



ST Math

Recipe for Success in Gaining Momentum with Math



Introduction

School and district administrators are up against tight timelines regarding accountability. The waivers appreciated in the middle of COVID are no longer, and districts everywhere are experiencing teacher shortage. Subject areas such as ELA and math are especially under the spotlight regarding accountability. Appreciating the landscape of mathematics education today and the challenges of teacher shortages, math confidence in learners and teachers can help administrators build strong learning environments in math classrooms and establish math cultures in buildings. Math intervention solutions may be abundant, but an intervention is a short-term solution to a long-term issue. Utilizing neuroscience research to build the right environment for learning math is the optimal solution for long-term academic success.

Mathematics Landscape in the U.S.

[Every Student Succeeds Act](#) (ESSA) requires states to measure math performance, provide a “State Report Card” accessible online for parents to review state test information, and develop a plan for spending federal funds. In addition to the required state report cards, The National Center for Educational Statistics publishes the Nation’s Report Card each year. In 2022, the [National Assessment of Educational Progress Report Card](#) reported a 9-point decline in scores for eighth-grade students from the beginning of the pandemic, 2019-2020, to the current school year. [Math illiteracy](#) remains high in the US, with ~ one-third of eighth graders proficient in math, but even more concerning is that only 12 – 19% of Black and 18 – 19% of Hispanic eighth-grade students are proficient in math.

The National Research Council proposed the [STEM/STEAM Model](#) as a format for teaching K-12 science in 2012. The STEM approach supports curriculum integration between the contents of science, technology, engineering, math, and the arts. While some activities support math, it must be evident how math influences and contributes to the ideas of the other STEM disciplines. Shifts to make this happen include math becoming a sense-making activity and focusing on students’ disciplinary sense-making experiences. [Schoenfeld](#) (2020) found that norms and practices that should be moved to center stage in classroom instruction included a climate of inquiry, student ownership, big ideas, and classroom discourse. [A joint position paper](#) on the role of math in STEM was issued by the National Council of Supervisors and Teachers of Math. Helpful resources for teachers include [50 Tips, Tricks, and Ideas for Teaching STEAM](#) and for secondary teachers, [Mathematics Assessment Resource Service](#) (MARS), which uses the [Teaching for Robust Understanding](#) (TRU) developed at UC Berkeley Graduate School of Education.

The pandemic certainly impacted a student’s trajectory for academic success, especially in subject areas that depend heavily on scaffolding learning. Schools across the nation [have embraced technology](#) more than ever as a result of the pandemic. Still, they require good solutions and promising practices to ensure students regain the momentum of learning they experienced before the pandemic. Toolkits, such as the one offered through NCTM, are beneficial but do not include an exhaustive list of strategies.

The [lack of conceptually focused mathematical knowledge](#) led to [federally funded professional development](#) and district offerings centered on improving teachers’ mathematical knowledge across the country. Since these reforms have taken place, teachers’ math knowledge has made minor improvements; there has been increased use of standard-aligned curriculums,

and math instruction has improved somewhat. However, it was found that elementary and middle school teachers still used a teacher-directed format for delivering instruction.

[Through research](#) conducted at the University of Florida Lastinger Center for Learning, educators now understand what is required for higher student achievement; we need certified teachers with firm subject matter, pedagogical knowledge, and teaching experience. Additionally, [21st Century Economy](#) citizens must be competent in core math and digital technology, have technical, critical thinking, and problem-solving skills, approach tasks by thinking abstractly and methodically, and can focus on detail.

Math Initiatives Post-COVID

In 2021, the National Science Foundation awarded Math Initiatives PostCovid grants. Some of those awarded regarding education include funding for the [Maine Mathematics and Science Alliance](#) for The Discovery Research K - 12 program to develop innovative resources, models, and tools for teachers and students. Another project funded is the [Trans-modal Analysis: A Mathematical and Computational Framework for Equity Assessment of Multi-modal STEM Learning Processes](#), which will focus on the interactions between different learning modalities, the learning environment, and ways in which students might systematically differ as STEM learners. [Science and Mathematics Teachers Initiative Phase 3: Continuing to Improve Teacher Preparation and Retention through Real-World STEM Experiences](#) will be training and graduating thirty-two emerging teacher leaders in math, statistics, biology, chemistry, and physics. The training will be done with a local technical college using state-of-the-art STEM labs designed for those entering STEM professions. The goal is to train these scholars to effectively teach diverse learners through innovative coursework, research-based interactive seminars, and project-based learning experiences.

Neuroscience of Learning Math

As evident in the state's report card data and National Report Card results, a significant achievement gap remains the same or widened. If the same learning recovery pace stays in place, current 4th – 6th graders will need 3 – 5 years and 8th – 9th graders will need more than five years to close the gap. The National Academies Press publication [Adding It Up: Helping Children Learn Mathematics](#) laid the groundwork for how math is taught today. Mathematical proficiency, defined as what is necessary to be successful at math, was composed of these five components: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition.

[NCTM's President emphasized](#) that throughout Adding it Up, the development of proficiency in math was that the five strands were interwoven and interdependent, not a one-dimensional trait, and not achieved by focusing on only one or two strands. He also reiterated the importance of focusing on all five strands for students to master and be proficient in math. The more exposure a person has to math, the greater their [ability to think and reason](#).

Connecting [neuroscience with the learning of mathematics](#) helps us understand the significant impact mathematics has on brain development. One such example is the neuroscience applied to the design for learning in Spatial-Temporal (ST) Math, a program designed by neuroscientists at U of CA, Irvine, that teaches math the way the brain learns. Spatial-temporal

reasoning is the ability of the brain to manipulate objects in space and problem-solve. At the start of any learning path, there are no written or verbal directions because everything is presented visually, with the task being how to get JiJi, the penguin, across the screen. When solving a problem in ST Math, students use the [perception action cycle](#).

MIND Education has been at the forefront of neuroscience and education research for over 20 years. With the innovative idea of teaching math the way the brain learns, MIND has developed an alternative solution to language-heavy methods of learning math with a research-based visual approach. The spatial-temporal reasoning method develops [conceptual understanding](#) and effectively conveys mathematical concepts. This approach provides a deep impact on student learning by building a robust framework to solve unfamiliar problems and integrating new knowledge.

[Medical research suggests](#) that by teaching math the way the brain learns—through spatial-temporal patterns and experiences—students learn how to visualize and manipulate images through space and time. This allows the brain's innate capacity to receive information and internalize mathematics more conceptually. Students who learn via the spatial-temporal model learn to understand math ideas that are more accurately communicated through a concrete approach. By starting with the foundational math concepts through visual spatial-temporal models, students are then gradually exposed to the symbols representing those mathematical concepts. Without language barriers, math becomes more accessible to [all student subgroups](#).

The spatial-temporal (ST) math approach underscores the importance of productive struggle, the cognitive effort required to deepen conceptual understanding among math students. In a whitepaper, [Spatial-Temporal Math: Underlying Scientific Concepts and Mechanisms](#), MIND delineates the impact of struggle as “making sense of mathematical problems that are just within students’ reach of understanding as opposed to simply memorizing a presented solution method.” By requiring students to put more effort into their learning, they can form stronger connections, or [schemas](#), in their brains and expand their knowledge base.

The neuroscience of learning math also presents an opportunity to accelerate learning. With concerns over the decline of math proficiency in the U.S., students need access to highly accessible content to get them back on grade level. For students who are behind, rather than allocating time to content from the previous year, they need scaffolded learning progressions to transition them to grade-level content. This requires a gradual shift from a purely visual approach to symbolic representation, as previously described. MIND provides a more integrated and detailed accelerated learning strategy in their ebook, [How to Accelerate Learning with Neuroscience](#).

Developing Confidence in Mathematics

[A Mathematica Policy Research Brief written by Harris and Petersen \(2017\)](#) shows that being competent in early math connects with success in school and may be the strongest predictor of later success in reading and math. Children entering kindergarten with weak early math skills will likely remain behind their peers in later grades. Unfortunately, these kindergarteners tend to be from minority and low-income groups. Math concepts at this early age include counting, shapes, measurement, and patterns. While children this age interact with their environment through exploration, they must interact with adults to learn the words

that represent these basic concepts. Progression in math at this age includes learning basic math vocabulary, recognizing math in the world, and learning how to express more complex math concepts over time. Efforts to help parents teach their children should focus on understanding the importance of math at an early age, help them overcome their math anxieties, and provide them with tools, such as math stories, books, and appropriate “math talk” at this age. The [American Psychological Association](#) found that early math skills are a predictor of later learning that lays the groundwork for the deep conceptual understanding that helps create a problem-solving foundation that STEM is built upon.

[Five ways](#) that we can bolster confidence in math for our learners is to immerse students in problem-solving in all aspects of math, expose them to the high-quality problem-solving, be intentional that problems given contain a blend of previously learned skills, make cross-content connections with other content areas, and ensure that our grading/assessment practices reflect our math values. In an online article by [Cengage](#) (2019), students with confidence can perform better under stress, rebound from a setback, get on track again, and are more willing to step out of their comfort zone and take risks.

The [Collaborative for Academic, Social, and Emotional Learning \(CASEL\)](#) has identified three SEL-Focused Classroom components. They include a supportive classroom environment, [explicit SEL instruction](#), and integration of SEL with developing a growth mindset. In her research, Carol Dweck says students can have either a fixed or growth mindset about their intellectual abilities, but no individual has either exclusively. For students with fixed mindsets, some interventions can be used to help students move to a growth mindset. She also has emphasized that the teacher’s mindset plays a role in a classroom environment. In a longitudinal study of STEM professors who believe that ability is a fixed attribute, the racial achievement gaps were up to two times larger than in classes taught by professors with growth mindsets. Building on the work of Dweck, [Jo Boaler](#) (2019) has researched developing math mindsets. Her definition of a math mindset is that a child knows that math requires growth and is expected to learn and think about these new ideas. ST Math also helps to produce problem solvers and critical thinkers who are part of a [STEM mindset](#).

Growing and Keeping Math Teachers

While teachers were leaving the profession before the COVID-19 pandemic, [54% of teachers](#) are now considering that option after the pandemic. However, it is important to note that many [who say they’re considering leaving won’t do so](#). Also, Black male teachers cited [isolation and being pigeonholed as disciplinarians](#) as reasons for leaving. The [We Are Teachers](#) website shared 18 of the most alarming statistics regarding the 2023 teacher shortage, some of which were burnout, pressure, stress, mental health, and the need for more support for student health/behavior issues. [Forbes](#) reported teachers are leaving for jobs in ed tech to create and deliver professional development, take a sales position, or take their educational skills to another professional field. Other options include instructional design, managers, software engineers, UX designers, or working at museums or nonprofits. [Education Week](#) shared that districts wanting to keep good teachers are [giving teachers more flexibility in how and where they do their jobs](#), improving [their mentorship programs](#), and prioritizing teachers’ mental health. Lastly, The American Institute of Research (2022) published six strategies to recruit highly qualified math teachers.

A paper by [Chua](#) (2018) reviewed relevant literature that mapped the development of the Mathematical Knowledge for Teaching (MKT) framework and instrument to measure that knowledge created by Hill at Harvard Graduate School of

Education and Debra Ball at the University of Michigan School of Education. He also synthesized the literature from several studies to clarify the relationship between the MKT measures and other variables to determine the effects on a teacher's quality in teaching math and student achievement. His final remarks state that additional research needs to be done to apply the findings from the MKT instrument to see if it can be used to inform and influence classroom practices and professional development and substantiate the knowledge of the instrument to see if it can make a dramatic change in the way we prepare future teachers. The [Mathematical Knowledge for Teaching \(MKT\)](#) or the MKT instrument is available through the Harvard Center for Education Policy Research.

Designing Rich Math Learning Environments

Learning environments for math must be welcoming, non-threatening, and positive. Also, remember that students are interested in math when it connects to things they are [naturally interested in learning](#) and their futures. Creating a blended learning environment, also known as hybrid, where face-to-face and online learning are combined can be done through various [models](#) such as station, lab, or individual rotations.

John Van de Walle provided strategies based on learning theories grounded in teaching all children and opportunities for students to connect mathematical ideas while building their knowledge. For teaching math, he recommended prior knowledge be used to build new knowledge, students engage in discourse, reflective thought, and [productive struggle](#) and treat mistakes made as opportunities to learn, use flexible learning/grouping and multiple approaches, honor the mathematical knowledge and experiences each student brings to the classroom, and move students from an [instrumental understanding to relational understanding](#) by using the five different representations of ideas (pictures, written symbols, oral language, real-world situations, and mathematical models), tools and manipulatives, and technology-based tools. Neuroscientists define the way our brain learns as the [perception-action cycle](#). In multiple large-scale research studies, a game-based math program, [ST Math](#), embeds spatial-temporal reasoning, which requires students to solve problems by manipulating visual models. This has been shown to have [statistically significant positive outcomes](#) on state assessments and [increases students' self-efficacy](#) for mathematics.

By creating a classroom environment like that described above, students can become mathematically proficient, meaning that students have a conceptual understanding of math, are fluent in procedures, can use multiple strategies and adaptive reasoning to solve problems, and have a positive, productive disposition towards math. Helping students become mathematically proficient will help them learn new concepts and procedures more easily by requiring less to be remembered, increased recall and retention, and enhanced problem-solving ability.

Whole Student Learning

The "[Whole School Approach](#)" is a growing movement that focuses on students becoming the best they can be physically, mentally, and emotionally. One excellent source for helping teachers relate this to the classroom is an article by Brown-Jeffy, and Cooper (2011) entitled "[Toward a Conceptual Framework of Culturally Relevant Pedagogy](#)." The five components of the framework include identity/achievement, equity and excellence, developmental appropriateness, student-teacher relationships, and teaching the whole child, which includes parents and community. An excellent edWebinar for those working with ELL students is English Learners: Focusing on the Whole Student Ecosystem.

Equitable Impact in Math Education

[Equity in Mathematics Education](#) by Vithal, Brodie, and Subbaye is a paper just released in June 2023 on research regarding equity in mathematics. Five themes seemed to emerge from the review of the literature that included a growing voice and visibility of equity in mathematics education, social justice in math, the type of research done and the positions of the researchers on the topic of math equity, equitable practices and pedagogy, and curricula, content, access, and pathways.

[Studies indicate](#) that students who use ST Math have significant outcomes across all groups of children by ethnicity, gender, ability, and economic status. The research conducted in Texas demonstrated that ST Math usage increased the average STAAR Math Scale Score between 29.2 - 44.7 points.

Conclusion

Since the passage of ESSA was signed into law, math scores in the United States have remained the same. Recent findings show that only about one-third of U.S. eighth graders are proficient in math and that Black and Hispanic students' proficiency scores are 19% or less. In the past decade, programs for math have been designed with STEM/STEAM-based content and used neuroscience to help close the gap. Professional development for teachers has been designed to integrate math and science with other content areas, teaching to the whole child and making learning interesting and equitable. Finally, there are a variety of reasons for teachers currently leaving the classroom. To maintain its workforce, states and districts offer teachers more flexibility in how and where they do their jobs, improve teacher mentorship programs, and prioritize teachers' mental health.

Ultimately, incorporating a technology solution can expand on the teacher's instruction while also improving a student's success in mathematics. Increasing math outcomes is on everyone's agenda, and choosing the right partner for math is essential in closing academic gaps. Identifying a partner grounded in research-based practices is not easy to find in today's environment. Still, there is one clear leader in math education that is supported by extensive research in both academic and medical journals. ST Math, created by MIND Education, is proven to attend to equity challenges by offering each student the same experience but allowing for personalization as they complete tasks while engaging students and walking them through productive struggle. Additionally, ST Math students have increased academic outcomes in all math strands. Maximizing high-quality digital resources can make a difference in overall student achievement and build the confidence in math that every student deserves.