EDUCATION WEEK

Math Educators See the Right Angles for Digital Tools

Teachers use adaptive-learning software, on-demand videos to customize learning

By Ian Quillen

While multimedia tools have been slow to penetrate instructional methods in some subjects, the math world is bursting with tales of teaching technologies that visualize concepts, adapt to students' strengths and weaknesses, and align with state academic standards.

There's adaptive-learning software that gears math lessons toward individual student progress—a concept that drew mainstream media attention when *Time* magazine named the **School of One** math program in New York City as one of the top 50 inventions of 2009.

There are on-demand videos that give tutorials on nearly every concept in basic mathematics, algebra, calculus, and even applied math fields like accounting. For building one such repository, the Khan Academy, that now hosts more than 2,300 videos, Sal Khan made a name for himself and is now a featured speaker at innovation pow-wows like last summer's Big Ideas Fest in Half Moon Bay, Calif., and this past March's TED 2011 conference in Long Beach, Calif.

And there are Web-based tools that allow students and teachers not only to construct, but also to alter and examine the relationships in angles, shapes, and even quadratic equations. In some cases, those tools have reached more than half the nation's high schools.

While educators in other subjects may still be figuring out how best to create multimedia tools for the classroom, math teachers appear to agree that their main challenges center around gaining access to already-existing tools and how best to weave them into students' education. And just because there's a lot to choose from doesn't mean all the programs possess the same ability to teach math on a long-lasting, conceptual level.

"Basically, the research says when students have the ability to engage with multiple representations of a problem, then they are better able to apply these tools with problem-solving and reasoning," said Mark W. Ellis, a board member for the Reston, Va.-based National Council of Teachers of Mathematics and the

Multimedia Transformation

Technology Evolves to Offer a Clearer View of Science

Math Educators See the Right Angles for Digital Tools

Language Arts Educators Balance Text-Only Tactics With Multimedia Skills

Digitized Historical Documents Give Students Direct Access to the Past

Art and Music Learning Emphasize Interactivity, Real-World Relevance

Teachers Hold the Real Keys to Whiteboard Effectiveness

'Safe' Social Networking Tailored for K-12 Schools

Film Students Power Video-Production Business

Quality Content in Demand as

chairman of secondary education at California State University, Fullerton.

"Just having access to technology is not enough," Mr. Ellis continued. "It's the role of the teacher or of the curriculum that's essential. Although kids are quick to pick [technology] up, they're not that quick at learning to relate it to a mathematical concept."

Rules and Relationships

Many multimedia-tool developers have been striving to address the conceptual level of understanding that Mr. Ellis says is so important. But each one has a different take on how that's done best. And sometimes it is the simpler tools that more easily enable comprehension of mathematical rules and relationships.

For example, online drawing programs that allow students and instructors to draw and manipulate shapes and graphs—like the **Geometer's Sketchpad**, made by Emeryville, Calif.-based Key Curriculum Press, or the independently run **GeoGebra**, which has established dozens of institutes across the globe—immediately give users a sense of the relationships that govern geometry, algebra, and even calculus.

A student stretching an equilateral triangle can see that two sides and two angles remain equal no matter how the size changes. The same student can also adjust the rise, run, or intersecting points of a quadratic equation graph and see how the variables shift.

The downside is that, while allowing a teacher to demonstrate or a student to explore those relationships, it's not something that's embedded into a set of problems for a class or homework assignment.

But Elizabeth DeCarli, a managing development editor for Key Curriculum Press, says an instructor who thinks creatively can offset the tool's stand-alone nature.

"I'm modeling this as an exploratory tool. I really want students to be playing with this," Ms. DeCarli said of the Geometer's Sketchpad, which she said has reached about 60 percent of the nation's high schools in some form.

"As a teacher," she said, "what you want is for students to realize, 'I don't need to memorize a thousand different rules. I'm beginning to observe commonalities.' I can import a picture and then say I want you to make this parabola and make the parabola match this fountain."

Reinforcing Concepts

Some adaptive-learning software, which tailors lessons and exercises to individual student progress, also uses visual representation to demonstrate relationships. Such programs appear to be in greater use in the lower grades.

For example, software designed by the **MIND Research Institute**, a Santa Ana, Calif.-based nonprofit group that focuses on how neuroscience links to education, uses virtual manipulative diagrams—in which quantities are represented by graphic units as well as numbers—throughout its

complete set of math content for grades K-5.

Throughout the software—used as a curriculum supplement in about 1,000 schools nationwide—users must solve math problems to help the character Ji Ji the penguin cross from one side of the screen to the other. Often there is more than one correct answer to the problem—especially when it involves teaching spatial orientation—but users will typically be prompted to solve the same challenge using several different methods.

While the quantities and complexities of functions increase by grade, the framework and look of the character, landscape, and game-like nature of the content remain constant. And while Nigel Nisbit, MIND's director of content creation, says the format is backed by neurological research, he admits the program's appearance can initially be off-putting for teachers.

"For many teachers, when they see the games are purely visual, they're sometimes very suspect of where this is going, so it's trying to show them the why and how," Mr. Nisbit said. "It's about putting almost a sequence together. This is something, when we look at games in isolation, they don't necessarily appreciate."

While software from Bellevue, Wash.-based DreamBox Learning also uses visual approaches, it differs from MIND's software because it lets students in grades K-3 choose their own visual representations. After completing a problem one way, students will often be prompted to solve the same problem by choosing a different visualization to reinforce the concept.

Choice is important for student engagement, says Suzanne Farmer, a math intervention specialist at Toliver Elementary School in the 1,600-student Danville, Ky., school district, which uses DreamBox to aid students with special needs in math instruction.

"They really feel like they're in charge, like they're controlling what is happening," said Ms. Farmer. "I don't think any kind of intervention should be punishment. ... These kids are already feeling insecure in their mathematic ability."

(DreamBox's chief executive officer and president, Jessie Woolley-Wilson, is a trustee of Editorial Projects in Education, which publishes *Education Week* and *Digital Directions* magazine.)

Matching State Standards

But elements of adaptive-learning models still have to match with state standards and other demands, says Todd Hausman, a 4th grade teacher at Lowell Elementary School in the 11,000-student Bellingham, Wash., school district. He uses similar adaptive software made by Newton, Mass.-based **TenMarks Education**.

Mr. Hausman, a former employee of the publisher Houghton Mifflin Harcourt and of the Bill & Melinda Gates Foundation, acknowledges that the software helps students gain conceptual mathematical knowledge.

But he adds that what "sealed the deal" on incorporating TenMarks' content into his classroom, at the expense of other companies, was its ability to import data from thrice-yearly Washington state standardized testing.

Mr. Ellis, the National Council of Teachers of Mathematics board member, agrees that standards and other national, state, and district guidelines can shape decisions about procurement of

adaptive-learning software as well as other multimedia tools. He says he's hopeful that the Common Core State Standards Initiative will help enable more interested districts and individual teachers to use such tools while aligning with the standards, particularly the initiative's eight standards for mathematical practice, which give broad goals for best practices in math classes across all grades.

"What I like about them is they say, 'Here is what we want to see students doing in a math classroom,' not 'Here's how you teach math,' " Mr. Ellis said of the common-core math standards, which he said stress broad principles and work habits over narrow learning goals.

"If you're going to create an environment where it's actually going to happen and students are going to be doing those things," he said, "you're going to need to bring in tools beyond pencil and paper."

Until then, teachers may continue to frequent resources that more easily align with their set district or state curricula and standards, such as video tutorials that break down specific math concepts, as well as related audio clips, audio files, or online diagrams.

Some content services like **Learn360**, from Woodbury, N.Y.-based AIM Education Inc., offer the ability to combine resources into playlists of media set specifically for the needs of individual students, to help give some of that multidimensional understanding of content. And while it may not be as high-tech as an online drawing tool or adaptive-learning software, the back button can still help foster student comprehension of complex concepts.

"A lot of the videos we have on our site are really addressing concepts from different forms of learning," said Anne Feldkamp, a content-acquisition and product-development manager for AIM Education Inc. "I think that's really the key—being able to have those different approaches, and being able to say, 'I still don't get it; let me rewind it.' "