ST Math

How Instructional Technology Can
Bridge the Math Achievement Gap for English Learners

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Summary

When it comes to providing equitable access to high-quality math education for English learners (ELs), what role does technology play in math classrooms? In this paper, we share how innovation through educational technology has the potential to help:

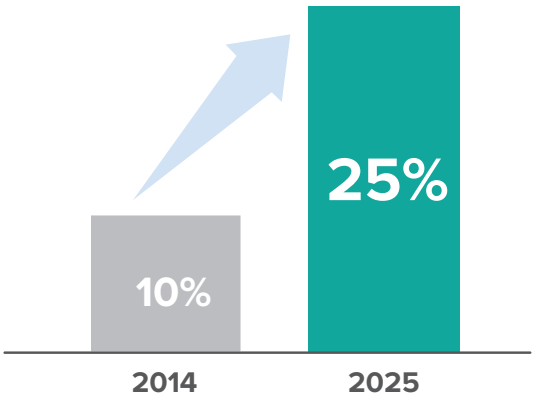
- Remove barriers to deeper learning for your students
- Boost effectiveness in all your teachers
- Actively engage families from all backgrounds

See examples from the ST Math® visual learning program and hear from educators who are leveraging the power of technology to impact EL math education.

The Forecast for ELs

As the U.S. continues on the pathway of progress and diversity, the proportion of English learners in public schools is rising rapidly.

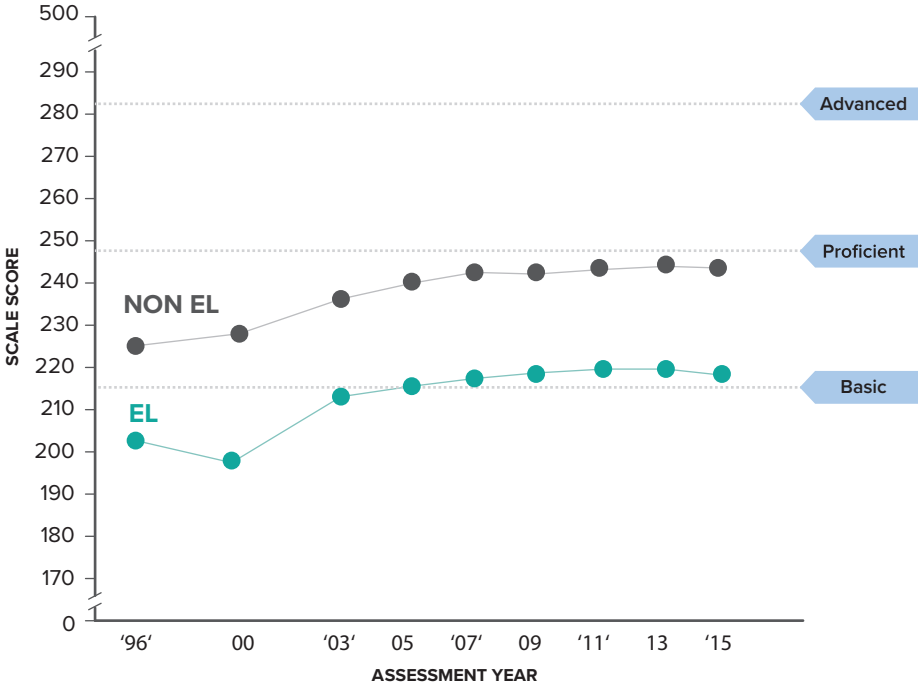
In 2013-14, 10% of students enrolled in public schools were learning English as a second language. By 2025 it has been predicted that this proportion may increase to 25%.[1]



Predicted rise in English learners from 2014 to 2025.

Today's educators are intimately aware of the hard reality that many English learners are falling through the cracks. EL test scores are chronically lower than those of English proficient students.[2]

Average Math Scores from the National Assessment of Educational Progress (NAEP)



In 2015, English learners scored an average of 25 points lower on the NAEP report.

1 "English Language Learning Challenge," newschools.org, http://www.newschools.org/ignite/ell-challenge/.

2 "Lower mathematics scores for White fourth-grade students compared to 2013," nationsreportcard.gov, https://www.nationsreportcard.gov/reading_math_2015/#mathematics/groups?grade=4.

Math curriculum and assessments often prove dishearteningly difficult for English learners. When reliance on language proficiency increases in math classrooms, so does the disengagement of ELs. Alarmingly, graduation rates are showing the effects of this disconnect—ELs are four times more likely to drop out of high school than native English speakers.[3]

4x

English learners are four times **more** likely to drop out of **high school** than native English speakers

Although the data looks grim, taking a close look at the challenges can provide fuel for change. And recent studies have confirmed that mathematics may just be the best place to start.

Bridging the Math Achievement Gap

Math: The Greatest Predictor of Success

Traditionally, literacy has been the leading focus in K-12 education. The National Center for Education Statistics (NCES) found that the average classroom spends twice as much time on reading as math between 1st and 4th grade.[4]

However, it may be in our students' best interest to revisit these instructional proportions. Researchers have found that math skills are the highest predictor of later success at all levels of a child's education.

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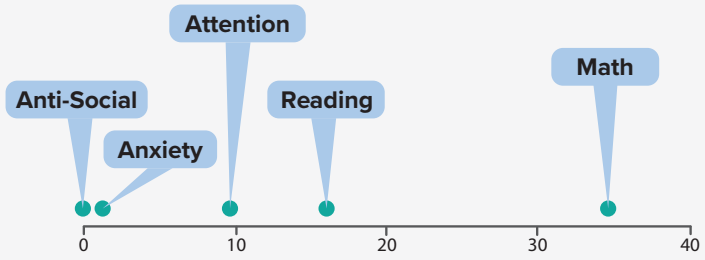
3 "McKeon Denise. "Research Talking Points on English Language Learners." Last modified June 2015. http://www.nea.org/home/13598.htm.

4 Marianne Perie, David P. Baker, and Sharon Bobbitt, "Time Spent Teaching Core Academic Subjects in Elementary Schools: Comparisons Across Community, School, Teacher, and Student Characteristics," NATIONAL CENTER FOR EDUCATION STATISTICS. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.144.6659&rep=rep1&type=pdf.

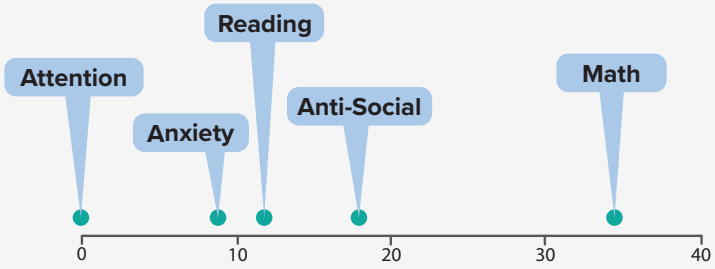
The following study measured the effects of five influential skills and behaviors on student success over multiple years. Math skills proved to be imperative for boosting student achievement, college attendance and adult earnings.

Percent Increase in Average Achievement, College Attendance and Earnings[5]

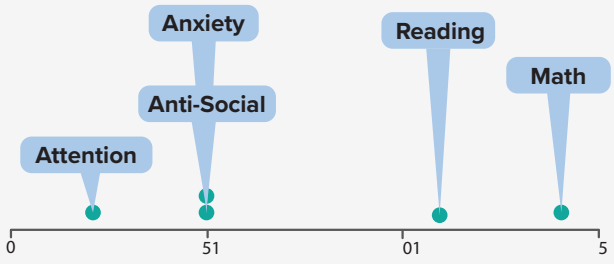
Effects of Pre-Kindergarten Skills on Late Achievement



Effects of Persistent K-5 Problems on Never Attending College



Effects of Age 14-16 Skills and Behaviors on Earnings (male only)



5 Greg J. Duncan, Amy Claessens, Mimi Engel, Chantelle J. Dowsett, Aletha C. Huston, Katherine Magnuson, Pamela Klebanov, Linda S. Pagani, Leon Feinstein, Kathryn Duckworth, Jeanne Brooks-Gunn, Holly Sexton, Crista Japel. "School Readiness and Later Achievement." Last Revised November 30, 2007. http://www.apa.org/pubs/journals/releases/dev-4361428.pdf.

Mathematics has potential to be a game changer for English learners. While English literacy should remain a high priority, research supports that developing students' math skills has a stronger effect on their future academic and career success than literacy skills or behavioral improvement.

Math and the English Learner

If language presents the biggest barrier for ELs then wouldn't it make sense to focus first on building language skills? Why doesn't the research support this seemingly intuitive idea? Perhaps it's because of the very nature of math that has long been misunderstood in schools and by the general public. Mathematical thinking and ability involves much more than reading word problems correctly, recalling the right formula and computing the right answer. Rather, recent shifts in the understanding of math rigor point to conceptual understanding and creative and persistent problem solving as key fundamentals. In other words, math presents deeper opportunities for growth because of how students can develop those areas of critical thinking, problem solving and intrinsic motivation to seek out understanding. And what's more, you don't need language to do it.

Many of history's greatest math minds admitted that language was not a substantial part of their mathematical processing. Math offers unending opportunity for students to engage in rigorous problem solving no matter what language they speak.

> **"The words of language, as they are written or spoken, do not seem to play any role in my mechanism of thought.**
>
> *- Albert Einstein*

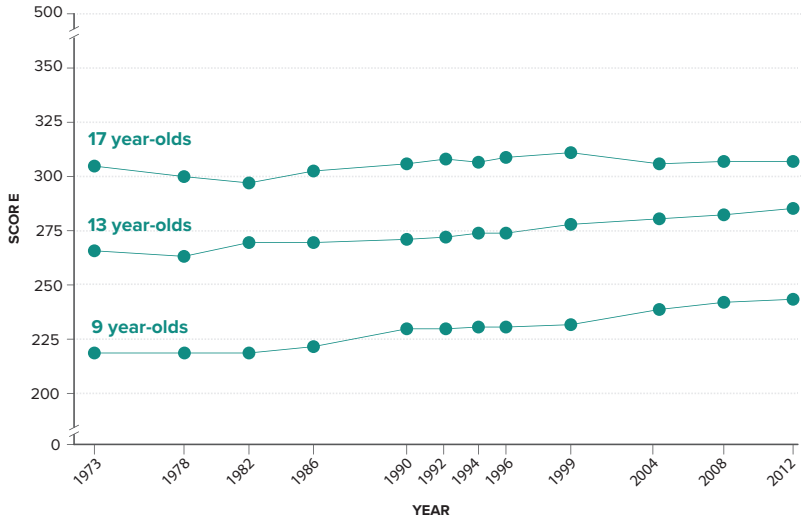
So how do we provide rich math instruction without relying on English as the sole delivery mechanism? More than ever, educators can look to well-designed and innovative instructional software that pushes the bounds of what has traditionally been possible. Technology has the potential to offer greater instructional support than ever before for teachers who have long since carried the responsibility of meeting the varied needs of students at different levels of English proficiency.

Expect More From Your Math Instructional Technology

How Edtech Has Been Failing You

Technology has revolutionized industries across the board, but the same effects have yet to be realized on math education. The National Assessment of Educational Progress reports that mean mathematics scores have remained essentially unchanged since 1973.[6] Since then, we have seen every major technological advance from the creation of the internet itself to the smartphones that give us constant access.

NAEP Scores for Mathematics Over Time



It could be argued that in education, technology has largely filled the same mold of classroom learning that has been in place for hundreds of years—the same pencil and paper experience transferred to computers. As classrooms become more diverse, educators will need more innovative instructional programs.

Instead of asking how technology can complement the way we teach ELs, perhaps we should ask ourselves how technology can change the way we teach ELs.

Finding the right technology for English learners requires careful consideration of all aspects of a child's education. Effective instructional software will directly support the needs of students, teachers and families.

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6 "Reading and Mathematics Score Trends," NATIONAL CENTER FOR EDUCATION STATISTICS. https://nces.ed.gov/programs/coe/pdf/coe_cnj.pdf.

New Expectations for Effective Math Programs

Consider how common applications of math technology essentially digitize direct instruction and paper and pencil practice. Not only has this proven ineffective, it does no justice to the unending, innovative possibilities technology can provide. Here is a framework to help measure exactly how instructional technology can support critical aspects of student learning from school to home.

Student

Teacher

Family

Primary Goal	***Equitable Access***	***Increased Efficacy***	***Parent Empowerment***
Critical Features	✓ Language Independence ✓ Self-Directed Exploration	✓ Individualized Instruction ✓ Conceptual Learning	✓ Family Interaction ✓ Transparency

Beyond this framework, math technology should show clear and consistent results over long periods of time (see: What If You Held Your Math Program Accountable for Long-Lasting Impact? at mindresearch.org/blog). Expecting this level of efficacy can give you the assurance that your instructional technology is truly supporting all your students.

The ST Math Model

Technology-based instructional programs have the potential to bring about the kind of change in EL math education that, up to this point, teachers alone have been held accountable for.

ST Math—created by neuroscientists, mathematicians and educational innovators at MIND Research Institute—is a visual instructional program that leverages the brain's innate spatial-temporal reasoning ability to solve math problems. Students are able to *see* abstract math concepts through graphically rich visual models and real-time informative feedback.

ST Math's rigorous puzzles facilitate students in action-oriented learning, which increases problem-solving skills. Students work through the mastery-based, standards-aligned curriculum at their own pace; meanwhile the teacher monitors progress, facilitates students who are struggling, and utilizes the digital manipulatives from the software in class lessons. This learning environment has proven positive effect on English learners.

In the next section, we will take a deep dive into how ST Math helps educators answer three critical questions.

- Do all our **STUDENTS** have access to deep and meaningful learning?
- Do our **TEACHERS** have the tools necessary to enable deep and meaningful learning?
- Are our **FAMILIES** participating in their students' deep and meaningful learning?

Providing Students Equitable Access to Content Standards

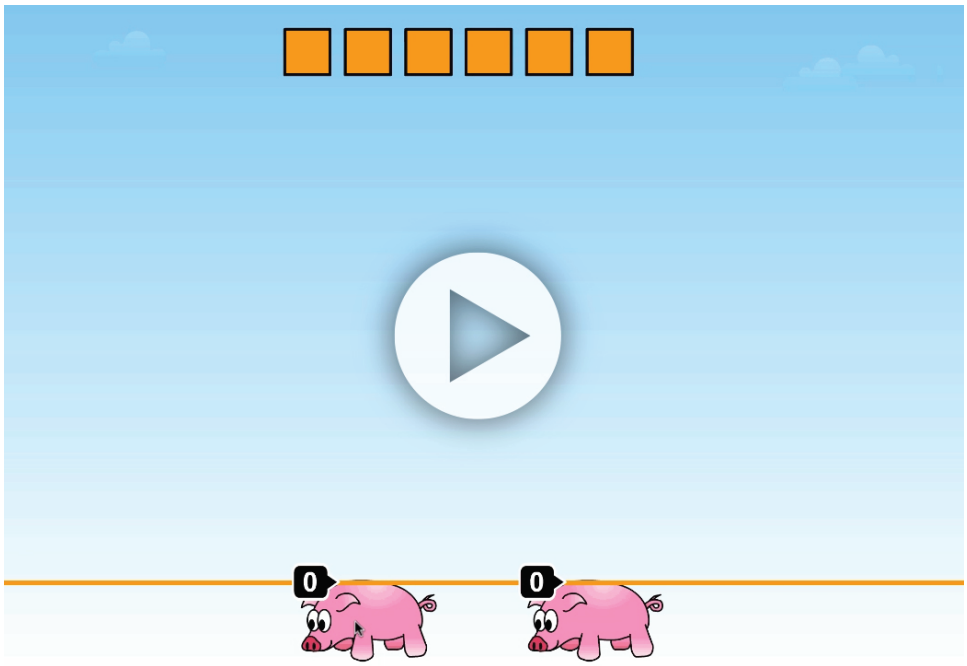
Guiding Question

How can we ensure all **students** have access to deep and meaningful learning?

1. Language Independence

It's obvious that the words and symbols of mathematics present significant barriers for English learners. Consequently, the level at which educators are able to minimize these barriers will make or break a child's experience with mathematics. Educational software like ST Math offers the opportunity to introduce complicated math concepts without words. Through the use of graphically rich visual models, students have direct access to the heart of rigorous, mathematical problem solving.

Take a look at the following examples of division. The first set of problems in this series of division challenges looks like this:



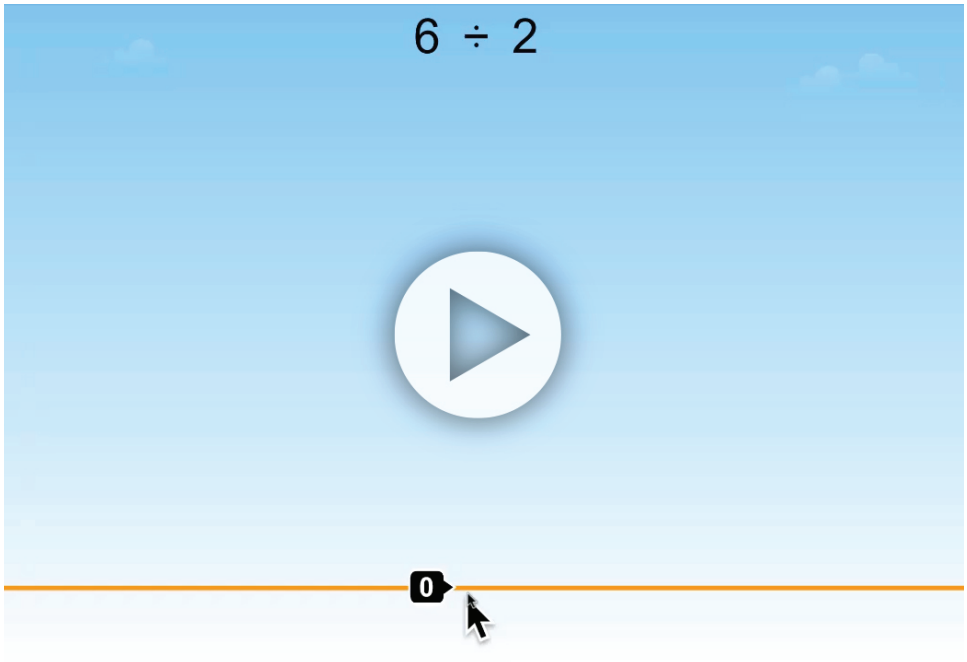
CLICK TO WATCH THE ANIMATION

In this puzzle, the student determines how many orange boxes each pig will get if six boxes are divided equally between two pigs.

Notice how the student solves the problem 6 ÷ 2 without words or symbols telling them what to do. This student has the freedom to reason in any language and in any way they feel most comfortable.

> **When we replaced intimidating word problems with visual word problems, it empowered our students to persevere and build their stamina in problem solving.**
>
> *- Kalim Rayburn, Principal, Rea Elementary, Newport Beach, CA*

In the next set of problems, the symbols are introduced.



CLICK TO WATCH THE ANIMATION

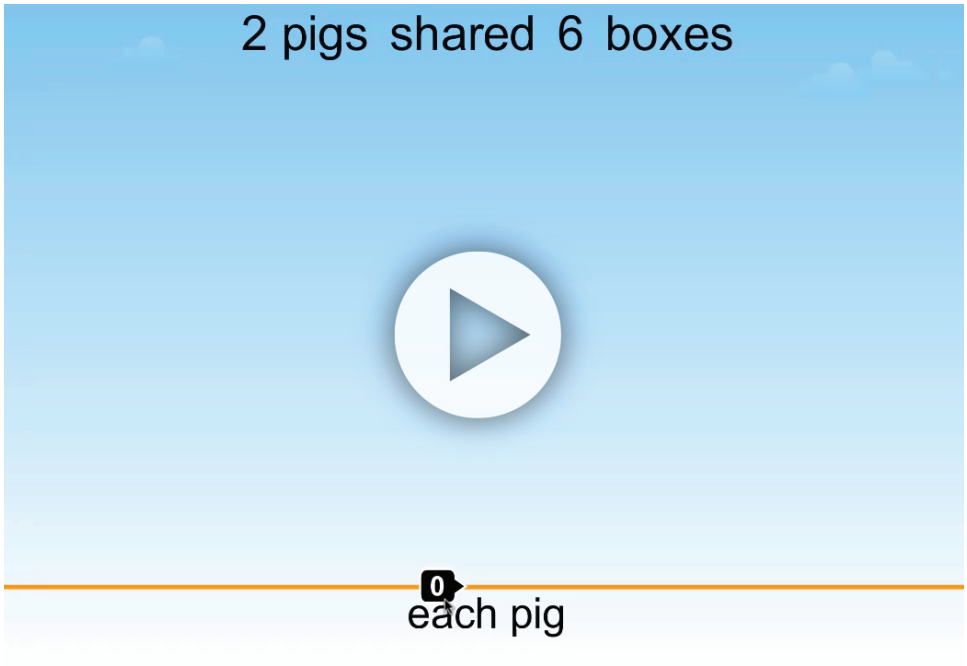
This puzzle contains the same problem as the last, except now students must create their own mental picture to help determine how many boxes each pig will get if we divide six boxes between two pigs.

Notice how the program makes a clear connection between the picture and the symbolic problem. This step encourages students to visualize the abstract concept of division. ST Math starts by teaching the foundational math concept, then connects the concept to the symbols and language.

ST Math does not require language proficiency, because it helps students *see the math*.

> **One aspect that we really like about ST Math is the non-linguistic approach.**
>
> *- Matt Blundin, Lead Instructional Coach for Mathematics at Albermarle Public Schools, VA*

In the final set of problems, the question is presented with language.



CLICK TO WATCH THE ANIMATION

ST Math presents words and symbols systematically in order to develop mathematical language.

At this point, students are prepped and ready to connect the concepts they have visualized to the words. In this way, ST Math actually develops math language proficiency. The words in this problem are not a barrier, but rather an exciting and accessible challenge. When presented with this kind of language-independent instructional environment, English learners can recognize patterns and construct their own understanding.

1. Self-Directed Exploration

Exploration and experience is key to deep understanding for all students, especially English learners. In order for students to develop the critical thinking and reasoning skills that will serve them in progressively higher-level mathematics, they need a learning environment that offers freedom to experiment and learn from their mistakes. Recent studies have shown that the human brain has potential toward greater attention and propensity to learn when given the opportunity for error analysis.[7]

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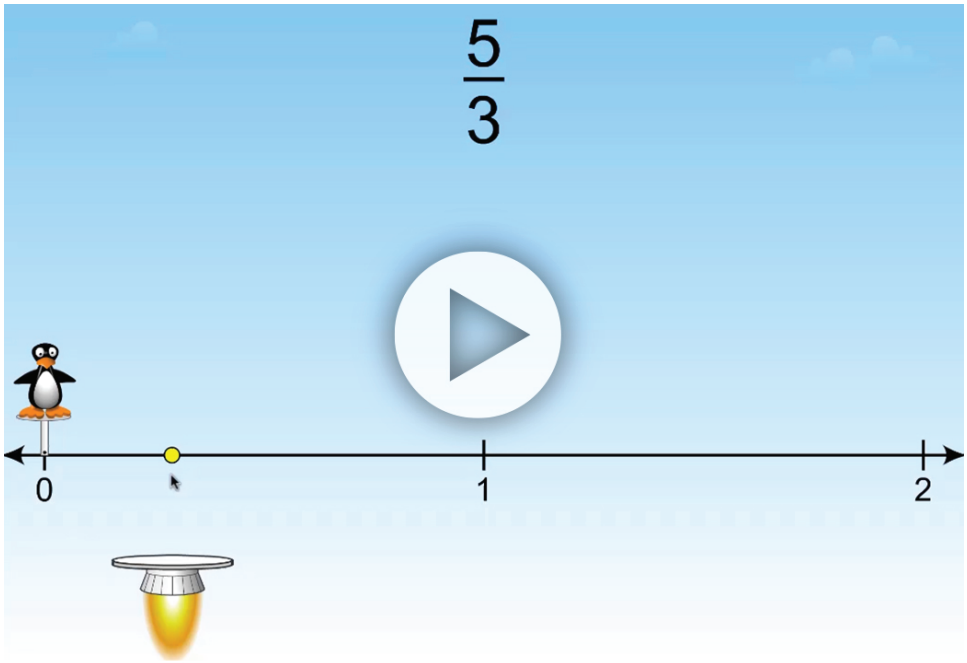
7 "McGonigal Kelly Ph.D. "The Science of Willpower: How Mistakes Can Make You Smarter." Psychology Today. Last modified December 6, 2011. https://www.psychologytoday.com/blog/the-science-willpower/201112/how-mistakes-can-make-you-smarter.

For ELs, this kind of trial and error can be facilitated by providing real-time (immediate), visual feedback that shows why a solution did or did not work without the use of language. Interpreting feedback should not depend on English proficiency. Watch what happens when a student answers incorrectly in ST Math:



CLICK TO WATCH THE ANIMATION

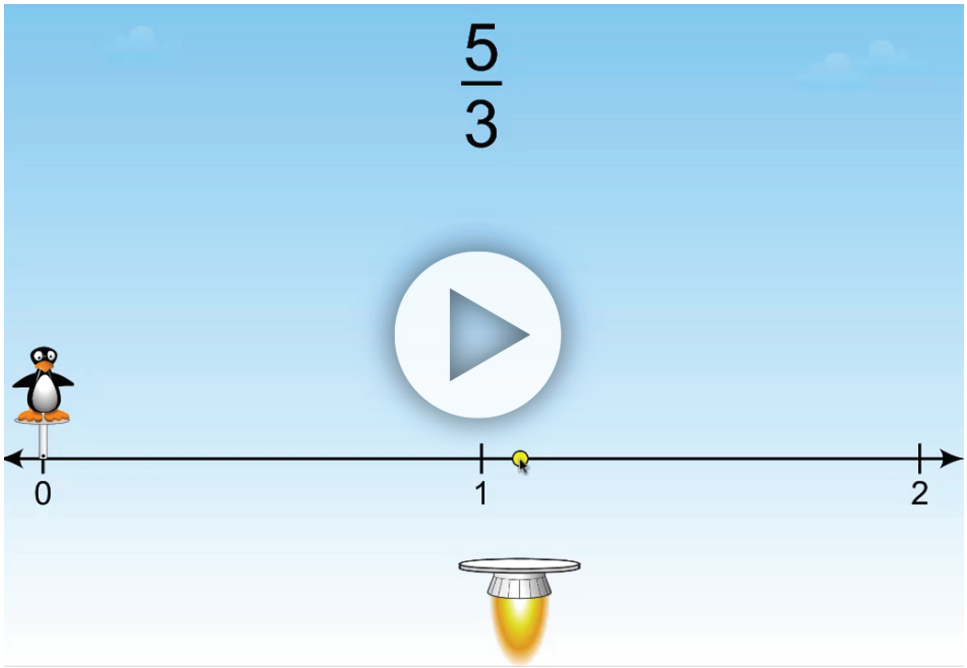
In this example, the student predicts that $\frac{5}{3}$ is located just to the right of 1 whole on the number line, which of course is incorrect. The animation builds the fraction $\frac{5}{3}$ by first dividing a whole into three equal "hops" to represent the denominator. Then the animation shows five of these $\frac{1}{3}$ "hops" put together.

Without the use of language, ST Math has shown the student exactly why the solution was incorrect. The visual feedback provides critical information that students need to correct their thinking in future problems.

ST Math has helped us to motivate students and build their self-confidence.

- Lisa Solomon, principal of Madison Elementary, Santa Ana, CA

Watch how this student completes the same problem in a second attempt.



CLICK TO WATCH THE ANIMATION

The informative feedback gives the student visual proof that they have correctly placed $\frac{5}{3}$ on the number line and the student moves on to a new problem.

Well-designed math instructional technology can provide your English learners equitable access to content standards through language-independent, self-directed exploration of math concepts.

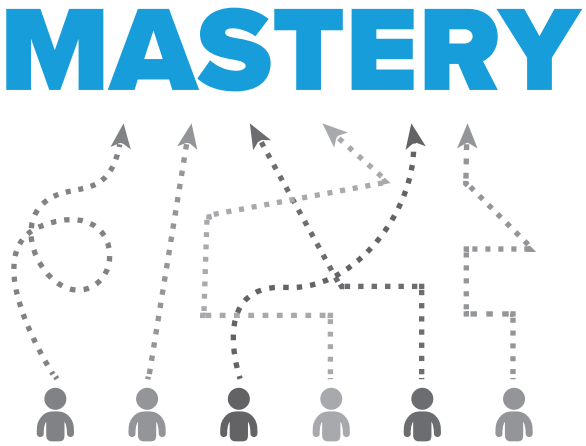
Increasing Teacher Efficacy

Guiding Question

How can we provide **teachers** the tools and training to enable deep and meaningful learning?

1. Personalized Learning Paths

Among the largest pain points for today's teachers is the challenge to meet the unique needs of every student in their ever-growing classes. At the heart of every educator is the desire to provide an environment where all students can learn at their own pace and in their own way. However, with growing teacher-student ratios and limited support, often the challenges outweigh the needs, and classrooms fall short of effective differentiation.



Technology can help teachers provide students their own unique pathways to mastery.

Instructional technology that assists teachers in administering personalized learning paths are poised to help schools level the proverbial playing field by providing equal access to rigorous learning. Teachers need access to 21st century tools that help bring all learners to content mastery regardless of their starting point or individual needs. This is especially crucial for English learners.

With ST Math, students are able to work entirely at their own pace through each intentionally sequenced learning objective. The mastery-based system provides the right level of exposure to each concept, depending on student needs. Additionally, teachers have the ability to align ST Math objectives to the whole class to match the core curriculum, or to individual students to reinforce conceptual understanding or provide additional challenge.

ST Math progress reports inform teachers exactly how many minutes and puzzles students have been working on, and provides actionable alerts for students who are struggling with objectives.

The flexibility and the information that the program provides really does drive my instruction.

Bryan Williams, Teacher, Douglas L. Jamerson Elementary Center for Mathematics and Engineering, Pinellas, FL

For teachers, efficacy skyrockets when they aren't bogged down with individualizing their entire curriculum. Furthermore, with progress tracking tools that inform teachers exactly where students are struggling, they are better able to individualize core instruction.

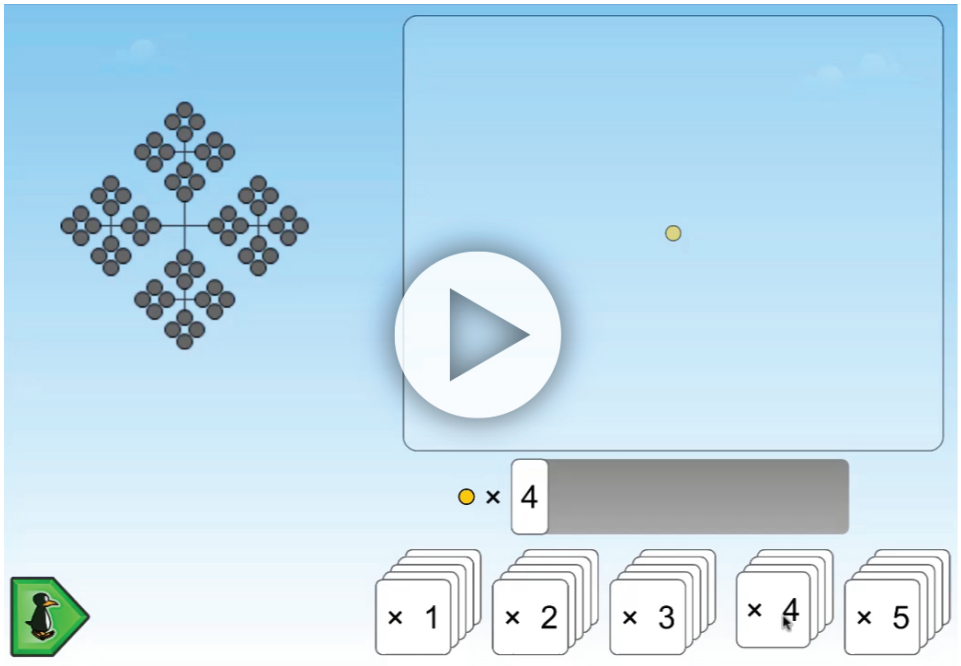
2. Conceptual Understanding

Deep, conceptual understanding is always the goal for teachers, yet getting there with English learners often seems just shy of impossible. Developing this kind of understanding may require more hours in a day than teachers are able to give, especially when it comes to mathematics. We must equip teachers with tools that provide a fast track to lasting, conceptual knowledge through the use of interactive, digital manipulatives.

ST Math provides a staple resource teachers can rely on to provide wonderful visual representations they can align to their lessons.

Kalim Rayburn, Principal, Rea Elementary, Newport Beach, CAEngineering, Pinellas, FL

The following example shows how the highly abstract concept of Exponential Growth can be represented with an interactive visual model.



CLICK TO WATCH THE ANIMATION

The object of this puzzle is to match the shape on the left using repeated multiplication. Since the given shape contains multiple groups of four, the student has predicted the solution is 4 x 4 x 4. The animation proves this correct.

Through this “hands-on” experience, the student gains foundational knowledge of Exponential Growth (4 x 4 x 4), which is the core concept behind Exponential Notation (4^3). ST Math provides the most crucial step for English learners in the learning process: conceptual understanding.

Think of how far teachers could go with tools that provide their ELs individualized pathways toward conceptual learning.

Empowering Parents to Engage in Student Learning

Guiding Question

How can we equip **families** to encourage students toward deep and meaningful learning?

1. Family Interaction

Research has consistently found that academic collaboration between parents and students significantly increases school achievement. One study explored the effects of parent-student interaction with online math activities and the results were positive. The more parents and their children used an online math app outside of school, the higher the student's math achievement at the end of the year.[8]

ST Math provides the perfect opportunity for educators to encourage this type of invaluable family interaction. The game-based, visual platform allows English learner parents and students opportunities to engage in high-level problem solving, regardless of prior knowledge. Parents can be coached to facilitate their students in finding answers to tough problems through open-ended questioning and curiosity.

8 Talia Berkowitz, Marjorie W. Schaeffer, Erin A. Maloney, Lori Peterson, Courtney Gregor, Susan C. Levine, Sian L. Beilock. "Math at home adds up to achievement in school." Science. Vol. 350, Issue 6257, pp. 196-198. Last modified 09 Oct 2015. DOI: 10.1126/science.aac7427.

ST Math Facilitation Questions for Parents

Step 1
Uncover Thinking

- What have you tried?
- What happened then?
- Why did you _____?

Paso 1
Descubrir qué Piensa

- ¿Qué has tratado?
- ¿Cuál fue el resultado?
- ¿Por qué hiciste _____?

Step 2
Examine Animation

- What is happening in the animation?
- What did you notice? What else?
- When you clicked _____, what happened?

Paso 2
Examinar la Animación

- ¿Qué pasa en la animación?
- ¿En qué te fijaste? ¿Qué más?
- Cuando hiciste clic en _____, ¿qué pasó?

Step 3
Apply Hypothesis

- What do you think will happen?
- How will this work on this problem?
- What steps will you take?
- How did you decide that was correct?

Paso 3
Aplicar Hipótesis

- ¿Qué crees que va a pasar?
- ¿Cómo va a servir eso en este problema?
- ¿Qué pasos tomarías?
- ¿Cómo decidiste qué era correcto?

These facilitation tips can assist parents in collaborating with their students on ST Math.

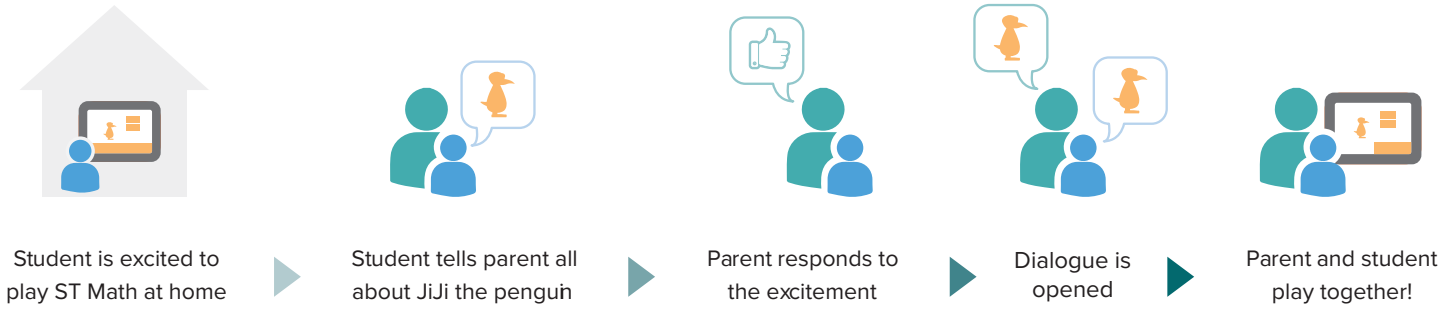
We have a link to ST Math on our school website so all they have to do is click it and JiJi the penguin is instantly in their living room.

- Kalim Rayburn, Principal, Rea Elementary, Newport Beach, CA

It's common that enthusiastic students will ask their parents to share in their experience with ST Math. Student invitation is one of the most influential ways of generating parent involvement.[9] When students come home excited to play ST Math, parents notice, ask questions and before long, math conversations become a regular occurrence after school!

9 Kathleen V. Hoover-Dempsey, Joan M. T. Walker, Howard M. Sandler, Darlene Whetsel, Christa L. Green, Andrew S. Wilkins and Kristen Closson. "Why Do Parents Become Involved? Research Findings and Implications." The Elementary School Journal. Vol. 106, No. 2, pp. 105-130. Last modified November 2005.

Pathway to Student and Parent Collaboration



2. Transparency

Parents must be equipped to monitor their child's academic progress. When parents know what their student is learning and why, they are informed and invested. However, providing this level of transparency can be difficult if language barriers exist for parents. Many times, the only sources of information parents have surrounding their child's math achievement are test grades and homework frustrations.

ST Math changes the equation through a robust online archive of student progress. Teachers can invite parents to track student progress at home, which increases buy-in and generates pride in student accomplishments.

Researchers agree that teachers should offer specific suggestions for what parents can do to be involved in their child's learning and ST Math provides the perfect opportunity.[10]

10 Kathleen V. Hoover-Dempsey, Joan M. T. Walker, Howard M. Sandler, Darlene Whetsel, Christa L. Green, Andrew S. Wilkins and Kristen Closson. "Why Do Parents Become Involved? Research Findings and Implications." The Elementary School Journal. Vol. 106, No. 2, pp. 105-130. Last modified November 2005.

Guiding Questions

to Support EL Math Success

How can we ensure all **students** have access to deep and meaningful learning?

- ☐ **Language-Independence:** Can students engage in deep, mathematical problem solving regardless of language level?
- ☐ **Visual Modeling:** Are students interacting with graphically rich models that build conceptual understanding?
- ☐ **Self-Exploration:** Does curriculum allow for multiple pathways to finding solutions?
- ☐ **Mastery-Based:** Are students required to master concepts before moving to new content?
- ☐ **Rigorous Problem Solving:** Are students prompted to use higher-order thinking to solve non-routine problems?

How can we provide **teachers** the tools and training to enable deep and meaningful learning?

- ☐ **Personalized Learning:** Does instruction provide all students a pathway to mastery regardless of their starting point or individual needs?
- ☐ **Self-Paced:** Do students work at their own pace to solve problems?
- ☐ **Conceptual Understanding:** Does instruction help build a conceptual foundation of math knowledge.
- ☐ **Standards Alignment:** Are instructional resources aligned to content standards?
- ☐ **Curriculum Enhancement:** Do supplemental programs provide an opportunity for teachers to enhance their core math curriculum?”

How can we equip **families** to encourage students toward deep and meaningful learning?

- ☐ **Family Interaction:** Are families invited to join in student learning experiences at home?
- ☐ **Transparency:** Can parents easily monitor student progress at home?
- ☐ **Intrinsic Motivation:** Do students come home excited to engage with instructional technology outside of school?
- ☐ **Math Communication:** Are parents encouraged to talk to their student about mathematics at home?

To learn more about how the ST Math® visual learning program can bring positive change in these critical areas, contact info@mindresearch.org or **(888) 751-5443**.

Creators of the ST Math game-based learning software and the MathMINDs hands-on learning events, MIND Research Institute supports schools and communities in ensuring that all students are mathematically equipped to solve the world's most challenging problems.

About the Author

Jessica Carlson is author of the ebook, What Is Math Rigor?, was formerly Program Manager of Partnerships Enablement at MIND Research Institute. She began her career as a middle school math teacher serving a high EL population before moving into education consulting and teacher professional development. She emphasizes the use of innovative technology and instructional practices that promote conceptual, student-driven learning.

Request more information about ST Math PreK-8 visual instructional program

Request Program Information

Or go to: stmath.com

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