Connect™

Innovations in K–8 Science, Math, and Technology

January • February 2010 Volume 23 • Issue 3

21st-Century Math and Science: Making It Real

A New Frontier for *Connect:*

This issue marks a bold beginning for ***Connect***: after twenty-three years in print we will be published exclusively as a digital edition! It seems only fitting that this change occur for our current issue, *21st-Century Math and Science: Making It Real.* Technologies and communications are changing at a rapid pace. We are learning new methods and reframing our thinking to create a lively, useful, richly varied digital publication that retains all the integrity ***Connect*** has had while in print.

The new possibilities are very exciting: Imagine reading a story about work in the classroom of a skilled teacher and then, with a click, seeing a video of her students at work or listening to an audio discussion of her work! And by selecting the PDF and printing, it is still possible to get a hard copy filled with the insights and stories from fellow teachers for which ***Connect*** is known.

We hope to serve a greater number of people throughout the world while consuming fewer resources. A digital magazine requires no printing, which means fewer trees are cut down and less water used in processing; and with no postal delivery, fewer gallons of fuel are consumed with each issue. We hope you enjoy this issue and take full advantage of the features available to highlight text, bookmark pages, and add notes to pages.

Making It Real

The Twenty-First-Century Skills movement has received much attention in recent years, with both supporters and critics weighing in. How can we best prepare children for the world of the future? How do we help them to become lifelong learners? Is there any difference between twenty-first-century teaching, and what progressive educators have been advocating for centuries?

In this issue are examples of fine teaching for this century. Some teacher-authors take their guidance from a specific framework incorporating the kinds of skills and patterns of mind that experts say will best prepare today's students for jobs, citizenship, and meaningful life in the coming decades. Some simply teach in ways they believe are best suited to foster a joy of learning, both for today and throughout life. Their methods use active, challenging, compelling, and supportive techniques that incorporate immediate and local concerns as well as global issues.

Regardless of whether their teaching is linked to a specific set of strategies named for this century, or follows a set of best practices, the educators writing in this issue engage their students in meaningful ways, making math, science, and technology real.

Connect™

published by SYNERGY LEARNING INTERNATIONAL™

***Connect* is published online five times per year (bi-monthly through the school year) and offers a wide range of practical, teacher-written articles. Each issue is thematic and supports hands-on learning, problem solving, and multidisciplinary approaches.**

Editor: Heather Taylor

Circulation: Susan Hathaway

Design and Production: Judy Wingerter

Synergy Learning Executive Director: Casey Murrow

Connect (ISSN: 1041-682X) is published five times per year, September, November, January, March, and May, by Synergy Learning International, Inc., PO Box 60, Brattleboro, VT 05302. Tel. 800-769-6199, Fax 802-254-5233, e-mail connect@synergylearning.org.

How to Subscribe: Send $20.00 and subscriber's e-mail address for a one-year subscription. Site License: $160.00 per year allows distribution to individuals and groups within a school, school district, or college. Back print issues are $7.50 each, ten or more $5.50 each postpaid. Mail to Synergy Learning, Inc., PO Box 60, Brattleboro, VT 05302-0060.

For more articles and focus topics, see the ***Connect*** archive on our Web site: **http://www.synergylearning.org.**

PHOTO CREDITS: Cover, inside cover, pp. 10, 11, 12, Dwain Hammett; pp. 1, 2, Bill McWeeny; p. 3, Lisa Burton/Mainely Solutions; pp. 4, 5, 6, Courtesy of Catalina Foothills School District; p. 8, Steven Branting; pp. 22, 23, 25, California Academy of Sciences.

ILLUSTRATION CREDITS: Page 9, courtesy of Catalina Foothills School District; pp. 13, 14, 15, Steve Branting; p. 24, student work courtesy of California Academy of Sciences.

Synergy Learning International, Inc. is a 501(c)(3) not-for-profit corporation, engaged in publishing and professional development for educators, pre-K to middle school. We are dedicated to supporting schools, teachers, and families with challenging science, math, and technology learning for children.

The CALVIN Project

Science as a Verb

by Bill McWeeny

Todd Nelson, the principal of the Adams School where I teach in Castine, Maine, is a wonderful and thoughtful writer. In his latest column in *Middle Link*,[1] "The Learning Curve," he argues, "'School' is a verb." I *know* that science is a verb. The people who taught me science certainly considered what they were doing to be *sciencing*. When I was a student, our teachers arranged activities such as field trips, speakers, science fairs, and science clubs. We were always exploring science through some kind of activity.

The Calvineers on a field trip on the Bay of Fundy

Inspiration for active science

I fondly remember one field trip my eighth-grade science teacher, Murray Hoy, took us on. Mr. Hoy had just procured a three-foot concave mirror from army surplus and a brand new camera. He announced that he would set up the "telescope" at 12:00 AM one night in the middle of January. Any students who wanted to meet him at the Blue Hill Reservation, in Quincy, Massachusetts, could view the full moon and take pictures of it with him.

My dad and I drove to the designated spot and sure enough there was Mr. Hoy adjusting the mirror that was simply sitting on the ground. When you stood in the correct position the light rays from the moon entered the mirror and were focused at a point that gave an unbelievable image. Right in front of us, just a few inches away was an incredible "three dimensional" miniature moon. The image appeared so real that we all tried to pick it up in our hands, but to no avail. The image was simply that, an image. Yet it was far more than that. We could bend down and inspect the moon like never before.

Soon, Mr. Hoy took out a brand new Polaroid Land camera, focused it on the image and snapped a picture. He pulled a tab and out came a package of black paper. He quickly put the package under his jacket and up into his armpit. We all thought he was crazy but he explained that the chemical process needed a critical temperature in order to work. About two minutes later we were looking at a picture of the moon. That night we were scientists, viewing an ancient process with modern technology, actively engaged in science. When I think back to that single night I know I learned more science than I could have in a month of classroom assignments.

That night we were scientists, viewing an ancient process with modern technology.

The Animaineacs

It is only natural that my teaching would include activities similar to the ones that made an impression on me when I was a student. My latest and perhaps best example of teaching science actively is The Calvin Project. The Project began when a group of students formed an animal rights club that I volunteered to advise. The small group of students began by helping local animal shelters. Soon it became apparent to me that the "Animaineacs" had a lot of enthusiasm and energy and needed a bigger project. At that time I shared my

Calvin, the right whale who inspired the name of the student group

lifelong involvement with the New England Aquarium's (NEAq) Right Whale Research Team and my hope that the most endangered large whale in the world would someday be taken off the endangered species list. Without hesitation the Animaineacs joined the cause.

Efforts have been under way to help the whales since 1980. The first question for us to answer was, "How could the Animaineacs help the whales?" The students and I started our own research community in which I was the principal investigator and they were research scientists. We modeled ourselves after the NEAq's right whale research team. The first task was information gathering. We divided up the task and when we compared results, the truth was obvious. The general public had little access to good information about right whales. There were few news articles and most repeated the same basic information. There was little more available on the Web. So the new student research team stumbled into its role because of the lack of information. They formed a hypothesis and stated it as a positive: "Endangered Species Recovery Through Education."

Calvineers walking through the streets of Quebec with their mascot, a 7-foot model of Calvin the right whale. They are on their way to the Biennial Conference where they had a chance to speak informally with many scientists.

Meeting Calvin

The Animaineacs first asked scientists for detailed information. Amy Knowlton, senior scientist at the NEAq, befriended the students and gathered technical papers for them to review on subjects ranging from physiology and reproduction to ship-strikes and policy making. She also introduced them to Dr. Moira Brown, a scientist at the Center for Coastal Studies at the time. Moe Brown told the Animaineacs an amazing story about a right whale named Calvin who had somehow survived all the modern perils of right whale life.

The Animaineacs saw that the way to educate the public was to tell Calvin's story to the public. They went to the Annual Right Whale Consortium meeting in New Bedford in 2005. They presented their ideas to three hundred right whale scientists and received rousing applause. They were on their way and even had a new name, "The Calvineers," buccaneers of the twenty-first century! More importantly, the Calvineers were inspired by talking to and listening to scientists explain details of whale research.

Meanwhile, I worked basic science about marine mammals into the Calvineers' science curriculum. When they studied human anatomy, they also studied whale anatomy. When they studied body systems and functions, they would compare the human's to a whale's. Their studies in chemistry and nutrient cycles were linked to ocean health and the production of copepods, the right whales' main food supply. They even linked their studies of Newtonian physics to ship-strikes of whales through various sizes and speeds of ships and to the breaking strength of rope by entangled whales. When we talk about ecosystems we had a ready-made example in the Bay of Fundy where the whales forage for swarming copepods part of the year.

The next round

In 2007 the torch was passed when the first Calvineers graduated. The second generation Calvineers built a PowerPoint presentation telling the life story of Calvin. The presentation pointed out just how dangerous it was to be a right whale on the East Coast of North America. Even though it has been illegal to kill a right whale since 1935, many right whales were still being killed by shipstrikes and entanglements, human hazards. The Calvineers traveled to area schools and organizations presenting Calvin's story. They presented to more than 400 people in a year's time, including Senator Susan Collins who actually visited their classroom for the presentation. They felt they were making a difference. This group attended the 2007 Consortium meeting in New Bedford and reported their efforts to an overwhelmed crowd of right whale scientists.

The third generation of Calvineers is currently giving one presentation a month about the plight of the right whales. They have presented to more than 1,000 people from Massachusetts to Quebec City. The project has allowed my students not only to behave like scientists but also to rub shoulders with scientists. In 2008 I asked Consortium scientists to mentor Calvineers. Each Calvineer had a scientist mentor who was an authority in the subject the Calvineer was researching for their part of the presentation.

Using modern technology (all seventh- and eighth-grade students in Maine are issued a laptop) each Calvineer produced three PowerPoint slides on a specific aspect of right whale research. They then wove all the slides together into a comprehensive presentation.

Into the field and out on the sea

Our field studies are unique. My seventh and eighth graders all travel to the Bay of Fundy to witness the last remaining right whales in the North Atlantic. I run a field trip every two years that Mr. Hoy would love. I take all my seventh- and eighth-grade students to Grand Manan island in the Bay of Fundy. We pile into three minivans with cameras, binoculars, and science journals and spend two days in Canada. We first visit the New Brunswick Museum where the skeleton of Delilah, Calvin's mother who was killed by a shipstrike, hangs from the ceiling. I have the students lie under the skeleton to imagine the enormity of a 49-foot creature. The same day we travel to Grand Manan Island by ferry and stay overnight at the Boys and Girls Club, camping out on the floor there. The next day we board the research vessel, *Elsie Menota*, for a firsthand look at right whales. This past September the students saw more than twenty right whales and also saw a Surface Active Group (SAG) of eight whales playing socially.

This video from the New England Aquarium shows a typical SAG, or Surface Active Group, of right whales.

2009 was special for The CALVIN Project. The Calvineers presented at the 18th Biennial Conference for Marine Mammalogy in Quebec City where they also attended three days of talks by internationally renowned marine mammal scientists. Their presentation, in a Plenary Session to 1,800 scientists, was interrupted three times by applause and given a standing ovation. The Calvineers received the Conference Committee's award for "Scientific Communication and Innovative Research."

Students perform the song they wrote about Calvin's mother.

The teaching of science is the *doing* of science. In the twenty-first century, basic science concepts and teaching can be an active process beyond the classroom. Getting students involved with big ideas through meetings, conferences, and lectures only makes sense. These activities lead to dialogue directly with scientists and often to a mentor relationship. What better way to teach science than through apprenticeship? Twenty-first-century science teaching is way outside the classroom and rightly so.

Resources

Middle Link, Maine Association for Middle Level Education newsletter (http://www.mamleonline.org/documents/MAMLE_newsletter_spring2009.pdf).

New England Aquarium (http://www.neaq.org/conservation_and_research/projects/project_pages/right_whale_research.php).

The Urban Whale, Scott Kraus and Roz Roland, editors. Discusses history, biology, and plight of modern North Atlantic right whales.

In 2010 Bill McWeeny celebrates his fortieth year as a middle school science teacher and more than twenty-five years volunteering for the New England Aquarium's Right Whale Research Team. He currently teaches in Castine, Maine. Check out Bill's 21st-century classroom curriculum on Harvard Project Zero's ALPS Web site: http://learnweb.harvard.edu/ALPS/tfu/pop3.cfm.

Twenty-First-Century Skills in Everyday Teaching

by Wayne Thornes

Everyone today wants to know if we're teaching twenty-first-century skills in our schools. You hear it in the news, read about it in educational publications, and talk about it with the local parent-teacher association. My district, the Catalina Foothills School District in Tucson, Arizona, has answered these challenges through the adoption of a twenty-first-century learning framework for implementation across the curriculum. But just what is twenty-first-century learning, and what does it mean for teaching?

What's different?

A twenty-first-century learning environment isn't much different from what every teacher strives for. Self-directed students, excited about what they're doing, are actively engaged in learning. By and large, most of these skills are not new. Good teaching integrates these skills into learning opportunities for students on a regular basis, whether you call them "twenty-first century" or not. As a society, though, we've been focused on the basics (reading, writing, and math) for a long time—and while those skills are important, in order to be successful in today's world, students need to leave school with more than a mastery of algebra and the ability to write a cohesive paragraph. Students need to be able to communicate and work collaboratively, they need to develop a better understanding of other cultures, they need to be better and more creative problem solvers, and they need to be well versed in the basic tools that are used in business today.

The core academic subjects are still the foundation of a strong curriculum, but teamwork, global awareness, critical thinking, technology, and systems thinking are key components across the academic curriculum and are critical for student success in school, at work, and in life.

These skills are requiring students to interact with each other, and they allow more creativity and choice.

Changes for the students

Another key aspect of a twenty-first-century learning environment is that it makes learning, and the classroom environment, more enjoyable. The current drive towards high-stakes testing has a tendency to make learning a lot less fun. But in my experience, students genuinely enjoy learning when twenty-first-century skills are regularly integrated into the curriculum. These skills are requiring students to interact with each other, and they allow more creativity and choice than the traditional learning environment allows. We know young people are social; they are comfortable using technology, and are curious about interacting with their world. Applying twenty-first-century skills taps into that, and when we do it right, we encourage teamwork, use cooperative learning environments, and teach students how to effectively interact and communicate with a broad audience.

Additionally, technology is used as a tool to facilitate collaboration, develop presentations, and solve problems. It encourages students' natural curiosity and creative thinking. Students are still getting the basics, but the inclusion of authentic environments that students are familiar with make it both meaningful and fun!

Changes for the teacher

As a middle school math teacher for many years, I have worked hard to get students to recognize the value of math and be excited about learning it. My own interest in technology, combined with a personal drive to make math more meaningful for students, led me to use twenty-first-century skills in an effort to increase student engagement in learning.

The change in my teaching style didn't happen overnight, but the process of creating a twenty-first-century learning environment has really pushed me to reflect on what I'm doing and why I'm doing it. Creating a PowerPoint and running through a lesson by giving examples and providing guided and individual practice was the standard I worked by, but it wasn't until I began to incorporate more twenty-first-century learning skills that I saw students get excited about what I was teaching. Students were asking more questions and talking about math in the hallways and during lunch. Students were engaged in learning, making more connections among themselves and with the larger world around them. What they were learning was making an impact, both for them and for myself.

It's a challenge to manage thirty students in an interactive environment. It's a lot more talkative; there are technical challenges; students move at different paces; and the energy level in the class is a lot higher. Repeating that for six periods a day, I would often go home exhausted. But when I heard the "average" student after school talking excitedly about what he or she had been doing in my class that day . . . that was getting me pretty darn excited too. As a secondary benefit, I've learned a lot. I have had to learn about graphing calculators, dynamic statistics modeling software, and motion-sensing probes, none of which existed when I was a student in school. I've had to learn to manage students more effectively as they work in groups, and had to develop better questioning skills so that I could help students move towards the learning goals I had set for them without giving them the answers. And as I learned, I was able to share more with my colleagues, and give more to my students.

Teachers rightfully point out that this style of instruction requires a significant investment of time and energy in a teaching climate that already has us stressed to near breaking. Most packaged curriculum series don't incorporate twenty-first-century skills, so a lot of lesson development has to occur before the curriculum is ready for students.

The need for digital-age literacy also brings a new dimension to teaching and learning, providing impetus for creating more learning opportunities with interactive communication and the use of technological tools.

Assessment of these skills adds an additional challenge: in particular, traditional assessment methods are ineffective for many of those skills. With these hurdles in mind, it is clear that districts need to provide teachers and schools with some kind of help.

As I learned, I was able to share more with my colleagues, and give more to my students.

Teacher support is crucial

Teachers need support in learning how to use and teach both new tools and software. Ideally, a master teacher with technology skills and experience should be available at each school to provide "just-in-time" training and support. Research has shown that professional development is most effective when it is provided in an ongoing, as-needed, when-needed basis.

My district has answered this need through the creation of Curriculum and Technology Integration specialists (CTIs) at each site, and that is my role this year. In this role I provide immediate professional development on curriculum and technology integration for teachers during the lesson and unit planning stages, and am available to go into other teachers' classrooms to model how to teach within a twenty-first-century learning framework. I

Numerous small changes over time will result in manageable and significant change.

also serve as a facilitator, encouraging teachers to share and collaborate as they develop their own skills and confidence, and work with my administrators to help identify and develop other site-based leaders, providing teachers with an opportunity to learn from and support each other.

It is important to make the distinction that I am not a computer technician. I don't install software, fix computers, or manage a network, though helping teachers learn to troubleshoot is also a regular part of my day. My sole responsibility involves helping teachers implement the twenty-first-century framework into the core academic curriculum.

Challenges to overcome

Time is also a significant issue, particularly as planning time has begun to shrink in many districts due to budgetary constraints while class sizes have grown. This need is being addressed in my district by educating teachers, administrators, and the public that the migration to a twenty-first-century learning environment will not happen overnight, and is indeed evolving at such a rate that we will never be satisfied with where we are.

New tools and software are generally introduced at staff meetings, where an hour might be spent exploring and learning about the tool. We also spend a small portion (10–15 minutes) of our regular early-release time in staff development, either sharing what someone has done that worked or in learning a specific skill that could be useful to everyone. During these times, teachers are reminded that huge, immediate changes are not expected, but that numerous small changes over time will result in manageable and significant change.

My position also allows teachers the opportunity to schedule individual and small-group development opportunities on their own time with me—and this occurs during individual plans, lunch hours, or after school on an as-needed basis. As teachers have realized that it's okay to not "do it all," they've become more comfortable, less stressed, and more successful at integrating twenty-first-century skills into their classroom environments.

Finally, there is the infrastructural support required for any kind of technological push. Teachers and students need access to computers, software, and networks. Projection units, interactive white boards, student response systems, and probeware are all part of the twenty-first-century learning environment.

There is a significant cost associated with all of these, and acquiring funding can be challenging. We are lucky in that we have a very supportive community and an active district foundation, which supported recent technology bond initiatives that have provided the district with the financial means to implement technological changes district wide.

Every teacher now has a laptop, a projection unit, and speakers in the classroom. Teachers who opted for additional training over the summer were given SmartBoards for use in their classrooms. All schools in the district received several sets of student response systems that can be shared by teachers. Laptops for students are bundled onto COWs (Computers on Wheels) that both charge the laptops and allow them to be easily moved from room to room, improving the ease of access to technology that was among the most common roadblock in years past.

In the coming year, the district will be using those bond funds to increase the bandwidth and networking capabilities at all the schools. We also have strong and active family faculty organizations that have stepped up with software and peripheral purchases, such as headsets and digital cameras, which were not provided by the district. It has truly been a community effort.

As we move forward we are constantly asking ourselves what can we do that is in the best interest of our students. Children today live in a rapidly changing and interconnected world, and the teaching methods of the previous century do not always meet their needs. Clearly, implementing a twenty-first-century framework has many challenges, but the results we are seeing from our students, and the feedback we are getting from our community, are encouraging us to continue the effort.

Wayne Thornes has taught middle school mathematics for sixteen years. This year he is working as a Curriculum and Technology Integration Specialist and is splitting his time between two elementary schools: Canyon View and Ventana Vista, both a part of the Catalina Foothills School District in Tucson, Arizona.

Teaching in Any Century

by Heather Taylor

In the fields of math, science, and technology education, the phrase "twenty-first-century skills" has gotten a lot of attention. The need for promoting such a skill set is expressed by many, not least among them, the White House:

> President Obama will reform America's public schools to deliver a 21st Century education that will prepare all children for success in the new global workplace. . . . all Americans should be prepared to enroll in at least one year of higher education or job training to better prepare our workforce for a 21st century economy.[1]

A more concrete sense of urgency is expressed by Jo Boaler in her 2008 book, *What's Math Got to Do with It?* She writes, "American students do not achieve well and they do not choose to study mathematics beyond basic courses, a situation that presents serious risks to the future medical, scientific, and technological advancement of society . . . the advent of new technologies means that all adults now need to be able to reason mathematically in order to work and live in today's society."[2]

In fact, it was due in large part to Professor Boaler's compelling arguments in the introduction of her book that ***Connect*** chose the topic of this issue. The results of the Third International Mathematics and Science Study (TIMMS) certainly seem to echo the idea that the U.S. is not at the top of the list when it comes to math and science abilities: "At the end of secondary schooling . . . U.S. performance was among the lowest in both science and mathematics, including among our most advanced students."[3]

Addressing these concerns seems like a responsible, forward-looking action: we need to figure out how to help our children learn better so they can become informed, active citizens, maintain meaningful employment, and be adequately equipped to deal with the problems of the future. Enter the Twenty-First-Century Skills movement. Like most initiatives in education, however, it is not without controversy.

The movement to meet these needs has picked up speed in the last three years, especially perhaps because of the work of the Partnership for 21st Century Skills (P21), a diverse group of business leaders, technology corporations and education companies, based in Tucson, Arizona. They have partnered with sixteen states to create a framework for use in schools, one that will work with twenty-first-century skills as the core.

What are twenty-first-century skills?

There are four main areas on which various groups tend to agree when defining this skill set.[4]

One relates to *technology*, meaning *digital literacy*: being able to operate devices such as data-gathering probes, use software that assists with data analysis, and communicate and conduct research using the newest technologies available.

Another aspect has to do with *creativity*: fostering thinking outside the box, problem solving, imagination, and entrepreneurship.

The *core skills* comprise another branch: math, language, the sciences, history, the arts.

The last component is *cooperation*: working in groups, communicating effectively, understanding team dynamics, etc. Some groups incorporate *productivity* as its own category.

Surely in surveying the history of education, none of these ideas is new, although the specific technologies have changed since the time of the Greeks, the progressive constructivists of the 1920s, and even the "open plan" movement of the 1970s. This point has prompted criticism

An emphasis on global competition, critics argue, creates an atmosphere in which only one entity is the "winner."

of the Twenty-First-Century Skills movement from many, including Diane Ravitch, a Research Professor of Education at New York University. In September of 2008, she posted online:

> The notion of "21st century skills" is a fiction. There are no such skills. Every single skill listed as a "21st century skill" has been in demand long before the 21st century, in some cases for many centuries. Most of what is now proposed—whether critical thinking skills or working in groups—has been an integral part of the progressive education movement since the early years of the twentieth century.[5]

Digital literacy is one of the prime goals of twenty-first-century learning.

Diane Ravitch is also co-chair of the Washington, D.C.–based group Common Core. Common Core believes that recent pressures to leave no children behind and prepare them for the future have meant that teachers and schools are in effect abandoning the core curricula of liberal arts and sciences. The only way to create truly able learners is to continue to expect students to retain a certain amount of content learning.[6] Without a firm base in history, language, and cultural studies, all the fastest high-speed Internet access in the world won't mean clear global communication.

Common Core and other highly vocal groups have raised concerns that the Twenty-First-Century Skills movement is motivated more by economists and the business world than by education. *Education Week* recently published an article that examines controversy regarding the relationships of P21 with E-Luminate,[7] a company specializing in software and marketing communications that has received about half of P21's spending on professional development affiliates. Ken Kay is the president of P21 and the CEO and co-founder of E-Luminate. Does this connection alone imply a conflict of interest, or shady dealings? Are we being duped by the corporate sector to churn out workers that will benefit their bottom line, at the cost of providing excellent, meaningful education to our students?

I asked David Sobel, Director of Certification Programs at Antioch New England's Education program, what he thought of the criticism that the framework seemed to have received more input from economists and the business sector than from educators. "My experience is that much of corporate America is more innovative and learner-centered than the education community, so this doesn't bother me." At first this comment surprised me, but it seems to point out the key to the parts of the movement that are working well: taking innovative ideas from other systems (the business world) and applying them, with teacher input, to reorganizing programs and learning. Antioch New England has been teaching curriculum similar to much of the twenty-first-century skills framework for the last two decades, calling it "Critical Skills." Their program was also developed with input from business leaders who described a lack of creativity and collaboration in recent graduates.

Another angle of criticism comes in response to the expressed need for the U.S. to be number one in education. An emphasis on global competition, critics argue, creates an atmosphere in which only one entity is the "winner," and others either ranked in descending order or classified as "losers." The misplaced focus on competition distracts us from considering how to improve education and opportunities for children everywhere.

The presence of so much criticism raises the question of whether twenty-first-century skills are worthy of our attention. Is it worth trying to come up with a new framework in which to fit all that teachers are already struggling to fit into the school day?

The skills in action

I noticed when doing a search about twenty-first-century skills that one school district's name kept coming up. Their carefully thought-out and clearly presented Web pages seemed to do the best job of outlining what these skills are. I spoke with Mary Jo Conery, their Assistant Superintendent for 21st Century Learning.

It is clear that Catalina Foothills School District (CFSD), also in Tucson, Arizona, has a powerful desire to do the best they can for their students. In contrast to the criticism of twenty-first century skills being a global economic competition, however, CFSD's striving for excellence does not seem based on being

"better *than*" anyone—it seems appropriately geared toward doing their very best for the children in their district.

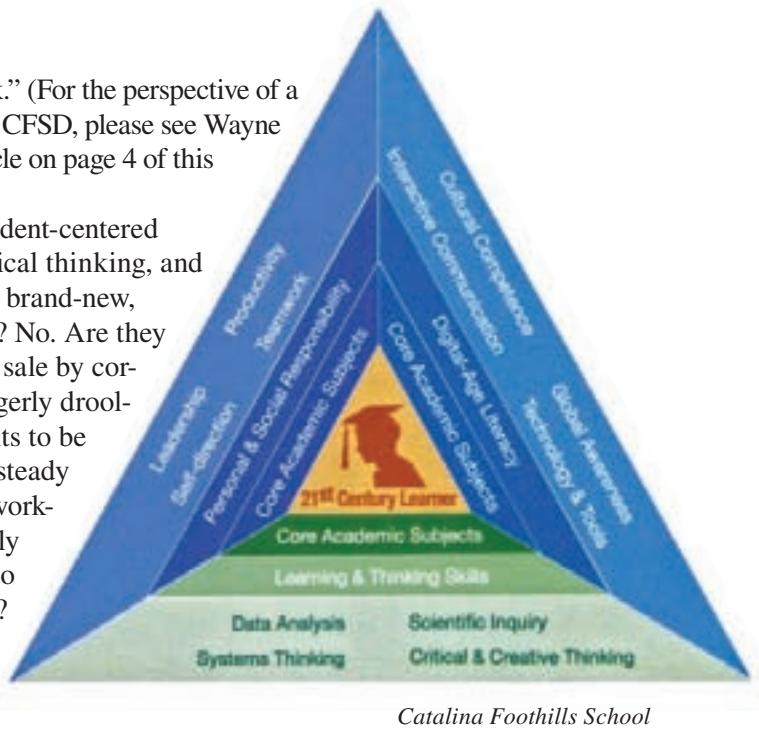
CFSD used the P21 Framework as a guide to develop their own local framework based on community input. They have been working closely with P21 for the last three years through a local P21 group of school districts that are implementing twenty-first-century skills, keeping them abreast of their curriculum overhaul.

Ms. Conery states, "We created a CFSD Advisory Group on twenty-first-century skills that included local CEOs, university and community college staff, parents, community members, high school students, teachers, and administrators. The Partnership did an overview of the P21 model and participated in the group to select the specific skills for CFSD. The district asked the advisory group, 'What are the skills our students will need to thrive in the twenty-first century?'"

As a result of that work, CFSD has redesigned the standards in four major content areas, embedding specific skills into the actual curriculum, so as not to burden teachers with another layer on top of what they are already doing. The framework is integrated into the curriculum every day.

The district makes every effort to support teachers in the transition to adopting the new standards. Teachers are provided with in-service time and technical support, for instance. However, Ms. Conery says, "Implementing the P21 Framework isn't about adding a skill here and there. They must be deeply embedded in our daily work with students. They are not a magic bullet. This is really hard, complex work." (For the perspective of a teacher in the CFSD, please see Wayne Thornes' article on page 4 of this issue.)

So, are student-centered learning, critical thinking, and collaboration brand-new, unique skills? No. Are they packaged for sale by corporations, eagerly drooling over profits to be made by the steady new trail of workers, adequately prepared to do their bidding? Perhaps. It is difficult to make an accurate generalization, especially about the motivations of large entities rather than distinct personalities. Will these skills contribute to the loss of core curriculum? Nowhere in the literature of either P21 or CFSD did I find ideas to support that, or even the leaving behind of content in favor of process. They seem to advocate a balanced emphasis.



Catalina Foothills School District's diagram of their twenty-first-century skills framework

I think the most troubling aspect of the publicity about twenty-first-century skills is the emphasis on being "number one" and the idea that we are competing in a global economy. When that alone becomes the impetus for creating curriculum and establishing the needs of children, then I find I agree with Alfie Kohn, who writes: "Education ought to aim higher. Our loyalty, after all, is not to corporations but to children. Our chief concern—our 'bottom line,' if you must—is not victory for some but learning for all."[8]

Before becoming the editor of **Connect**, *Heather Taylor taught K–2 multi-age classes in southeastern Vermont.*

1. http://www.whitehouse.gov/issues/education.

2. Jo Boaler, *What's Math Got to Do with It?* (Viking, 2008), 3–4.

3. National Center for Education Statistics, "Highlights from TIMMS: Overview and Key Findings across Grade Levels," http://nces.ed.gov/pubs99/1999081.pdf.

4. Generalized from material of Partnership for 21st Century Skills, http://www.21stcenturyskills.org, and NCREL, the North Central Regional Educational Laboratory, http://www.learningpt.org.

5. Diane Ravitch, responding to comments on the National Journal Expert Blogs: Education, "Has the P21 Movement Succeeded?" September 8, 2009, http://education.nationaljournal.com/2009/09/has-the-21stcentury-skills-mov.php#1352513. Note that *CommonCore.org*, referred to here, a Washington, D.C., non-profit, is distinct from the newer effort, *The Common Core State Standards Initiative*. The latter is a fourty-nine-state effort coordinated by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO).

6. http://www.commoncore.org/wwd.php.

7. Stephen Sawchuk, "Motives of 21st-Century-Skills Group Questioned," *Education Week*, December 9, 2009, http://www.edweek.org.

8. Alfie Kohn, "Against Competitiveness," *Education Week*, September 19, 2007, http://www.alfiekohn.org/teaching/edweek/competitiveness.htm.

The Threshold of Technology

By Dwain Hammett

We need to maintain a balance that nurtures critical thinking while developing an adeptness in working with our hands.

The middle school level class I teach at the South Meadow School in Peterborough, New Hampshire, is called Integrated Art and Technology. It's basically a creative approach to what most adults would traditionally remember as Industrial Arts or Wood Tech. In my course, the students are presented with a variety of challenges in which they must apply basic engineering principles to problem solve using their hands, brains, and materials.

When the students first enter the classroom, you can see the excitement on their faces. It's not like any other classroom that most of them have experienced. We have a whole selection of power and hand tools, workbenches, and stools instead of chairs.

Defining the work

I initially ask the students what they think Integrated Art and Technology (IAT) means. We break the name down. Integrate: combining more than one thing. Art: creating something of beauty. The "Art" part of IAT refers to the creative process. Technology: This is where it gets interesting—students immediately raise their hands and say, "computers." Of course, they have been submerged in a world of electronic devices since they were really young.

I then hold up a pencil and say, "If you handed one of these to a person 450 years ago, they would be puzzled at first. After fiddling around with it for a bit, they would probably be delighted by what this nifty little device can do. Many years before that, *the wheel* was an exciting development or discovery in technology."

The students seem to find all this amusing. So much is taken for granted in this age of technology, by virtue of all the technological conveniences that have evolved. But we need to maintain a balance that nurtures basic critical thinking skills while developing an increased adeptness in doing the kind of work with our hands that has gotten us this far.

In my class, students physically apply their ideas as they approach a challenge. Included in our sixth-grade problem solving projects in IAT is a packaging unit, in which the challenge is to create a container from found materials that will protect an egg from a twenty-foot drop. We also build kites and bridges. These projects have been around for years. This corroborates the point that learning to problem solve far pre-dated the computer, withstanding the test of time with integrity and effectiveness just as the bridges that we cross every day.

When designing their projects, my students often ask, "Is it going to work?" I just reply, "I don't know, because there is more than one answer to this problem. I guess we'll find out." Obviously, if the egg survives, the kite flies, or the bridge doesn't break, they have successfully accomplished the challenge.

For some of these projects, we follow up with a written assessment in which the students answer the questions, "What materials did you use? Why? What would you do differently if we did this project again?" I explain that even if their project "fails" we always learn something from unsuccessful outcomes.

During the egg packaging and bridge building units, I incorporate math by keeping a tally of the survival or success rate for each class (each class works as a team). After all the testing is done, I figure out the percentage of successful projects algebraically on the board:

Example: 13 out of 22 survived

$$\frac{13}{22} = \frac{x}{100}$$

cross multiply

$$22x = 1{,}300$$

divide both sides by 22

$$x = \frac{1{,}300}{22}$$

$$x = 59.09\% \text{ success}$$

It's a little disturbing that almost every time I do this "old math" formula in front of the class, usually a student will say, "Why don't you just use a calculator?" (Argh!) This is an example of how things have culturally evolved in modern society with technology. My grandparents would have added a column of numbers with a paper and pencil and maybe checked it using the same tools. My parents' and my own generation would perhaps figure the problem with pencil on paper but then check it with a calculator. Now, there seems to be a "why bother" attitude that jumps to "just use a calculator!" The basic skills are still taught, but our emphasis on thinking skills to decipher problems may be lagging. I think we are becoming overly dependent on these electronic devices, or at the very least, we have reached a threshold. But, enough of the soapbox talk.

Team challenges

Friendly competition between the classes promotes the students' enthusiasm. If they don't devote their full effort to the project, they handicap their class's ability to have a higher success rate. The various layers of these challenges keeps the projects fun. If the students are having fun, they will like going to school! If they like going to school, they will be more invested and successful.

Students also have the opportunity to build small wooden projects and work with both hand tools and power tools such as the band saw, drill press, and the stationary belt sander. Most of the students have never had the opportunity to work with these tools and are often intimidated and a little nervous. I work with them individually. Once they get past their fear, self-confidence grows and a great sense of pride develops with their accomplishment when a project is successfully completed. They leave with a tangible product that represents their effort.

Seventh graders build a miniature solar car during the spring of the year in IAT. This has proven to be a great culminating project for the students' IAT experience. There are several dynamic learning opportunities that encompass basic engineering principles using science and mathematical concepts while creatively solving problems.

Solar racers and the larger world

First, the students have the challenge to build a structure that will be structurally sound, yet light. The structure must support the weight of a motor, the miniature solar panel, and a cargo of an empty soda can (as an added challenge). They must address wheel alignment to reduce friction. They explore the concept of gear ratios and how this will affect the transfer of power from the motor to the drive axle. Basic electrical theory is discussed as we learn about how the direction of the current will effect the direction in which the motor turns, as well as how the silicon cells in the solar panel turns sunlight into electricity. Most

The structure must support the weight of a motor, the miniature solar panel, and cargo.

New Hampshire Chronicle, a television program on WMUR, featured South Meadow School recently.

significantly, we discuss the importance of solar energy as a renewable resource while we currently work as a society to move away from fossil fuels.

To relate energy consumption to the world around us, I bring in a copy of my electric bill that shows the energy usage for the past year as a bar chart. I have the students find the mean, median, and mode for the twelve-month period displayed on the bar chart. With this data, we discuss why certain months had greater or lesser kilowatt usage. This brings reality to the project by connecting it to a real world example. We discuss the benefit to our world if alternative energy were the main source of our power and how the environment would be improved by reducing pollution.

Eventually, several groups will be selected to compete against other schools in a competitive event called the Junior Solar Sprint. The winners of the regional competition will have the opportunity to compete in the Northeast Championship where students representing schools from other states will attend.

Dwain Hammett has been teaching Integrated Art and Technology to sixth- and seventh-grade students at the South Meadow School, a public middle school in Peterborough, New Hampshire, since the fall of 2000. Prior to teaching IAT, Dwain taught art and music at the elementary level and worked in a variety of trades.

The author and his class, in a photo signed by President Obama

Electronic technology

I know I've been a little hard on modern technology with my ramblings. Please don't get me wrong, I enjoy computers, all the devices that make our lives easier, and the merits they offer to society. However, these devices are only tools. As part of the statewide technology requirements, I too need to schedule my classes on occasion in the computer lab for projects to keep in line with our school-wide technology curriculum requirements.

One computer program I work with is iMovie HD, where the students learn digital movie editing. To combine this with my IAT curriculum and keep in line with state standards, I have the students make a "safety film." The content of the footage reinforces these concepts by having the students act out skits that demonstrate safe practices in the IAT room as well as examples of following classroom rules. The students are engaged with the projects because they are having fun working with footage of themselves and/or their friends. At the same time, they are learning the tools of the program and being creative.

Where the students are so hungry for this kind of experience, it is unfortunate that there is a trend in some districts to replace hands-on work with "canned" programs, where the students primarily go from one module to another to explore problem-solving virtually, on a computer. I certainly hope these virtual programs are followed up by an applied physical experience.

When an individual works with their hands, he or she gets a sense confidence, of feeling capable. When people feel capable, they learn to trust themselves. When they trust themselves, they'll be empowered and have the confidence to take risks. The experience of working with one's hands can transfer metaphorically to other avenues of life.

I am fortunate to work at a school with a supportive administrator and a high quality group of colleagues. You can get a better idea of the big picture at the South Meadow School by going to the link of the recent *New Hampshire Chronicle* profile at the top of this page.

"Doing the Math" in Geography

by Steven Branting

The quest for integrated curriculum can bedevil even the most proficient teacher. What seems imperative to one discipline may barely ruffle the pages in another. Nurtured by *No Child Left Behind*, an academic culture has emerged steeped in objective testing that too often marginalizes conceptual learning and isolates disciplines, setting up stumbling blocks to communal activities at the secondary level. Historically, geography and mathematics shared many common, reinforced tenets and protocols: scale, projection, Cartesian coordinates, and the calculation of latitude and longitude, to name but a few. However, the popularization of the Global Positioning System, or GPS, in the early 1990's exacerbated a developing and unfortunate disconnect for most students and teachers. Geography retreated and math drew in upon itself, each living parallel but sadly different lives.

Geography has spiraled into a precipitous decline as an easily dismissed curriculum. In Idaho, for example, social science majors are not required to take any geography courses prior to earning a teaching degree. Recent surveys are exposing a complacent, widespread geographic ignorance among young Americans, whose mental maps are often flawed.

Gathering data

Let us explore a collaboration of algebra and measurement, statistics and demographics, and geometry and cartography. This is possible using geographic information systems (GIS), promoted by ESRI, the leading developer of GIS software, as a means to "view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts." A GIS map image consists of many layers of simultaneous information, all of which are constructed from volumes of digital data, primarily numeric. Every point, line, and polygon is geo-referenced, meaning they are tied to coordinates, such as latitude and longitude.

The visual component of GIS is backed up by attribute tables that may remind one of spreadsheets, only these are filled with *metadata*. The United States Geological Survey describes metadata as answering the "who, what, when, where, why, and how about every facet of the data that are being documented." One can readily begin to see the mathematical possibilities, of which the following are only a meager sampling.

First, consider the comparatively easy task of measuring distance. In geometric

The popularization of the GPS exacerbated a developing and unfortunate disconnect for most students and teachers.

Figure 1

Figure 2

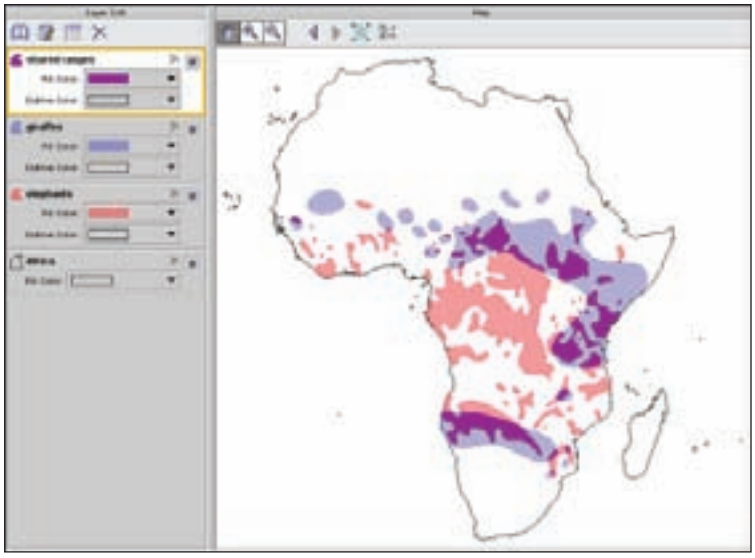


Figure 3

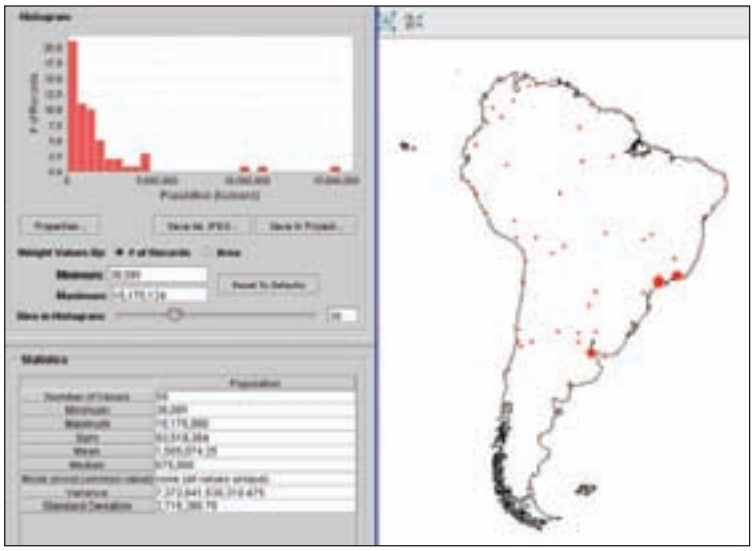


Figure 4

terms, paper maps are a two-dimensional representation of a three-dimensional, curved surface. Even in the open ocean, the horizon is a mere three miles away when standing on the deck of a boat one meter above the water. GIS adjusts for the curvature of the Earth, as in these examples.[1] In *Figure 1* (a Miller Cylindrical projection), the distance between Los Angeles and New York City is 2,465 miles. The path is curved to demonstrate the shape of the Earth. In *Figure 2* (an Orthographic projection), the distance is the same, but the path is now straight because the projection is spherical. The software can measure in kilometers, meters, miles, yards, feet, or nautical miles. Try *that* with a ruler.

A spatial science

The mathematical power of GIS clearly emerges in its capacity for spatial analysis, whereby the software probes the data in terms of its geographic, geometric, and topological properties. This primary tool includes various set theory functions. In *Figure 3*, I have created a shared habitat range map for African elephants and giraffes. I used a Robinson projection, which was for many years the most popular representation found in textbooks. Math teachers will recognize this map as an intersection of two sets. Other functions available are union, subtraction, distance, crossing, and containment—all processes that are simple with small number sets but extremely arduous with the masses of geographic data that studying even a small region can generate.

Large collections of data pose tangible problems for students. GIS manages that data immediately. In *Figure 4*, I have cut from a data layer about world cities to fit the South American continent in a Mercator projection. That new layer has been disaggregated into a histogram, with thirty "bins" (categories based on population). The student mapmaker now has a wide range of statistical information telling him or her that South America's city population data is skewed by three megacities: Buenos Aires, Rio de Janeiro, and Sao Paulo. GIS reveals its true identity as a *spatial science.*

Learning from data

In discussions about population and race, it became clear that students had a misconception that urban areas and Southern states had a higher percentage of African-American residents. We investigated this question while learning about scatter plots. A scatter plot provides a graphical display of the relationship between two variables. The vast array of data available from the U.S. census is a fertile field for teaching the concepts of correlation and distribution. A correlation between the variables results in the clustering of data points along a "best fit" line. In *Figure 5*, a scat-

ter plot has been created from the census comparing the population ages twenty-five to thirty-four against the African-American population.[2] The reader will notice that the correlation is relatively low: .7982. When a scatter plot shows an association between two variables, a cause-and-effect relationship is not necessarily the answer. Both variables could be related to some third variable that explains the graph. There could well be some other factor. What do we learn? A majority of states lie below the correlation line. Comprising 14.7% of the total population, twenty-five- to thirty-four-year-old African Americans are dispersed unevenly across the country, with few large concentrations outside major cities and some states in the South.

The term "buffer" is used for a wide variety of scientific, computer, and mathematics applications. In GIS, it can function as a range setting for map features within a specific constraining descriptor. For example, if we wanted to know the statistical data for cities located within ten miles of the Columbia River, the resulting map would look like *Figure 6*, which is set to a Washington South projection, as the river forms most of the border between Washington and Oregon. The region is a major agricultural center that has developed a thriving Hispanic community. The software identifies seventeen cities, and a histogram/statistics table has been created to show the distribution of residents in those cities, with the largest Hispanic population living in the Portland, Oregon/Vancouver, Washington, metropolitan area.

In 2006 a report from the National Research Council stressed the importance of spatial thinking in everyone's life and recommended embedding spatial thinking across the K–12 curriculum. According to the Council's findings, GIS technology can confidently play a powerful role in promoting spatial thinking.[3] Unfortunately, spatial education has proven to be a uniformly neglected topic in America's schools, much as is creative problem-solving.[4] GIS has forged the connections; its architects have fashioned the tools. "Those who say it can't be done," wrote novelist James Baldwin, "are usually interrupted by those doing it." Schools embracing GIS have honed their axes and are setting to work.

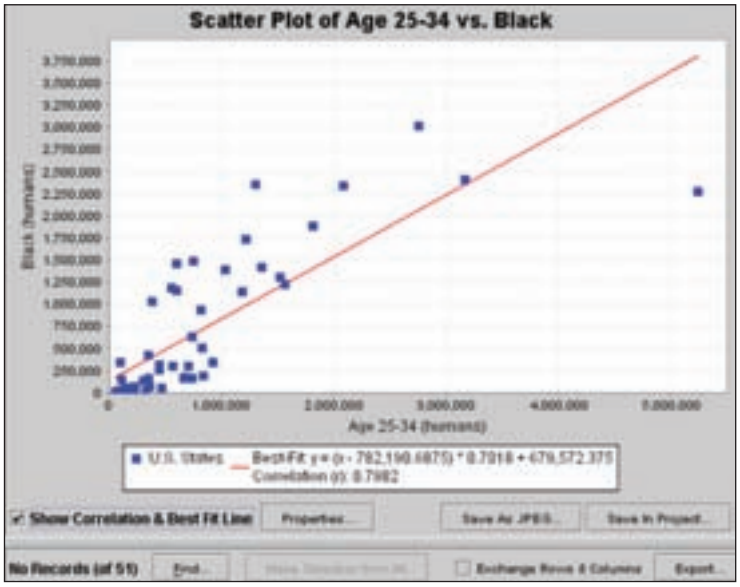


Figure 5

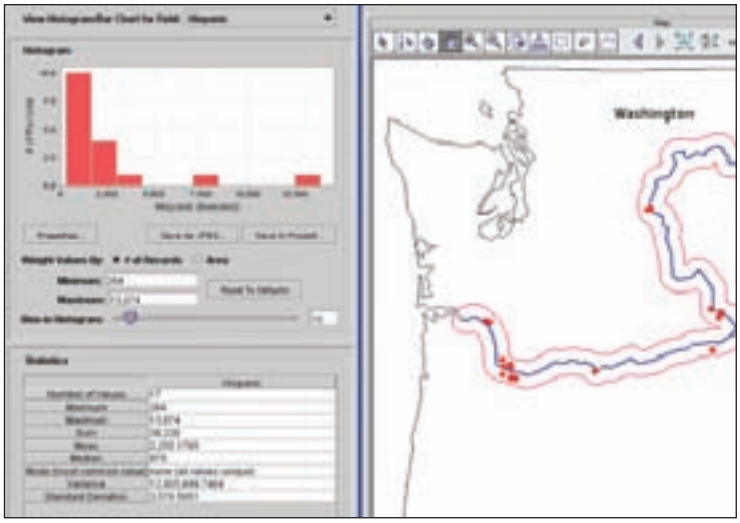


Figure 6

1. Images in this article were created using *My World*, developed by Northwestern University specifically for middle school classrooms. ArcView 9.3 (ESRI) is recommended for high school settings, as it provides a school-to-work link with the GIS professional community.

2. U.S. Census Bureau, "Facts for Features: Black History Month, February 2009," http://www.census.gov/Press-Release/www/releases/archives/facts_for_features_special_editions/013007.html.

3. Roper Public Affairs, "National Geographic-Roper Public Affairs 2006 Literacy Study" (Washington, DC: National Geographic Education Foundation, 2006), http://www.nationalgeographic.com/roper2006/findings.html.

4. Daniel L. Shea, David Lubinski, and Camilla P. Benfow, "Importance of Assessing Spatial Ability in Talented Young Adolescents: a 20-Year Longitudinal Study," *Journal of Educational Psychology*, 93 (3), 604-614.

Steven Branting's work in archaeology, geography, engineering, and history has been honored by The History Channel, the Association of American Geographers, the Society for American Archaeology, and the American Association for State and Local History. His article, "Not Your Father's History Lesson: Idaho Students Solve a Necrogeographic Mystery" (Western Historical Review, XXXVIII, 2, Summer 2007, pp. 205–214), has been nominated for the American Historical Association's William Gilbert Award. Mr. Branting retired in 2009 after 33 years as a consultant for gifted and innovative programs.

Is It Real Science, or Only a Model?

by

BOB COULTER

As we search for ways to make our students' learning experiences "real," it is increasingly hard to avoid the use of computer technology. Aside from the ways that computers can help with organizing, managing, and analyzing data, they are increasingly finding their way into the core practices of what it means to do science. Think of recent science news you've heard and this becomes clear: Climate change, disease, and other topics rely heavily on models to better understand the underlying phenomena. By modeling these situations, scientists can explore what factors have the greatest influence and which interventions are most likely to be effective. This basis in modeling is also at the root of why different scientists get different results: If you change the variables considered or the ways they interact in the model, you will get different results.

In some ways technology extends existing science, sometimes in transformative ways. For example, models of ecosystems draw on sophisticated computations that can account for a broad range of variables. This allows scientists a nuanced view of how variations in populations of prey and predator species as well as a range of other factors influence the health of an ecosystem.

Other fields have essentially come into being because of the technological capacities we now enjoy. Models of climate change and disease transmission simply didn't exist in a meaningful way before appropriate tools were available. When John Snow mapped cholera in the 1800's, it was simply descriptive—powerful for its time, but limited to describing past events instead of projecting into the future.

In recognition of this expanding role for computers in the practice of science, some are starting to argue that we need to recognize computer-based science as a core element of the discipline. In addition to the experimental science found in the lab and theoretical work that underlies some aspects of physics and astronomy, there is growing interest in how models and simulations give a third way into doing science. For the balance of this column, I'll be considering how students can do this in age-appropriate ways, giving them a new vision of what science really involves. Examples are drawn from my work with kids and what others have done, framed by the "Six Strands of Science Learning" recently promulgated by the National Research Council in their *Learning Science in Informal Environments*.

Sparking and developing interest and excitement

By building and manipulating models, your students can test "what if" scenarios. What if we planted new trees: How much would that help the environment? CITYgreen from American Forests can help you model different scenarios. What if a sick student comes to school—can the whole class become infected? StarLogo models let you see how quickly this can happen. Instead of memorizing and repeating factual statements like "Trees are good for the environment," your classroom comes alive as teams of students explore different scenarios, look for results, and debate the outcomes.

Understanding scientific knowledge

Building on the interest and excitement students gain when they can take an active part in learning, they are also learning specific content framed within an authentic investigation. Seeing how each concept relates to others builds a conceptual network that gives your stu-

Bob Coulter is the director of Mapping the Environment, a program at the Missouri Botanical Garden's Litzsinger Road Ecology Center that supports teachers' efforts to enhance their science curriculum through use of the Internet and Geographic Information Systems (GIS) software. Previously, Bob taught elementary grades for twelve years.
bob.coulter@mobot.org

dents usable scientific knowledge that can be applied more readily to new situations. For the tree modeling project, students in our after-school program had to measure a number of key factors such as each tree's species, size, health, and growing condition, as each had a bearing on its environmental impact. Similarly, a StarLogo model of a garden can factor in growth rates and limiting factors such as soil quality and precipitation. In each case, useful knowledge is seen as the integration of related facts, not a collection to be stored for recall.

Engaging in scientific explanation and argument

By comparing and contrasting the results of different models, your class becomes a community of practice, engaging in debates about the models themselves and what it means practically. How accurate is each model? Are there important factors not being considered? As student teams explore prey-predator relationships in Stella, they can debate the practical impact of a species going extinct. Does it matter for our local ecosystem?

Understanding the scientific enterprise

As noted above, computationally-based science is a new and rapidly expanding aspect of doing science. Even if we put aside "science" classes that are really just reading about science, there are still too many classrooms that have some activities happening but are mired in a rigid view of science as being the "five steps" of the scientific method—working with models and simulations is one option for moving forward.

Engaging in scientific practices using the tools and language of science

As your students work with authentic science tools like models and simulations, they will be called on to use the language of science, both in the processes (looking at measurement and variables, for example) and in the specific content being explored (such as the impact of soil quality and precipitation in a plant growth model).

Identifying with the scientific enterprise

Looking back to the interest and excitement that modeling encourages, students can see science as an exciting and dynamic field, perhaps even one that they want to pursue further. Given documented drops in science interest as students get older, upper elementary and middle school kids need all the support we can give them to build their science identity. Only some will pursue a career as a scientist, but many fields require at least a passing understanding, and everyone needs science to be an informed citizen. "I'm not a science person" simply doesn't work in the twenty-first century.

A century ago, John Dewey suggested that one of the fundamental challenges of science education is that science itself was too new to the subsoil of the human mind. While we have come a long way in building a science-based culture, the new horizon of computationally-based science remains before us. We need to move confidently forward, giving our students the chance to see the science of their future.

Places to start with models and simulations

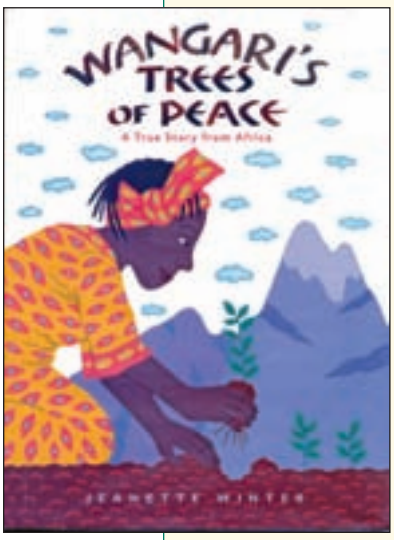
There are some good modeling tools available for schools, such as CITYgreen from American Forests (http://www.americanforests.org). You may also find modeling tool kits like Star Logo (http://education.mit.edu) or Stella (http://www.iseesytems.com) helpful, as they allow students to actually create their models once they have gained experience with some examples that come with the software. A third avenue to consider is to work with your students to critique models implicit in the resources you already use. Several years ago my class of fourth graders had a very thoughtful critique of the underlying model of the Oregon Trail game, both in its treatment of native people and its allowance of hunting well past what a person needed with little in the way of ecological consequences.

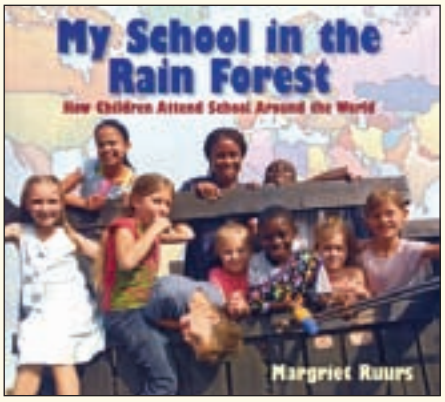
Literature Links

Here are books that emphasize creativity, collaboration, invention, and global awareness, just a few of the many important skills for students today.

Girls Think of Everything, by Catherine Thimmesh (Houghton Mifflin, 2000), is a wonderful collection of stories about inventions created by women and girls. From Kevlar to Tollhouse cookies, baby carriers to "space bumpers" (shields against flying space debris), we have women to thank for their brilliant contributions. Each short chapter is a narrative outlining the need seen by the inventor, a synopsis of her process (including frustrations), and historic details. Why suggest a book focused exclusively on women and girls? Until as recently as the early 1800s, it wasn't legal for women to own a patent in their own name. In a more recent picture book about inventors, covering a 600-year span of time portraying over forty inventors, only *two* women are mentioned. Unfortunately, this kind of oversight is still typical. One way to prepare our students for the twenty-first century is to give them role models. Girls need to see lots of examples of women who think of themselves as mathematicians and scientists, and women choosing math and science as careers. The stories in this book are good read-alouds for students in first grade and up, or independent material for older elementary students.

Wangari's Trees of Peace: A True Story from Africa, by Jeanette Winter (Harcourt, Inc., 2008), tells the story of Wengari Maathai, the Kenyan environmentalist, activist, and winner of the Nobel Peace Prize for her work in the greening of her homeland. 30 million trees now stand where there were none. Maathai's simple acts and ability to mobilize thousands of women to plant tree seedlings provided an environmental solution to many problems: lack of fire wood, poor soil, erosion, and lack of clean drinking water. Here is a beautiful example of employing twenty-first-century skills to have a global impact, yet using simple technology. The book includes brief description of Maathai being beaten and jailed, but it is still a fine biography for ages six through twelve. Illustrations by the author communicate the cultural flavor of Kenya.





My School in the Rain Forest, by Margriet Ruurs (Boyds Mills Press, 2009), is a non-fiction book that features children in school throughout the world. Readers meet a student who has fled religious persecution in the Sudan learning online from teachers thousands of miles away. Students in India sit on the ground in the jungle with an occasional chicken or cow wandering through. In Scotland we read about a boy who boards with 300 others in a school founded over 175 years ago. Aspects of life for the children outside of school are also described. Each nation's flag is shown and simple maps show where in the world each child lives. This is an attractive and informative group of photo essays that will help broaden perspectives of life and school around the planet. The text can be read aloud to younger students and enjoyed independently by students through age fourteen.

The Boy Who Invented TV: The Story of Philo Farnsworth, by Kathleen Krull (Alfred A. Knopf, 2009), is a wonderfully written biography of the man who invented television. Philo was born in Utah in 1906, and from a

young age was interested in mechanics and technology. The author describes what life was like in this era with simple, colloquial language that not only communicates information, but does so in a way that engages and compels the reader. She tells stories from a very human perspective. Readers learn that Philo raised sheep and played violin to raise money for his projects and that later his wife, described as the love of his life, learned to use a precision welder to help Philo build the prototype for the television. Philo's inspiration for breaking down, sending, and reassembling electrons into parallel bands of light came at age fourteen when he was plowing a potato field. The dream-like illustrations by Greg Couch help to set the tone of this intriguing book for seven- to twelve-year-olds.

All of the Above, by Shelley Pearsall (Little, Brown and Company, 2006), is an interesting young adult book that tells the story of a group of four reluctant, inner-city students on a journey to break the world's record for the biggest tetrahedron. Each chapter is told from one of seven characters' perspective. This format creates a dramatic effect. Based on a true story, intense interpersonal dynamics, portraits of low-income families, broken homes, and learning differences are featured. A fair amount of geometry and calculation is included as part of the plot. At one point, their nearly-finished project is destroyed—they must collaborate and decide together what will happen next. This is an unlikely but powerful example of twenty-first-century skills for students ages ten through fourteen.

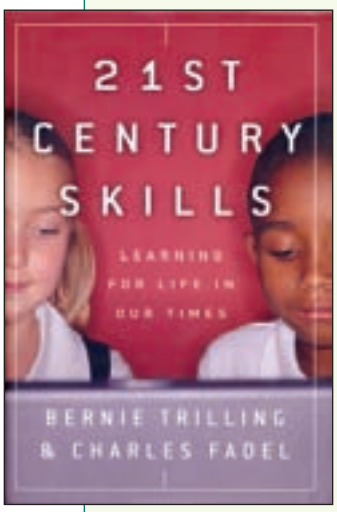
Manfish: A Story of Jacques Cousteau, by Jennifer Berne (Chronicle Books, 2008), is a uniquely styled book that relates the life, personality, accomplishments, and inventions of Jacques Cousteau. Curious from a young age, Jacques first fell in love with the ocean and then became captivated when someone gave him a pair of swim goggles that let him see clearly underwater. This book is well-suited for ages nine and older. Although overall the images in this book seem dark and opaque, the pairing of Eric Puybaret's artwork and the Pia typeface create a subdued and wonder-filled mood appropriate to the compelling and beautiful text. Jacques Cousteau contributed much to the world, from promoting conservation and education through the Cousteau Society, to inventing the aqualung; and his innovative spirit serves as inspiration to young learners.

Fantastic Undersea Life of Jacques Cousteau, by Dan Yaccarino (Alfred A. Knopf, 2009), is a book for younger children than the book described above. Bright pictures and few words make for an exciting and color-filled book. Quotes of Jacques Cousteau dot each page. The appeal for this book is in the playful and child-like appearance of it. Young students can picture themselves perhaps doing the things this inventor and scientist did. Both this title and ***Manfish*** include a timeline of Cousteau's life and resources such as The Cousteau Society, http://www.cousteau.org, and the numerous films and books Jacques Cousteau created during his life.

Listen to the Wind by Greg Mortenson and Susan L. Roth (Dial Books for Young Readers, 2009), tells the story of Dr. Greg Mortenson returning from an attempt to climb K2, weak and ill, and meeting a couple of men from Korphe. In gratitude he promises to help build a school for the children of their village in Pakistan. This is a picture book version of the story, *Three Cups of Tea* (a *New York Times* bestseller) written by Dr. Mortenson. Collages by Susan L. Roth using cut paper and cloth add vibrancy to this incredible story. The names of characters, depictions of the landscape, clothing, animals, and housing show a different way of life. At the end of the story is a scrapbook of pictures and captions that show the real people and places of the story. The organization Pennies for Peace, http://www.penniesforpeace.org is mentioned as a way that our students can help buy much-needed supplies for the children of Korphe.

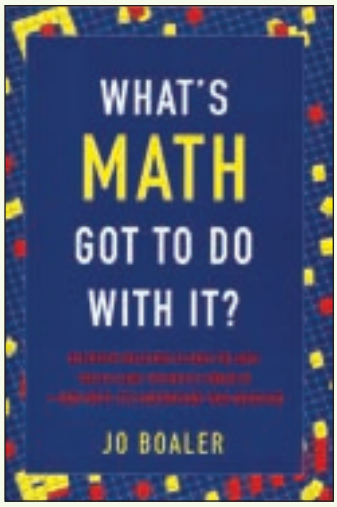
Resource Reviews

21st Century Skills: Learning for Life in Our Times, by Bernie Trilling and Charles Fadel, is a guide for parents, teachers, administrators, and policy makers for helping students succeed in school, work, and citizenship in this century. It offers insights for integrating core knowledge (math, science, language, history, etc.) with contemporary themes such as digital literacy, critical thinking, problem solving, leadership, and adaptability. The first part of the book examines a bit of educational history as well as future jobs and careers students may be moving into. It also looks at the converging pressures on education today and suggests strategies for coping with them. Part 2 describes 21st-century skills and the framework developed by the Partnership for 21st Century Skills. Part 3 shares practical applications and research that supports these methods. This is a clear and concise guide that will help individual teachers, schools, or districts initiate a responsive and comprehensive style of teaching with the future in mind.



21st Century Skills: Learning for Life in Our Times. Jossey Bass, 2009. 176 pages. $27.95. 800-225-5945. http://www.josseybass.com.

What's Math Got to Do with It?, by Jo Boaler, examines the disparity between the math of the world and the math of our classrooms. The author proposes that this travesty is one cause of the placement of the U.S. far down the list of excellence in math and science compared to other countries throughout the world. Rather than suggest a polarized approach (we must return to the basics, or we must only teach using reformed methods), she draws on extensive personal research to describe successful scenarios. Both core content and process are explored in programs that often integrate the two. While the book discusses general trends and pedagogy, it does so through specific examples that are

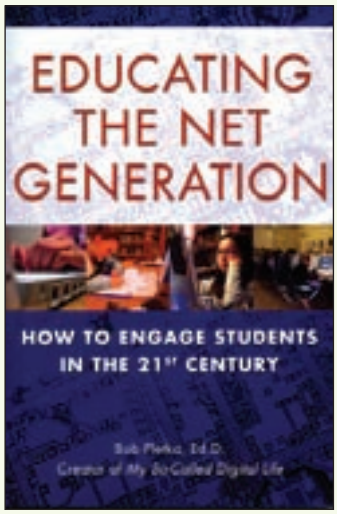


clearly enough described to be used as fodder for your next math challenge. "This book is all about giving parents and others the knowledge of good ways to work in schools and homes, so that we can start improving our children's and our country's futures." This is a smart, accessible, outstanding text that will help you discover your greater ability to connect with and teach math.

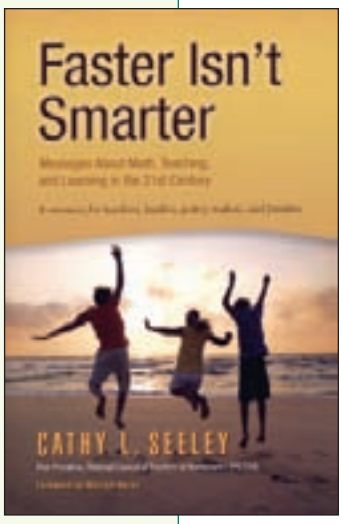
What's Math Got to Do with It? Penguin, 2008. 273 pages. $24.95. http://www.us.penguingroup.com.

Educating the Net Generation, by Bob Pletka, looks at the particular needs and abilities of the Net Generation, kids who have grown up in technologically rich environments. High School dropout rates are rising, with one of three students nationally quitting school. This generation has a great tendency to disengage, or "check out." How can teachers work with these characteristics to the greatest benefit? This book examines differences in characteristics of the Net Generation, their Generation X parents, and Baby-Boomer grandparents. It also delves into why many students resist formalized education. Interviews with teens and parents are included, as well as recommendations for changes in school policy and suggestions regarding the financial investment necessary to implement these changes. There is an inventory and checklist for parents,

teachers, and administrators to assess how their school is doing and where it needs to progress. This book offers real insight, particularly about high-school aged students, but these important ideas apply to middle schoolers as well.



Educating the Net Generation. (Santa Monica Press, 2007. 168 pages. $16.95. 800-784-9553. http://www.santamonicapress.com.



Faster Isn't Smarter, by Cathy L. Seeley, is a collection of "messages," or essays, relating to math, teaching, and learning in the twenty-first century. Each chapter, written as part of the "President's Messages" for the NCTM *News Bulletin*, includes the message plus discussion points for teachers, families, and policy makers. Following each essay are recommendations for how to address issues. Each chapter is linked to others by topic, and many are downloadable as PDFs from the Internet. This book of over forty essays includes topics for new teachers and veterans on everything from specific mathematical material to general ideas, such as, is it a teacher's job to keep students interested, or is boredom a developmental stage? One pivotal message looks at the practice of speed drills in math classrooms, whether they are effective, and how to gain the benefits of such an exercise while avoiding any of the potentially detrimental effects.

Faster Isn't Smarter. Math Solutions, 2009. 253 pages. $24.95. 800-868-9092. http://www.mathsolutions.com.

WEB SITES

MIT Scratch Ed is a site for teachers helping students learn Scratch, a programming language that makes it easy to create interactive art, stories, simulations, and games, and share them online. Children across the globe participate. http://scratched.media.mit.edu/.

WestEd is a research, development, and service agency working with education and other communities to promote excellence, achieve equity, and improve learning for children, youth, and adults. This site recounts a seventh-grade geometry unit http://www.wested.org.

Harvard Education Letter is an award-winning bimonthly newsletter from the Harvard University Graduate School of Education. It examines trends in education, policies, and other national educational concerns. Available in print as well. http://www.edletter.org.

iEARN (International Education and Resource Network) is a non-profit organization made up of over 30,000 schools and youth organizations in more than 130 countries. iEARN empowers teachers and young people to work together using the Internet and other new communications technologies. Over 2,000,000 students each day are engaged in collaborative project work worldwide. http://www.iearn.org.

Go Know! is a company devoted to providing teachers and students with effective, compelling, easy-to-use, research-based resources for handheld computers. They develop software and devices for individual technology (cellphones, PDAs, and other gadgets). http://www.goknow.com/.

Jim Moulton is a strong voice for making sure technology is integrated purposefully into the lives and learning of students. "It is the human network that will make all the difference in the benefits realized from any technology investment. It is all about what the people do with the tools…" He is a consultant, educator, and writer with insightful ideas about technology and twenty-first-century skills. http://jimmoulton.org/.

Using a Virtual Tool to Better Understand the Real World

by Jill Bible and Tina Ornduff

Their eyes were wide and the only noises in the room were exclamations of enthusiasm. "Whoa!" "Oh!" "Wow!" Small groups of fourth-grade students huddled around laptops. They weren't watching a movie or playing video games; they were exploring the world with Google Earth.

They took turns using the mouse to zoom, and then they went all the way underwater.

These students were participating in a special program at the California Academy of Sciences—a natural history museum, planetarium, aquarium, and rainforest, encompassed within a new green building in San Francisco's Golden Gate Park. In February 2009, Google launched the newest version of Google Earth at the Academy and the festivities included testing the product with students.

Although it is a virtual tool, Google Earth makes a variety of subjects come to life for students of all ages. It is a satellite imagery-based mapping product that puts the whole world on a computer. It enables you to "fly" from space to street level, exploring locations around the world. The latest version includes exciting additions, such as historical imagery and ocean floor and surface data. Now, users can investigate the terrestrial environment, and explore under the oceans without even getting wet.

Visiting students work with a Google educator to explore the oceans with Google Earth.

As educators at the California Academy of Sciences and Google respectively, we will use this article as a platform to share a few of the ways in which we have used Google Earth as a teaching tool. Two of the lessons we will describe are California-specific, but they give a sense of the kinds of topics you can use this free and easily downloadable resource to teach. The third lesson covers green building concepts and is appropriate for any classroom all over the globe. In addition to providing these classroom-specific resources, we have also listed Web sites where you can learn to use this technology in a myriad of ways in your classroom.

Ocean science tour

To coincide with the launch of the new Google Earth, educators from Google and the Academy collaborated on the creation of an education tool focused on ocean science. We designed a Google Earth tour that relates many of the Academy's ocean exhibits to real locations on the planet. It enables museum visitors to fly around the planet, exploring the places they have learned about at the museum. For example, museum visitors can discover the Academy's colorful Philippine coral reef tank and then use Google Earth to fly to the Philippines and investigate the real world locations of these reefs. Our ocean science tour connects eleven Academy exhibits with eleven real-world locations.

We first tested the tour with a class of local fourth-grade students. During their visit to the museum, the students had two separate experiences: a physical tour of the museum's ocean exhibits and a virtual tour of the real-world locations of the exhibits. Inside the museum, students met African penguins, discovered seahorses from New

Caledonia, and came face to face with coral reef fish from the Philippines. Then, they joined Academy and Google educators in our lab to travel to Africa, New Caledonia, and the Philippines, becoming some of the first people to explore the ocean depths from the comfort of their desk chairs.

Before flying to any of these locations, students had to answer a quiz question. The dual-purposes of the quiz questions, which are embedded within the tour, are to assess what the students learn during their museum visits and to add important science content to the tour.

For example, we asked students, "Which of these ocean ecosystems has the most species: Philippine coral reefs; Caribbean coral reefs; the California coast; or the Great Barrier Reef?" After some discussion, the students answered that Philippine coral reefs have the highest species diversity. They clicked on the button that corresponded to their answer on the Google Earth tour. They were correct, which meant they got to fly to the Philippines—to the exact location where Academy scientists conduct research. If they had guessed incorrectly, the tour would have directed them to try again.

Upon arriving in the Philippines, students were greeted with explanatory text and a video to bring the location to life. They took turns using the mouse to zoom in and out, in and out, and then they went all the way underwater. Again, the sounds of excitement echoed in our little lab. "Whoa!" "Oh!" "Wow!"

Upon returning to the classroom, their teacher assigned homework in which students reflected on their experiences at the museum. They described what they learned, what they liked, and what they wanted to know more about. One student wrote, "I learned that colorful fishes live in the Phillipiens [*sic*]. I liked how Google Earth can go underwater. I want to know more about deep sea life." For this student, seeing fish in the aquarium and exploring the oceans with Google Earth inspired a curiosity about deep-sea creatures. Another student wrote, "I learned that coral reefs protect land from storms and floods. I liked how on Google Earth you can go underwater and track fish. I want to know more about how to help sea horses and coral reefs survive." Are these the words of a young conservation biologist in the making?

Students at the Academy's Discovery Tidepool

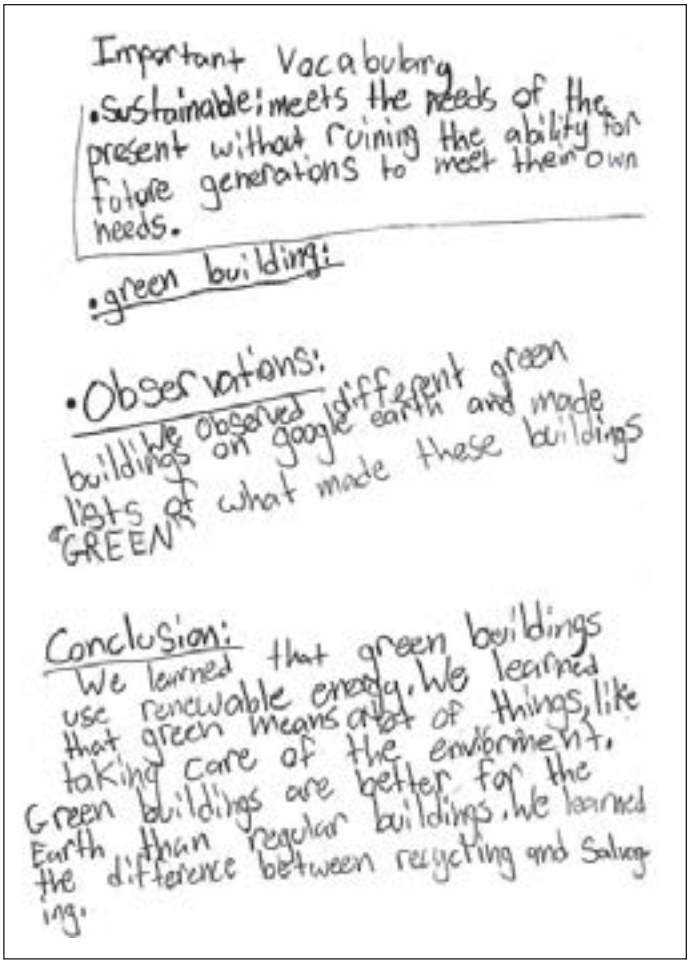
Permeating the Academy's educational programs

After using Google Earth to teach fourth graders about ocean ecosystems, we realized how powerful and inspirational a teaching tool it can be. We therefore infused many of the Academy's educational programs with this tool. We now use Google Earth on the museum floor for visitors, in workshops for teachers, and in programs for students. We use it to teach a plethora of subjects including geography, oceanography, biology, geology, and sustainable design. Below, we outline two specific ways the Academy is using Google Earth to teach science.

Geology virtual tour

When classes visit the Academy on field trips, some of them participate in lab programs. One of our labs focuses on geology; it incorporates looking at real rocks and journeying with Google Earth to the locations where the rocks were collected.

Most teachers cannot take their students on extensive geology field trips and yet their students are responsible for understanding local geology. In California,



Important Vocabulary
•Sustainable: meets the needs of the present without ruining the ability for future generations to meet their own needs.
•green building:
•Observations:
We observed different green buildings on google earth and made lists of what made these buildings "GREEN"
Conclusion:
We learned that green buildings use renewable energy. We learned that green means alot of things, like taking care of the enviroment. Green buildings are better for the Earth than regular buildings. We learned the difference between recycling and Salvaging.

Excerpt from a student journal of the "Green Building Tour" lesson

sixth graders are responsible for explaining major features of California geology in terms of plate tectonics. But many students never see the ocean or the mountains. They never see California geology in action. Without traveling around the state, it is difficult to visualize the different types of rocks and geologic formations in California. What if every student in California could take a journey from the Pacific Ocean to the Sierra Nevada? With this technology, they can!

We start our Google Earth geology tour hovering over California. We show the path we will take on our journey from the ocean to the high mountain peaks. Then, we swoop in to the beach where we discover something waiting for us. It is a photograph of sandstone with an explanation for how this kind of sedimentary rock forms. After discussing sedimentary rock formation, we move on to other locations. For example, we fly to the San Andreas Fault where we find serpentine, and then over to the Sierra Nevada to learn about obsidian. Through this virtual field trip students see nine different rocks: three sedimentary, three metamorphic, and three igneous. They see rocks in their natural surroundings and connect them with the geologic processes that create them.

Our geology is specific to California, but you can create similar tours for your local area. You can download our tours (see the resources section) and use them as templates for creating your own tour anywhere in the world.

Green buildings virtual tour

The Academy's mission is to explore, explain, and protect the natural world. Part of that mission is to educate about sustainability. We lead a series of sustainability-themed teacher workshops including one entitled, "Green Buildings and Landscaping." During this workshop, we tour the Academy's green building. But we want our teachers to see multiple examples of green buildings, so we use Google Earth.

As an introduction to sustainable design, we take teachers on a virtual tour to eleven green buildings around the world. Teachers explore the buildings and write down what they think makes the buildings "green." We use the virtual tour as a kick off for the workshop in which teachers engage in hands-on design projects to green their schools.

We train teachers to use Google Earth to explore science and sustainability themes. In turn, they return to their classrooms and teach their students. The impact ripples. One teacher who is participating in an Academy program called the Teacher Institute on Science and Sustainability has been using the green buildings virtual tour with her students. She frames the activity as a scientific investigation and has students document their exploration in their science notebooks. Through this activity, students discover what makes buildings "green." This introduction to green buildings around the world inspires students to green their schools. One student wrote, "We want to know how we can help Miraloma (their school) become a GREEN building and save energy."

Above and beyond: a tool for many subjects

The Academy uses Google Earth to engage people on issues of science and sustainability, but it can be used to illuminate literature, history, geography, math, economics, and much more. Google Earth is a powerful learning treasure chest that can help students conceptualize, visualize, and communicate information about the world in which they live.

Google Earth provides a way for students to learn complex material visually. For example Sky, Moon, and Mars in Google Earth provide an unprecedented look at millions of stars and galaxies, as well as current and historical information. Students can take tours of landing sites, narrated by Apollo astronauts, zoom into 360-degree photos to see astronauts' footprints, and even be the first human to view images downloaded by NASA just hours ago. This is a fantastic way to integrate history, science, and technology. There are countless other ways to use Google Earth for single subject lessons or to integrate subjects. Google has developed a Web site that guides teachers in using Google Earth in the classroom.

As educators, we strive to make all our lessons come to life for our students. Google Earth enables students to visit places to which they cannot physically go and to see the unthinkable. It engages students, creates compelling and meaningful learning experiences, and helps students become geographically literate. From history to environmental science, Google Earth can help bring a world of information alive for students. Whether it is a local beach, the depths of the world's oceans, or Mars, using Google Earth makes it real. It makes real explorers of us all.

Jill Bible is the Curriculum Developer for the Teacher Institute on Science and Sustainability at the California Academy of Sciences. Jill designs curriculum, teaches teacher professional development workshops, and provides in-classroom mentorship on science and sustainability.

Tina Ornduff is an Engineering Productivity Manager and Geo Education Outreach team leader at Google. She is working to help teachers use the power of Google Earth, Sky, Moon, Mars, SketchUp, and Maps in classrooms. She also writes developer documentation for several Google products.

Students come face to face with the Academy's Philippine coral reef.

Resources

http://earth.google.com/. Download Google Earth onto your computer.

http://www.google.com/educators/p_earth.html. Google for Educators: Google Earth. Ideas on how to use Google Earth in your classroom.

http://www.calacademy.org/google_earth/quiz/ocean_exhibits_quiz.kmz. Go here to access the California Academy of Sciences Ocean Science Quiz and Tour.

http://www.calacademy.org/teachers/resources/lessons/google-earth-geology-field-trip/. The California Academy of Sciences California Geology Flight.

http://www.calacademy.org/teachers/resources/lessons/green-buildings-virtual-tour/. California Academy of Sciences Green Buildings Tour.

From Copenhagen to the Classroom

The U.N. climate change conference in Copenhagen has come and gone with only a modest agreement among nations to work towards a reduction of greenhouse gases. No new treaty or firm agreement has come from the conference. Yet, all the participating nations seem in agreement that the issue of global warming is real, it is the result of human actions, and that it needs attention. While all of this may seem obvious to many educators, it does represent progress in international terms.

So what is the meaning of the conference—and of climate change—in the classroom? Are there new ideas to teach and ways to promote problem solving and inquiry? ***Connect*** authors have been writing about this issue for several years and we hope to hear from more of you!

Writing for ***Connect*** (21:2, 1–2) from a school on the northwest coast of Alaska in 2007, teacher Ken Stenek stated that for students, "I don't believe there's an age that they're too young to study climate change." Using transformation of energy as a topic, Stenek has middle school students measure temperature changes in a can painted black and one with a silver color. We all can guess the result, but then he adds the comparison of heating of soils and of water, showing that the darker surfaces absorb heat faster. Then Ken Stenek helps his students to discover that snow and ice are highly reflective, and that sunlight causes limited warming when hitting these surfaces. That the snow and ice are less prevalent is already clear to his students and their families whose houses are subjected to intense beach erosion because of decreasing sea ice and the loss of permafrost.

Writing from St. Louis, author Bob Coulter points to the complexity of climate change and the risk of leaving younger students feeling hopeless, or at least confused by things like a one or two degree change in the overall climate. He suggests that students explore variability and change in a variety of settings that are easier to comprehend. Coulter writes, "…What I am proposing here is a dual-use pedagogy: useful for students now and for building future capacity." (21:2, 22)

As far back as 1995, ***Connect*** urged educators to address climate change and related topics in age-appropriate ways. In 2005 we suggested in-class studies of artificial or natural ice that could lead to greater understanding. (Search the ***Connect*** archives for more ideas.)

Unite for Climate *is a Web site supported by UNICEF and many partners worldwide as one source of teaching and learning ideas regarding climate change.*

There is no conclusion

This challenge will grow and become more complicated over the coming decades. Some problems will be solved while others will develop and need the attention of experts and of all of us. But who will the experts be?

Some will come from your classrooms, along with students who are passing through schools all over the world. The old truism that the experts and problem solvers of the future are in school today takes on a new meaning in the face of climate change. Students learn early that math, science, and technology are tools for their hands and minds, or subjects beyond their skills or interest.

As educators, we need to ensure that our students of all ages are engaged in using problem solving skills to explore the world around them, knowing ourselves that this work today may become a resource for all of us in the future.

SYNERGY LEARNING INTERNATIONAL, INC.
PO Box 60, Brattleboro, VT 05302

Connect™
Innovations in K–8 Science, Math, and Technology

Volume 23 • Issue 3
January • February 2010