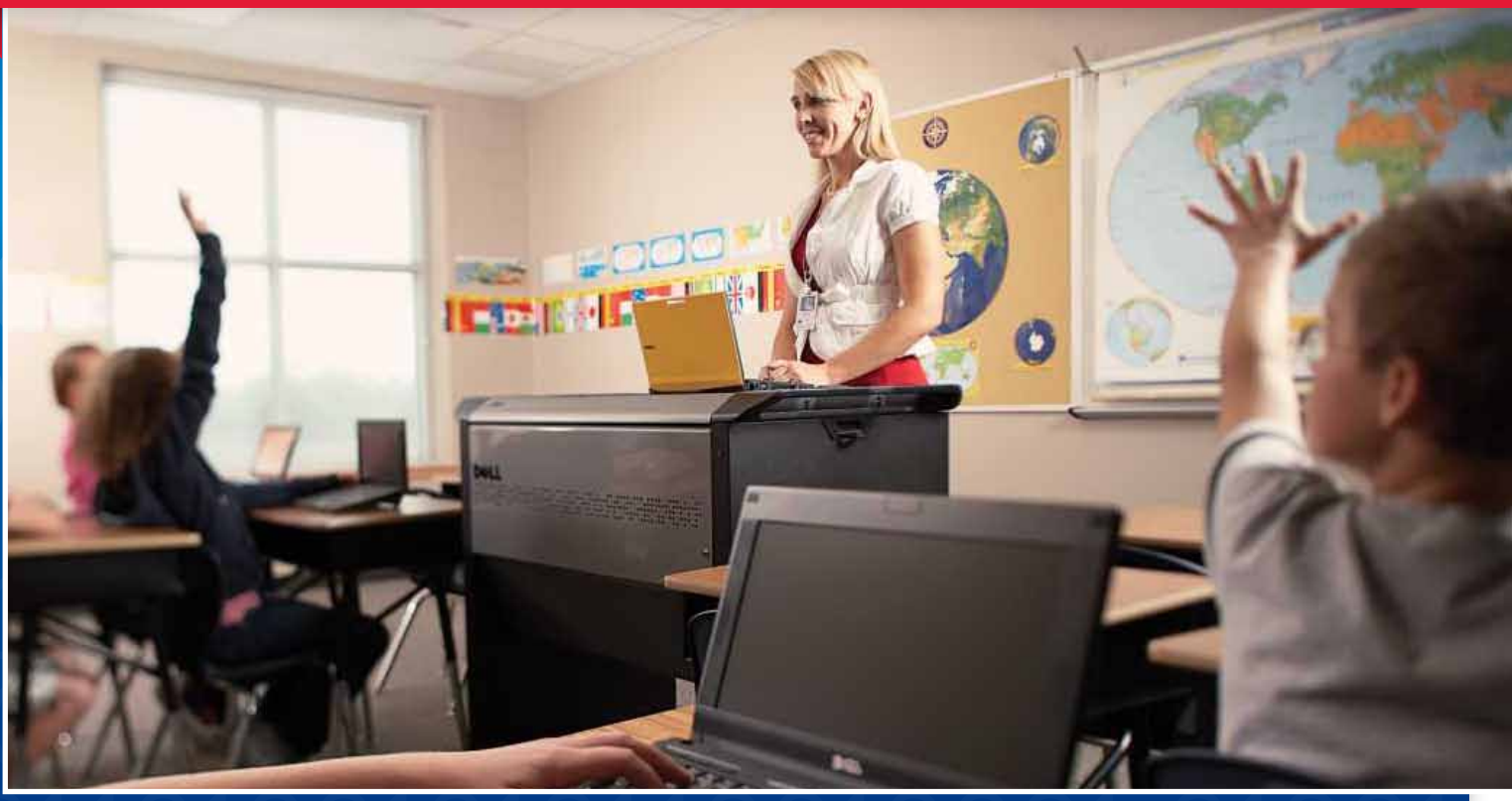
A STRATEGY PAPER FROM CENTER FOR DIGITAL EDUCATION

Transforming STEM Learning through Technology in Elementary School

Elementary School



DELL intel

Introduction

Lead-Deadwood Elementary School in the Black Hills of Western South Dakota has a problem. Students need science. Real science for real kids — the kind that sparks students' imagination.

Second grade teacher Carol Greco contacts the world's largest underground laboratory, the Deep Underground Science and Engineering Lab (DUSEL). One mile under South Dakota, the lab is not accessible to students. But this doesn't stop Dr. Warren Matthews, DUSEL's cyber-infrastructure chief engineer. As a scientist, Warren knows engaging elementary students with science means finding a "hook." That hook comes in the form of puppets — and not the brown paper bag variety.

Patty Petrey Dees, distance learning director for the Center for Puppetry Arts in Atlanta, Ga., starts to work her digital magic and begins researching what scientific content the lab can use for Carol's classroom. Patty envisions nanotechnology dancing in virtual micro cities and students playing the role of engineers in a virtual mission control room as their astronaut puppets explore deep space. This is a far cry from the current most popular elementary school distance learning topics — the lifecycle of a butterfly and paleontology lessons from puppetized dinosaurs — at the Center for Puppetry Arts. Watching first graders wiggle and giggle at the crystallization movements of crafted butterfly puppets is good, but watching them explore the world of dark matter through puppets is better. This is extreme puppetry through technology with digital content that has supersized itself.

For Carol, the ability to incorporate a sense of discovery and real-world problem solving into her classroom is critical. She wants to bring difficult science, technology, engineering and math (STEM) topics closer to home. Using every available technology in her classroom, from the electronic whiteboard to individual laptops, she sets the virtual puppet stage to bring STEM out of the physical text and into the virtual world. The infrastructure that seamlessly allows this to happen stays in the background, empowering Carol to teach, Warren to share his scientific expertise, and Patty to provide the instructional tools that link learning to laughing as the puppets play. This type of education really rocks.

Why the Focus on STEM?

- Top U.S. students are foregoing careers in STEM with steep declines in engineering (25%) and mathematics (19%).
- U.S. students finished 15th in reading, 19th in math, and 14th in science in the ranking of 31 countries by the Organization for Economic Cooperation and Development.
- Only 29 percent of American fourth-grade students, a third of eighth-grade students, and barely 18 percent of 12th-grade students perform at or above the proficient level in science.

Teaching difficult STEM topics to elementary students does not immediately conjure up puppets and interactive video conferencing as critical tools, yet these technologies link the arts and science in a way that fully engages students' imaginations. Second graders cannot tour the remote South Dakota lab, but they can do the next best thing by inviting the lab to come to them. Best of all, the lab is accessible through technology and content that they understand.

The Federal Focus on STEM

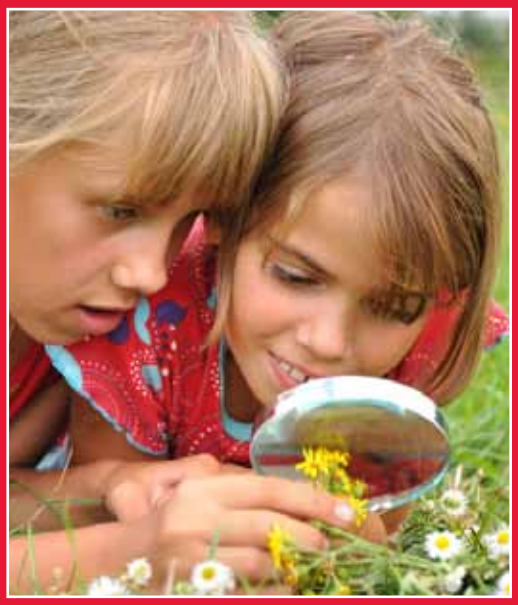
When presidential administrations convene task forces, reports get written and funding streams flow. STEM is not new to the educational agenda, but has migrated towards the front of the flock. The Obama Administration made STEM one of its top priorities, announcing three overarching goals:

- Increasing STEM literacy so all students can think critically in science, math, engineering and technology;
- Improving the quality of math and science teaching so American students are no longer outperformed by those in other nations; and

Bringing Students to the STEM "Field"

Instructional technologist (and prairie lover) Darren Gunderson, a recent "20 to Watch" recipient from the National School Board Association's annual technology search, works with the Konza Prairie Biological Station to bring K-12 students to the field — literally. Elementary students stand side by side collecting specimens such as grasshoppers or counting specific plant species that are hosts to egg-laying flies.

Students go back to the classroom and learn to enter their scientific data in a database where they can query their own research questions while building an understanding of database structures. The information students collect is in the same database as the information collected by nationally recognized scientists. For the elementary students, this is just plain 'cool.'



- Expanding STEM education and career opportunities for underrepresented groups, including women and minorities.[1]

To meet these end goals, schools need to take critical steps at the elementary level to prepare students for STEM fields. Before students can shoot for the stars, there is a need for an infrastructure on the ground in every district, school and class that creates, connects and communicates this digital learning environment.

For districts seeking grant money, linking STEM project-based learning into the narrative and rationale is a sure way to stimulate their bottom line and push students to the front of the line in the future workforce. Recent Race to the Top grantees succeeded in navigating these waters by paying attention to the competitive preference priority of STEM topics.

The STEM pipeline starts in elementary school. What happens in these early years can have a profound impact on a student's later development to shape hopes and dreams as adult career professionals. Infusing elementary schools with technology that inspires can create a culture where STEM expectations are high and students succeed. Tools need to be quickly deployed, easy to use and effectively maintained, especially with the downsizing and outsourcing districts now face daily. Affordability and scalability have become school districts' mantra. The best practice for STEM curriculum is weaving it into the fabric of learning at a systemic cultural level.

Teaching STEM Effectively with Technology

The instructional challenge for the elementary teacher is translating difficult STEM topics into interesting and engaging grade-level appropriate curriculum and assimilating it into a day where every instructional minute is counted. Multi-layered, rich content that is standards-aligned and accessible to all students — not just gifted and talented from STEM fields — is the first step. The second step is designing the delivery of the content that best suits the teacher's instructional needs and captures students' attention.

> "The earlier we can introduce them to science and technology the better, so why not start STEM now?"
>
> - Ann Dressen, STEM teacher, Minnetonka Public Schools

Digital natives desire invisible technology that is seamless, not polyfilm transparencies that teachers have to juggle at the front of the classroom, praying that the projector bulb is not burnt out. STEM solutions through technology innovations become one when students are able to manipulate 3-D images of DNA and solar systems in front of the class with sophisticated interactive whiteboards. Students are able to use all of their senses when STEM comes alive. The tactile experience of rotating geometric shapes in three dimensions is fundamental for understanding mathematical proportions when Styrofoam models break. Hearing rocket engines of space shuttles, embedded in digital files, turns the classroom into a high-definition theater experience.

Technology that works with the teacher can foster teamwork and collaboration by opening up new ways for students to edit one another's work, building not only technological confidence but educational confidence as well. Teachers can collect real-time data from mobile handheld devices. These wireless clickers or phone applications help teachers query students and launch "checking for understanding" questions, instantaneously receiving feedback critical in assisting students trying to grasp new STEM concepts. Combining quantitative tools with qualitative applications makes STEM workable for elementary students. This connected classroom is dynamic and integrated instead of static and fragmented. Thinking outside the box means bridging new connections for content that is constantly changing.

Finding the right digital content provider can be overwhelming. Issues of standards, quality and production value are pervasive. Finding customized solutions specific to STEM can be near impossible. Supporting high student achievement in this area is within reach with specific digital content adoption services provided by leading technological educators in the marketplace. Working together, content providers and technology leaders bring the classroom teacher within reach of once elusive STEM curricula.

Technology Allows More Hands-On Teaching

Elementary school teachers know the difficulty of keeping the attention of students in ever-increasing class sizes, and individualized and differentiated instruction can be even more of a challenge. The younger the student, the more multi-tasking their teacher does. Incorporating varied technology that enhances rather than competes for attention at the early grade levels maximizes instruction. As wireless technologies expand the teacher's reach in the class, more students are able to participate.

Teachers can be untethered from the front of the room to focus on student-centered learning interactions. By utilizing a tablet PC, a teacher can remain connected to the curriculum while circulating the classroom and assisting students with any problems. Portable and mobile technologies allow a teacher to maneuver around desks and offer one-on-one student help while also projecting images to the interactive whiteboard for a whole classroom experience.

The quieter student who does not willingly raise his or her

Must Model: STEM Program Linking Higher Education to K-12

Focusing on increasing teacher and student competencies in the math that undergirds engineering, the Curry School of Education at the University of Virginia has designed a teacher preparation program that empowers elementary students to explore digital fabrication systems. Teachers learn to use new technologies that help their students simulate objects based on their own engineering computations prior to production.

For example, the program includes an engineering project in which fourth, fifth and sixth graders determine the least amount of surface area needed for commercial products to be properly packaged.

"Digital fabrication can be an onramp that supports high-quality math instruction as well as science and engineering," says Professor Glen Bull, co-director for the Center for Technology and Teacher Education.

Must Have: STEM Resource
The National Science Digital Library, funded by the National Science Foundation, provides free resources that include "images, video, audio, animations, software, datasets, and text documents such as lesson plans and journal articles." This one-stop shop also provides technology tools for "blogging, collaborative workspaces, collection creation and management services, news reports, and online community discussions."[2]

Must Join: STEM community
The STEM Education Coalition includes over 300 organizations ranging from academic professional organizations, STEM-related business and community interest groups, and higher education institutions that come together in a unified voice to keep K-12 STEM education at the forefront of America's policy-making bodies.[3]

hand will not get overlooked when they ask questions on their student laptop, netbook or tablet. Linked to every student in the class, the teacher can ensure every student is called upon. Classroom voice is not just verbal, and learning can extend beyond the school day. No black holes here.

Classroom behavior changes when the right technology is introduced at the right time. For teachers, there is a direct relationship between introducing a technology that inspires high levels of engagement and the learning that ensues. This golden equation fosters time on task. When students' eyes sparkle with excitement over seeing their work digitized and shown globally, the world opens up.

Only with a highly connected interactive environment where the teacher can explore new ways of bringing STEM curriculum into the student's focus can all these things become a reality. The technology infrastructure that stands behind the teachers needs to be seamlessly in the background. Learning doesn't wait for the computer to load or the wireless connection to hum in sync with it. Tools need to be ready to go, day one and out of the box. Teachers need to be trained to use the technology effectively and without delay. If technology does not make STEM teaching easier by enriching the learning environment, the T can be taken out of STEM.

When learning is fun, education just happens.

An Interactive STEM experience

Integrating technology in elementary school sets a precedent for the use of technology in school early and provides

invaluable skills that students can build upon and ultimately bring with them into the future workforce. Best of all, elementary classroom technologies are not only available to schools flush with funding — not that those exist in this economic environment. Elementary classroom technologies are often affordable and can actually bring cost savings — a win-win situation for the cash-strapped school that wants to provide a world-class educational experience for students.

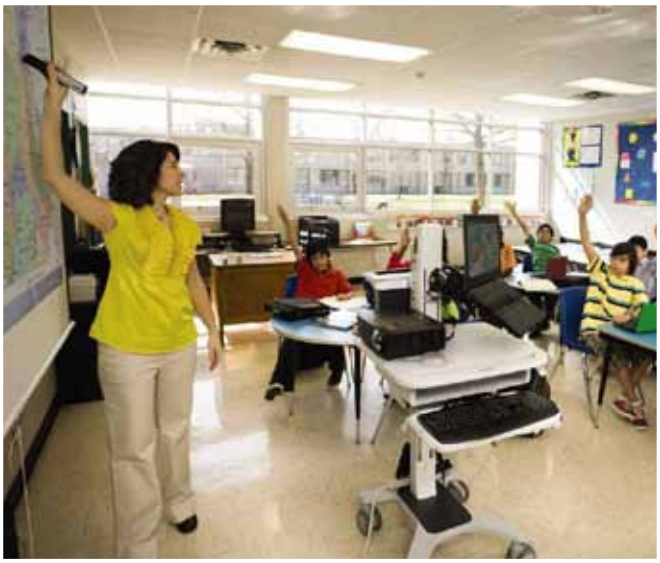
When schools need to trim technology budgets, handheld devices like e-readers, MP3 players, clickers, notebooks and netbooks become more the mainstay than peripheral in the classroom. The ability to scale up as the class grows in size and in digital content needs becomes important. Technology decisions need a sound planning backboard so students do not outgrow what is available. Using handheld devices are increasingly important as budget belts tighten. Students can bring an author's voice alive by listening, but real learning comes when they add their voice to the work as well through blogs and wikis.

Online gaming is an attractive option for students to learn subjects like math, history, English and science that have traditionally not been presented in an interactive way. Recent studies have shown that 93 percent of U.S. elementary schools now have Internet access,[4] making online gaming an easy and affordable way to spark elementary students' interest in school subjects and get them excited about wanting to learn.

What's more is that students are asking for it. In a recent survey conducted by Project Tomorrow, over half of the students in grades 3 through 12 said that they believe educational gaming would help them learn difficult concepts. Only 3 percent of elementary students polled said they do not play video games of any type.[5] Incorporating online gaming into the curriculum is a natural way for students to learn.

"Games tend to drive and increase interest in a subject area," says Dr. Kurt Squire from the University of Wisconsin — Madison. They are "problem solving machines, so we build games that have students solving the kinds of problems you want them to solve in the real world."

Squire's recent games center on a virtual lake, where students take samples and investigate why and how the lake



became toxic. Another genre is virology games where students act as a virus in the body to learn about immune systems. In areas where students need to learn complex, but abstract material, interactive gaming provides teachers with a STEM curriculum that suits students' natural state of play while bringing the academic experience into focus.

Building a Foundation

The skills and knowledge learned in elementary school leave a lasting impression with students as they embark on future educational endeavors. It is vital to start building the foundation of certain skill sets at this young age. Studies show that students begin to start losing interest in the fields of math and science as early as middle school. The crucial need for student interest in STEM isn't expected to subside anytime soon — the U.S. Department of Labor predicts that by 2014 there will be 2 million job openings in STEM fields.

Schools no longer think in terms of return on investment when it comes to technology, but return on instruction. Student success must be a factor in buying along with the district budget. Presidential priority has been given to incorporate STEM into the national education agenda and ensure that students meet the professional requirements of occupations that have yet to be created or named.

Educational technologies have evolved significantly in the recent past from counting tens on popsicle sticks and learning numerical placeholders to using visual digital technology and graphing in real time the counting lesson of the day. If Carol Greco is late for her second grade class in South Dakota, by the time she rounds the corner of the hall her student helpers have counted and graphed all the possible lunch box combinations for her. Why? Because math is more fun with technology; engineering is more than pipe cleaners and science rocks when kids move with the molecules.

There is a wide array of options that fit well into the elementary environment that can bring big benefits to schools if incorporated into curricula. For the teacher, instructing can become more hands-on — a must with elementary students — through portable mobile devices with the ability to provide a more student-centered approach. Individualized learning is paramount. Teachers in connected classrooms have more tools at their disposal to present lessons, assess understanding and track progress. Assessment in real time is real assessment. Knowing what the students don't know is just as important as knowing what they do know. Leveraging technology takes the ordinary classroom to the extraordinary.

Students are engaged, excited and can effortlessly breeze through tasks previously thought of as boring. Using technology daily in the early elementary grades sets the technological stage for higher expectations and confidence. STEM topics are complex and all too often confusing, but by using technology students begin to turn the virtual page in conquering their fears as they build 3-D models, communicate with scientists around the world, research university collections and collect and contribute specimens for a national ecological reserve. Their laptops and netbooks become their lab. If walking on the moon was one giant step for mankind, bringing the moon to the classroom is one giant step for studentkind.

As technology options have become more durable at the elementary level, they have also become more affordable. This is a brave new world of emerging rich digital content that requires dramatically restructured platforms to handle the amount of video, images, sound and programming that STEM requires. Capacity increases, performance heightens and students' minds ignite. Tracking and reporting for school leaders is easier, quicker and allows more time to focus on policy that will positively benefit teachers and students alike. School leaders can spend less time concerned about money and more time focused on what really matters — that students receive a valuable education that prepares them for success in their future.

Endnotes

1. http://www.whitehouse.gov/the-press-office/2010/09/27/president-obama-announces-goal-recruiting-10000-stem-teachers-over-next-
2. http://nsdl.org/browse/?subject=General%20Science%20and%20STEM%20%28Science,%20Technology,%20Engineering,%20and%20Mathematics%29&purpose=Educators%20and%20learners
3. http://nstacommunities.org/stemedcoalition/
4. http://nces.ed.gov/fastfacts/display.asp?id=46
5. http://www.networkworld.com/community/node/26782

Acknowledgements:

Dr. Kari Kelso is a senior fellow for the Center for Digital Education. Kelso earned her Ph.D. from the University of Texas at Austin in Organizational Communication and has over nine years of experience as the lead manager for two of California's larger school districts in Research, Evaluation and Assessments and one rural district. Having taught at the university level at three universities — combined with her K-12 school district leadership — she knows K-20 education from the inside out.

Dell is committed to enabling teachers to more effectively engage students with all types of learning styles and to prepare students to succeed in this digital age. As the top provider of technology to U.S. K12 classrooms, the company uses feedback from educators across the country to design and develop technology offerings like the Dell Connected Classroom, which includes student and faculty computers powered by Intel's® new 2010 Core™ processor family, digital content and resources, interactive whiteboards, audio systems and student response systems. These classroom technologies help teachers engage students, gauge their level of understanding and customize the learning environment to student needs.

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