T·H·E journal

STEM Picks Up Speed

by Jennifer Demski

The use of authentic scenarios to teach abstract concepts such as constant velocity is helping educators spark student interest in math and science.

A SOUND SOLUTION Inside SMALLab, an environment that blends the real and digital worlds, students can hear the relationship between their movement and the principle of acceleration.

SCOTT ANDERSON WANTS TO send your fifth-graders to the moon.

As the instructional technology coordinator for the NASA Digital Learning Network at the Marshall Space Flight Center in Huntsville, AL, Anderson regularly conducts videoconferences with middle school students across the country in the hopes of raising their interest in the science, technology, engineering, and mathematics professions that keep NASA running. According to Anderson, the last boom in STEM careers happened after the first moon landing in 1969, and the agency needs an infusion of youth. "Today, just under half of the scientists and engineers at NASA could retire if they wanted to," he says.

"NASA wants to go back to the moon around 2020. It turns out the middle school students-- that's right around the time they'll be graduating from college. We conduct these videoconferences to motivate kids to want to work here someday, to help us get back to the moon and then go on to Mars. When they graduate from college, if they graduate in a STEM field, there will be a place for them at NASA."

It's an exciting prospect, but one that will be hard to fulfill as long as students continue to find the subjects that lead to those NASA careers less and less appealing. Algebra, geometry, earth science, physics-- these require patience and perseverance to master. That kind of academic stamina is hard to advertise to kids nurtured on the instant engagement and gratification of modern digital technology. And there's little hope they'll be sustained by an intrinsic interest in math and science; they have to be shown how they can apply the material to their own lives. This is leading educators away from textbooks to search for teaching solutions that use real-world, interactive scenarios to engage students in STEM learning.

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"The kids who are coming through school now, if you can't give them a real-world connection to what they're learning, they turn off," says Helen Gooch, instructional technology coordinator for the **Clarksville-Montgomery County School System** in Tennessee. "If they can't see how it applies to them, how they're going to use it-- if you can't explain to them why they need to learn the principals of these subjects, you don't have them. They're not with you."

Video Algebra

Ed Fields knows what teachers are up against. "Today's middle school students have never not known the internet," says Fields, CEO and founder of HotChalk, a provider of online K-12 learning resources. "The vast majority of them have a Sony PlayStation or a Wii or an Xbox in their homes. And the amount of media that's focused on them is mind-blowing when you think about Nickelodeon, the Disney Channel, the Cartoon Network, and all the other content that's coming their way."

To compete with this maze of distraction, Fields created HotChalk's free online video series, Off-Road Algebra. By demonstrating an unexpected link between extreme sports and algebra, Off-Road Algebra is one of those rare educational products that may actually succeed in making math cool. An avid motocross enthusiast, Fields worked with a group of professional motocross racers and a video crew to create this collection of 30 online videos that teach algebra as it applies to the sport of motocross. The videos have a distinctly YouTube look, and feature a group of riders on a desert course encountering various problems that require students to use algebra to solve-- such as ensuring that a bike's gas tank will hold enough fuel for a long race-- before the race can advance. The teacher can pause the video while the students work out a problem, and then when the video resumes, the racer gives the answer and explains how it was solved.

Fields recruited Jason Dyer, a math teacher at **Pueblo Magnet High School** in Tucson, AZ, and creator of "The Number Warrior" math blog, to devise the algebra problems that are shown in the videos. Dyer says the weakness of textbook-based word problems that attempt to present real-life applications is that they require students to make too great a leap to see how the math and the real-world scenario are linked. "With this series, I was really focused on the integration," Fields says. "I came to it with the philosophy that I would be teaching both about the motocross racing and the math so that they would truly be integrated together."

Dyer focused the videos on algebraic principals that exist naturally in motocross, such as the formula for velocity. "'Velocity equals distance divided by time' is a fundamental formula for any kind of motion," he explains. "The ramifications of it go all the way through calculus, yet it's also essential to motocross. I could have done the entire series just on that principal as it applies to racing."

Although the Off-Road Algebra series just launched in September, Fields says his website has already seen about 100,000 downloads of the free videos, which he thinks indicates a strong interest in finding new ways to engage students in STEM subject matter.

Helen Gooch has just begun introducing Off-Road Algebra in her district. "When my math consultant and I looked at this series," she says, "we thought, 'How could we not want to use this?' It puts that relevance and that real-world application into what it is we're trying to get the students to learn."

Supplementing With Software

Also aimed at sparking students' interest in math, Brainingcamp offers a series of online math-based game modules meant to supplement traditional lessons. The games use real-life scenarios that students manipulate using math principles. "The brain works best when students can find real-world connections," says Dan Harris, CEO of Brainingcamp. "Without real-world connections, math is just formulas and equations that are difficult to understand and often boring."

The software currently features six units that each cover various algebra and geometry principles. For example, in one unit, students develop a strategy to board passengers onto a plane as quickly as possible, requiring them to use probability, data analysis, and problem-solving skills. The other units include planting a forest to offset carbon emissions; designing a mountain race course for bicyclists; programming a scanner in a package-sorting facility to sort boxes by their shapes; planning a flight route; and growing a Segway polo league into a sports empire.

YOU DON'T HAVE TO BE A ROCKET SCIENTIST

NASA VIDEOCONFERENCES INFORM STUDENTS ABOUT THE VARIETY OF CAREERS THE AGENCY OFFERS.

IN THE GREAT MAJORITY of the educational videoconferencing services that NASA offers to K-12 schools, Scott Anderson, the instructional technology coordinator for the agency's Digital Learning Network at the Marshall Space Flight Center in Huntsville, AL, focuses on the variety of science, technology, engineering, and math careers available at the agency. In fact, one of Anderson's most popular videoconferences is NASA Careers, where his main goal is to dispel the myth that the only career path offered at NASA involves flying into orbit.

"If I were to walk into a mall and ask 100 people to name a career at NASA," he says, "the majority would say astronaut. Here at the Marshall Space Center alone we've got close to 5,000 engineers and scientists."

While talking with students during the NASA Careers videoconference, Anderson displays a chart of more than 40 different professions they can find at NASA, and asks the students which ones look interesting to them. Many of the students are caught by surprise. "They wonder why NASA needs veterinarians," Anderson says. "Well, when we travel to space we often have experiments that we send along, oftentimes with insects or animals. So we need veterinarians on staff to make sure that the experiments are safe, and that we're going to get relevant data."

Melanie Turner, the instructional technology specialist for Colquitt County Schools in Moultrie, GA, recently offered the NASA Careers videoconference to her district's fifth-graders as a part of their Career Day. "The idea was to expose them to more than just the typical doctor, lawyer, teacher-type careers," Turner says. Mission accomplished: Her students learned about careers at NASA in scuba diving, nursing, and, of course, rocket science.

RaeAnn Pruitt, a middle school math teacher at **Mineola Middle School** in Mineola, TX, has been supplementing her lessons with the software for more than a year now. Pruitt used the flightplanning unit as a review tool for her eighth-grade students as they prepared for their year-end state assessment. "It worked really well because we did the module together," she says, "and it covered so many principles of the curriculum that I was able to see where they were struggling. I have no doubt it helped them with their test."

The authentic contexts in which the problem solving is done let students see the real effects of those math principles that had before only been distant abstractions to them. For example, in the flight-planning module, students are tasked with creating a flight route that minimizes time and delay. They discover how a faulty measurement or, perhaps, an incorrect fraction causes a plane to travel less efficiently.

"It gives the principles some relevance," Pruitt says. "We can talk about adding fractions or adding decimals, but to actually see it in action really helps clarify those objectives. Add to that the fact that so many of these students are so used to watching things on their computer-- when they can see it on their school computers, it really interests them more. The technology is key to keeping their attention."

Mixed Reality

Sometimes real-world scenarios need a blend of the virtual to really make science come alive for students. A major step toward fully interactive educational technology has taken place by means of a partnership between researchers at Arizona State University and a team of forward-thinking teachers at **Coronado High School** in Scottsdale, AZ.

David Birchfield, assistant professor in ASU's Arts, Media, and Engineering program-- a collaboration between the university's college of the arts and its school of engineering-- heads a team of researchers across a range of disciplines, including psychology, computer science, and education, that has developed an innovative learning platform called the Situated Multimedia Arts Learning Lab, or SMALLab. The lab requires students to interact directly with elements of both the physical and virtual worlds, what the researchers term a "mixed-reality" environment. The SMALLab platform consists of a 15-foot-by-15-foot interactive floor mat, a projector aimed at the mat, surround sound speakers, and two "glowballs"-- illuminated orbs that the students maneuver from point to point within the darkened space on the mat. A computer terminal linked to the platform collects information from sensors and the glowballs as the students move within the space, allowing the virtual objects that are part of whatever scenario is mounted on the mat-- such as an assortment of fossils and geological matter-- to react to the students' movement in real time.

SMALLab was designed in accordance with recent studies in the learning sciences regarding how students learn, especially in the context of STEM-based subjects, which stress the ideas of embodiment, collaboration, and multimodality-- the theory that concepts can be understood through different kinds of representations.

"An algebraic equation is one type of representation of a physics phenomenon," Birchfield explains. "A graph is another kind of representation. A diagram is another. There's a lot of evidence to show that seeing those different representations is valuable to students. Much of what we're trying to do in SMALLab is consider that there can also be sonic representations. Students can close their eyes, walk through the SMALLab space, and hear the relationship between their movement and the concept of acceleration."

Birchfield says the lab combines the best of computer-based simulation learning-- where, for example, a student can explore chemistry at a molecular level, or simulate the effects of an earthquake in different environments-- with the active, collaborative, hands-on experiments of a science lab. "The crux of what we're trying to do is mix students' real-world experiences with these digital experiences into one cohesive learning experience," Birchfield says. "You're physically present in this space, you're using digital media tools where they're appropriate, but it's a mix between the digital and physical environments."

The SMALLab setup is in its second year of use at Coronado High School. Science teachers Dan Sweeney and Norm Colling have both used the lab to enhance their lessons during that time, and also have taken part in weekly meetings with ASU staff to design and develop new interactive scenarios for the platform. Students in Sweeney's ninth-grade earth science classes have shaken Wii remotes to generate earthquakes and used the glowballs to "pick up" fossils from the interactive mat and "place them" with the correct layer and type of sedimentary rock.

"SMALLab gets everyone involved," Sweeney says, "and when using it, students tend to make connections that they otherwise wouldn't have made."

Colling, a physics teacher, has worked with Birchfield to create a scenario for SMALLab that teaches principles such as constant velocity. As the students move through the space with the glowballs, their movements are graphed and projected on the mat. Conversely, students are shown a "position vs. time" graph, and then have to duplicate the movement depicted by the graph. A metronome speeds up or slows down in step with the velocity of their motions. Meanwhile, students situated outside the platform are busy calculating that velocity as it rises and drops. "If your scenario's going to be valuable and different than show-and-tell," Colling says, "everybody's got to be involved."

LINKS

- **Brainingcamp**
- HotChalk
- **Institute of Play**
- NASA Digital Learning Network
- SMALLab
- "The Number Warrior" math blog

Although there are only three SMALLab platforms now in use-- the Coronado High setup, the original installation at ASU, and a new installation at New York City's Institute of Play-- Birchfield hopes that the lab will soon become a standard tool in STEM teaching. "A lot of the work that we're doing right now is to demonstrate that a mixed-reality platform is viable in a mainstream environment," he says. "We're in regular physics and science classrooms at Coronado. Once we build up the foundational tools and the infrastructure, we'd like to see SMALLabs in classrooms across the country."

The expansion of SMALLabs nationwide could do much toward creating new interest in math and science. Colling says as a result of having his students work with the lab, he has noticed an increase in their enthusiasm for science and an improvement in their reasoning skills. "If they have to work through problems, then they're going to become good at working through problems," he says. "That's going to be something that they can apply throughout their educational experiences and their real-life experiences. It's going to affect all aspects of their lives."

::WEBEXTRAS ::
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