By Matt Kuhn and Kathleen Dempsey

End the Math Wars

Increase your math students' procedural fluency and build greater conceptual understanding in virtual environments.

In 1999, Richard Lee Colvin published an article in *The School Administrator* titled "Math Wars: Tradition vs. Real-World Applications" that described the pendulum swing of mathematics education reform. On one side are those who advocate for computational fluency, with a step-by-step emphasis on numbers and skills and the algebra-geometry-trigonometry-calculus sequence. On the other side are those who think students must engage with real-world problems that employ a variety of mathematical disciplines and deep learning of math concepts that comes from struggling with complex problems, comparing multiple solution paths, and learning from trial and error. As the role of ed tech continues to evolve, can it bring the two together and help meet the needs of both sides in ways that were not possible or even considered in 1999?

Some schools don't look very different than they did in 1999, 1989, or even 1959, while others are rocketing into the future with one-to-one laptop initiatives, educational gaming, and intelligent tutoring. Printed textbooks are becoming dusty in these modern classrooms, and publishers know they must offer robust digital versions of textbooks or be left behind. Some schools and districts are not even buying printed books anymore. Instead, they are putting their precious funds into laptops that have enhanced digital versions of textbooks with multimedia, tutoring software, and statistical analysis tools. For an example, check out Empire High School in Vail, Arizona, USA (see Resources on page 21).

To understand what it will take to bring the two sides of the mathematics debate together, first consider the approach each side takes to improve student achievement. One side wants to focus mostly on building scaffolded computational fluency through repetition and practice, while the other wants to focus mostly on engaging learners in deep and meaningful problem solving. Do these goals have to be mutually exclusive, or is there a middle ground? Many would say that we have tried this combination and failed, and that the complexity of combining these approaches using just paper and pencil is very difficult with today's digital natives. Indeed, many integrated mathematics textbooks have produced mixed results. Ed tech, however, has changed the debate. Three areas where technology helps create schools where students learn what they need to know about math are:

- Engagement and relevancy
- Differentiation for digital natives
- Inclusivity and multiple feedback channels

Engagement and Relevancy

Engagement and relevancy are interdependent. If students think something is exciting and challenging, they usually perceive it as relevant. Likewise, if they see a problem's topic as relevant to their community, it tends to pique their interest and motivate them. In other words, it challenges them to engage in deep problem solving. Although using technology to learn mathematics is often merely drill and practice, much of the latest software is more engaging than ever.

For instance, the algebra game DimensionM uses exciting scenarios to engage learners in algebraic problem solving to overcome challenges and achieve a series of increasingly challenging goals. Students who play the game often have so much fun that they barely notice the large amount of mathematics they are doing. Teachers who employ educational games will tell you that they often see students searching sites, such as www.purplemath.com, frantically riffling through a book, or trying to get help from the teacher quickly to learn how to apply an equation that is holding up the game. To see the level of excitement a game can generate, go to www.dimensionu.com/math and view the tournament video between New York City and Chicago.

DimensionM is a 3D multiplayer game for learning math.

We can't think of any paper-and-pencil lesson that generates this amount of student enthusiasm about algebra.

Differentiation for Digital Natives

Let's face it, when it comes to inclusion, teachers are dealing with a wide array of student abilities, interests, and needs. And with budget cuts hitting schools hard, class sizes are only getting bigger. Under such challenging conditions, many teachers fall back on "teach to the middle" out of necessity, not desire. Here is where technology offers a better way.

For example, mathematics teachers can differentiate content by using intelligent tutoring software that is diagnostic, prescriptive, interactive, and adaptive to students' readiness. One such tool is Cognitive Tutor. This program works with Carnegie Learning's Bridge to Algebra readiness series, giving the student a battery of assessments to diagnose deficiencies in his or her mathematical background. It then produces a customized set of scaffolded lessons and gives the teacher and the student rich feedback as the student progresses through them.

When students learn, mistakes and misconceptions are inevitable. Technology provides a vehicle by which students can receive feedback without risking embarrassment.

The teacher's role is to guide, facilitate, give feedback, and monitor progress. As the student moves through the lessons, the software notices patterns and difficulties and adapts the package of lessons and types of feedback.

Inclusivity and Multiple Feedback Channels

When students learn, mistakes and misconceptions are inevitable. Technology provides a vehicle by which students can receive feedback without risking embarrassment. As you know, students are sensitive to the perceptions of peers, and faced with asking a question during class or remaining confused about a topic, many students simply choose to remain confused. One way to address this is through student response systems. These handy devices allow students to give a response anonymously and then learn whether the response is on target or off the mark. With student response systems, teachers have a better understanding of which topics their students have mastered and which they need to revisit. The fact that the feedback is immediate further affects a student's course of action. Generally, students will seek corrective steps if they realize they have made mistakes or have misconceptions.

Opportunities for online collaboration also allow students to seek and receive feedback in a less inhibited environment. Whether students are working on a group project, seeking input for ideas on a class blog, or asking the teacher for additional assistance, an online environment can help even shy students gain the confidence they need to enrich their learning.

Ed Tech in Math Class

If ed tech can help meet the needs of math learners better than ever, why aren't more of us integrating it into mathematics instruction? The reasons are complex and multifaceted. Economics, generational trends, and pedagogical knowledge all play a role.

While finding funds to pay for technology is still a challenge, this has become less of a barrier because hardware and software have become cheaper, and that is likely to continue. Math teachers' attitudes about tech integration, however, are still a hindrance to progress. You will find pockets of excellence, but many math classrooms are so textbook driven that technology is an afterthought or a reward rather than a systemic tool for learning. Consider the descriptions in the table below to determine your level of technology implementation.

Levels of Technology Implementation

Misconceptions, such as the belief that technology use does not improve learning, can also create barriers for tech integration. Many state standardized tests may actually support this notion because they measure learning from the lower levels of Bloom's Taxonomy, while the systemic use of ed tech spans a much wider range of learning activities. This misconception also stems from the difficulties researchers have with trying to measure the impact of ed tech, although many studies show technology can be used effectively in learning and teaching. For example, "Foundations for Success: The Final Report of the National Mathematics Advisory Panel" published in 2008 found that instructional software has generally been shown to have positive effects on student achievement in math, as compared with instruction that does not incorporate technology.

Another especially troubling misconception is that using ed tech means that "master teachers" will lose some clout if they admit they need to learn how to employ a new technology in the classroom. Some teachers find it easier to avoid the issue altogether and continue trying to use teaching methods that worked in 1980 but are now outmoded.

Encouraging More Tech Integration

Most individuals find change unsettling, so before real change can occur within an organization, you must create a demand for change, and members of your organization must understand that it will yield worthwhile outcomes. Creating a demand for change is a function of leadership, but that doesn't have to be relegated to the school principal alone. Working with leadership teams, a culture of tech integration can take hold. When the school's culture for tech integration gains momentum, a feeling of "this is how we do things at our school" begins to permeate the culture. Of course, high-quality staff development is essential, and according to the National Staff Development Council, professional development should be comprehensive, sustained, and intensive to improve teachers' and principals' effectiveness.

Staff development initiatives need sustained support, and this is especially important in technology integration. Timely, on-site support for integration can be the single factor that makes a difference in effective teacher implementation and increased student learning. A 2006 study published in the *Journal of Technology and Teacher Education* found that "teachers who believe that they have the skills to implement computers successfully and who valued the outcomes associated with integration were more likely to be at the high end of the 'technology user' spectrum."

Failing to maintain a tech initiative's momentum is common. Once you've launched an initiative, establish milestones to help individuals as well as the organization move toward its goals. Monitoring progress is also an important part of the implementation phase.

Levels of Technology Implementation

- I explore, evaluate, and use digital information regularly with students. Technology is an essential and regular part of pedagogy.
- I use technology with students as an instructional tool on a regular basis. I don't teach technology; I use technology to teach.
- I understand ways technology can be used to teach. I need little tech support, and students use technology in my class.
- I am comfortable using technology but still need frequent assistance. I mostly use technology for administrative functions.
- I do simple tasks on the computer as long as the tasks do not take a lot of time and know-how. I need a lot of tech support.
- I am aware of the technology available but do not use it. I am uncomfortable with the thought of using technology.

Leadership teams can keep the initiative in the forefront through discussions at staff meetings and through school learning communities. When teachers share information about the ways they are integrating technology, other teachers are more likely to move toward increased tech integration with their own students. Principals can also take a direct role by requiring that integration be a part of each staff member's professional growth plan. In this way, all staff members set individual goals for increased tech integration and establish an action plan to reach the goals.

Accountability in the subjects of science, technology, engineering, and mathematics (STEM) is greater than ever. To meet these rigorous expectations, educators must be willing and able to incorporate the best tools available. Whether using virtual manipulatives, intelligent tutoring systems, dynamic visualization software, or web 2.0 collaboration tools, teachers who understand and leverage the power of these resources will be better able to address their students' diverse needs.

Ed tech is bridging the divide in the debate over mathematics reform by providing opportunities to increase procedural fluency and integrate it with greater conceptual understanding. We encourage educators to set goals for tech integration and request ongoing professional development to support the initiative. In the end, students will be the ones who benefit most.

Resources

Carnegie Learning Bridges to Algebra: www.carnegielearning.com/secondary-curricula/bta
Cognitive Tutor: www.carnegielearning.com/secondary-solutions/adaptive-math
Empire High School: http://ehs.vail.k12.az.us
"Implementing Computer Technologies: Teachers' Perceptions and Practices" by Lori Wozney, Vivek Venkatesh, and Philip C. Abrami: http://doe.concordia.ca/cslp/cslp_cms/sites/all/themes/jframe/downloads/PDF/wozneyetaljte141.pdf
Purplemath: www.purplemath.com
Tabula Digita DimensionU Games: www.dimensionu.com/math

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