploration of open-ended problems, promote multiple solution strategies, and deepen conceptual understanding (Koehler & Sammon, 2023). AI tools are also aiding in the differentiation of instruction by providing personalized learning paths that appropriately challenge students with diverse learning needs (AI-Pro, 2024; Hanson, 2024; Koehler & Sammon, 2023).

The National Council of Teachers of Mathematics (NCTM) has issued a position statement on "Artificial Intelligence and Mathematics Teaching," endorsing the integration of AI tools in mathematics education. The statement emphasizes that while AI can enhance teaching and learning, the professional judgment, pedagogical expertise, and content knowledge of the teacher remain central to effective instruction. Furthermore, it highlights the importance of teaching students to critically evaluate AI-generated outputs for potential errors or biases.

A notable initiative in this area is the "Artificial Intelligence in Math" program, developed by the Concord Consortium in partnership with the University of Florida and Florida Virtual School. This supplemental certification program targets middle and high school students enrolled in Algebra I and aims to introduce them to real-world AI applications, ethical considerations, and career pathways related to AI. The program also offers professional development opportunities for educators (Langreo, 2025). The future holds untold possibilities in the area of AI in education.

As technological innovation continues to accelerate, educators have an expanding array of free and subscription-based digital tools to enhance math instruction. Below is a sampling of edtech platforms that can be implemented at the classroom, school, or district level:

- **Brainingcamp** (https://www.brainingcamp.com): A subscription-based platform offering virtual manipulatives such as base-ten blocks, fraction circles, and number lines. It includes over 300 ready-to-use activities and serves over 7.5 million users with a 4.7/5 rating.

- **CK-12** (https://www.ck12.org): A generative AI-powered platform with features such as Flexi, an interactive AI tutor that answers student queries and supports self-assessment. The site offers FlexBooks, simulations, study guides, and adaptive practice across multiple subjects and grade levels (1–12), including support in eight languages.

- **Dragonbox by Kahoot!** (https://dragonbox.com): Offers highly rated math and literacy learning apps for children ages four and older, with most apps earning four or five stars on Common Sense Media.

- **Educaide AI** (https://www.eduaide.ai/): A teacher-created workspace with more than 110 educational resources for teachers to enhance teaching and learning. It is fee-based and has a free trial.

- **Eureka Math** (https://greatminds.org/math/eurekamath): A K–12 curriculum aligned with college- and career-readiness standards. The program emphasizes conceptual understanding and includes print, digital, and hands-on instructional materials.

- **Frax** (https://frax.explorelearning.com/): An adaptive, game-based program that develops conceptual understanding of fractions through sequential missions. Sectors 1 and 2 address fractions as numbers and equivalencies, while Sector 3 (launching in fall 2025) will address fraction arithmetic.

- **i-Ready Math** (https://www.curriculumassociates.com/programs/i-ready-learning/classroom-math): A K–8 digital platform featuring diagnostic assessments and adaptive learning paths. It received moderate ratings on Common Sense Media for learning and community engagement.

- **IXL Math** (https://www.ixl.com/math): A digital math learning platform for K-12 that supports students' math fluency and confidence in solving math problems. Progress is tracked, and virtual rewards are provided. There are resources and supports available for parents and teachers. It is fee-based. It has received four out of five stars from Common Sense Media but has a 68% privacy warning.

- **Khanmigo** (https://www.khanmigo.ai/?step=login-signup): An AI chatbot that is used as a personal tutor for students and a virtual assistant for teachers. It is free for teachers and available at a low cost for students.

- **MagicSchool AI** (https://www.magicschool.ai/): A digital AI platform with more than 80 tools for teachers to use to create lesson plans, presentations, emails, vocabulary decoder, learning games, and much more. There is both a free and paid version.

- **Math Learning Center** (https://www.mathlearningcenter.org/apps): A digital platform for free math learning apps. It contains Apps Collection, App Activities, and App Launcher. There are math curricula available such as Bridges in Mathematics for a fee.

- **Mathletics** (https://www.mathletics.com/us/): A digital math learning platform for K-12 students at home or school. It boasts learner engagement, report generation, and improved math achievement. Fee-based. Ratings on CommonSense Media are four out of five stars. There is a 46% privacy warning statement.

- **Prodigy** (https://www.prodigygame.com): A game-based learning platform for grades 1–8 (math) and 1–6 (English). It is free for educators, with paid features for parents, and is rated three stars for learning and five stars for community support.

- **Reflex** (https://reflex.explorelearning.com): Focused on math fact fluency for grades two and above, this adaptive platform features engaging games and detailed performance reports for teachers and parents.

- **Toy Theater** (https://toytheater.com): A free website offering interactive games and educational tools in math, reading, art, and music, including puzzles and virtual manipulatives.

- **Zearn** (https://about.zearn.org): A widely adopted free platform for K–5 math instruction, Zearn integrates visual models and real-world examples to enhance conceptual understanding.

These tools illustrate the wide-ranging possibilities for using technology to enrich mathematics instruction and improve student outcomes.

Conclusion

Mathematics education is far more than mastering numbers; it is about cultivating the cognitive, analytical, and practical skills that individuals need to thrive in a rapidly evolving world. While recent assessment data underscore persistent challenges and disparities in math achievement, they also reveal areas ready for promising interventions. High-quality curricula, evidence-based instruction, instructional coaching, and targeted use of technology and AI can significantly enhance math learning and equity. When schools and educators commit to a comprehensive and student-centered approach to math education, they equip learners not only for academic success but also for responsible citizenship, career readiness, and lifelong problem-solving.

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