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Produced by the International Technology Education Association in conjunction with its Technology Education for Children Council
How will we meet the needs of society in the future? Where will the technologists, engineers, and innovators of the next generation come from? How can we stop the erosion of interest in science, technology, engineering, and math? The answers to these questions may lie within your own classrooms. Elementary education teachers who use lessons that introduce creativity and innovation can help students with career exploration and development. You can inspire students to take an early look at “frontier occupations” like alternate energy, green transportation, biotechnology, nanotechnology, and aquaculture to name a few. It is especially important that girls and other underrepresented populations are encouraged to fully participate in STEM-related experiences. However, the increased dependence on technology will require all students to have a solid foundation in the STEM disciplines.

An emphasis on design and problem solving in the classroom will allow students to use cross-disciplinary tools for discovery and for developing solutions to problems that are open-ended (allowing for iterative steps, rather than highly structured patterns). Such a classroom would give students an understanding of the relationships of STEM areas as they are used in the real world beyond the classroom walls. Instead of separating science, technology, engineering, and math into individual curriculum “silos,” STEM can provide our students with the integrative tools of investigation and analysis. Consequently, a STEM classroom shifts students away from learning isolated facts, to experience-based inquiry with major opportunities for independent learning. Using design as a framework for instruction has been heralded as a means to advance academic abilities, creativity, and learning.

A STEM-influenced elementary classroom should require students to participate in solving (age-appropriate) problems that encourage original research. Such a class would offer multiple problems for students to pursue. Students would design, model, and test solutions. They would analyze data and report their findings to one another, or to their peers in the school, or even to others over the Internet.

Identifying stakeholders in the community will be an important part of creating a successful STEM program in your school. Myriad reports indicate that both business and industry are ready to support any program that prepares students with skills that make them capable of good decision making, creative thinkers, and excellent problem solvers. All of these qualities benefit local groups because it makes them competitive in a global economy.
stem (science, technology, engineering, and mathematics)

“Science is for nerds!” “Math is boring!” “Technology classes are a waste of time!”

by Marlene C. Scott

These words can be heard uttered from the mouths of some secondary students. What these students fail to comprehend is that science, technology, engineering, and math can be their friends.

Some of the assumptions held by students could very easily be erased by the click of a mouse. STEM is more than just math equations, lab reports, and spreadsheets. It is about exploring subjects that can lead to exciting careers, making these same students better equipped and, yes, smarter individuals.

As many of our readers are aware, STEM is an acronym for Science, Technology, Engineering, and Mathematics and usually refers to education in one or more of those disciplines. There has been an alarming concern during the past decade over the decline in STEM education—hence the concerted push to bring STEM to the forefront in education.

In this 21st century and the new global economy, an education with a STEM focus is a vital step towards providing citizens with the necessary technological literacy that will enable them to take part in the exciting economies and careers of the future. Educating tomorrow’s scientists, technologists, engineers, and mathematicians is of critical importance to the survival of each state’s economy. It begins with building cumulative STEM competencies in students. This is only accomplished by building on the foundation of knowledge established at each level of education: from elementary grades, where students have incredible imagination and natural curiosity about their world and how it works, on through middle school, high school, and onward. Finally, we should not underestimate the power of public policy that needs to be enacted to address effective science, technology, engineering, and mathematics education at all levels, while paying special attention to making STEM attractive to minority and female students. We must do our part individually and collectively to keep STEM education alive and well.

Marlene C. Scott, Ed.D. is Principal of J.B. Watkins Elementary School in Midlothian, Virginia. She can be reached at Marlene_scott@ccpsnet.net.
Four years ago the decision was made to increase the technology available to students and teachers in the Henry Barnard Laboratory School. As a laboratory school at Rhode Island College it was important to provide technology for the education of our preschool through fifth graders; however, it was just as important to provide a site where teacher candidates could learn to integrate technology into their daily teaching. As we quickly learned, becoming a technology-rich school was like trying to capture smoke—it is possible, but not without a lot of planning and effort.

Since there are myriad types of technologies proposed for schools, the initial questions were: What technology do we really need? And subsequently: What technology would be used on a regular basis? Historical evidence in education repeatedly has demonstrated that purchasing every available technological aid would result in expensive hardware and programs taking up space in closets and storerooms. To avoid this possibility, we took an inventory of what we had, what needed to be replaced, and asked teachers what technology they would use on a regular basis. To supplement this list and provide teachers with insight into what the “new” technology could accomplish, we purchased some samples and participated in a few pilot programs. For example, a document projector was purchased and used in the technology classroom, and teachers volunteered to field test I-Clickers in classrooms with young children. There is no better way to determine the educational worth of something than to actually use it for a period of time in a classroom with youngsters.

A committee was formed to guide the efforts to increase student and faculty involvement in the perpetually evolving world of technology. This committee included the school administration, the technology teacher, and parents who worked in technology-related fields. Although it took three years (and still counting), by the fall of 2009 the technology at the Henry Barnard School had changed dramatically. The first step forward was to make the entire school wireless. Since the school building is more than 55 years old, this turned out to be more involved (and more expensive) than anticipated; however, this released the teachers and students from the restrictions of hardwiring all of the computers, and it was worth every penny. During the three years after becoming wireless we have been able to put desktop computers in every class: one in each preschool class; three in each kindergarten and first grade class; five in each second grade class; six in each third and fourth grade class; seven in each fifth grade class; twelve in the technology education room; three each in the library and art rooms; and one each in guidance, music, interventionists, Spanish, the nurse’s office, and the physical education office (for a total of 95 desktop computers in the school).

To supplement the desktop computers, there are 47 laptop computers on two carts that can be used in any classroom.
plus all 24 teachers have been assigned a laptop for professional use. Each room has a black-and-white printer, and there are three color printers available through the Internet. In addition to computers and printers, each classroom has a digital projector mounted on the ceiling that is compatible with the teacher’s laptop (and there are two additional portable digital projectors in the school). Each room is furnished with a document projector that may be used by itself or in conjunction with other technology. Flip cameras are shared (one per grade level) and there are two I-Clicker systems available for the classrooms. Whether all of this makes the school “technology rich” will be determined over time, but it is an initial step in the right direction.

Obtaining and installing technology was only the beginning step towards the goal of becoming a technology-rich school—the next critical phase was to ensure that teachers were comfortable using it in their classroom. This process was started using traditional professional development days at which the technology was introduced and explained, and time was provided for teachers to use the hardware. Additionally, the technology was positioned so that teachers could experiment with it. Of course, a huge advantage to having a technology teacher in the school is that he or she is able to follow up the professional development training with hands-on assistance as the technology is implemented into each classroom. Strolling around the school during the first week of classes this year revealed that our technology use is off to a great start. For example, on the second day of school a fifth grader presented his summer reading project to the class using one of the laptop computers connected to the ceiling digital projector. The document projectors have been used to demonstrate everything from pattern blocks to the foundations used to support bridges; and almost all of the teachers used the projection systems for the “back to school” night presentations to parents. Another positive sign was when a teacher remarked in the second week of September, “The new technology has already changed the way I teach.” It is early in the school year, and this is an indication of what should be an exciting and innovative year.

In February of 2009 the College opened a new STEM Center (Science, Technology, Engineering, and Mathematics). The STEM Center has created a new avenue for collaboration between the college and our elementary school. At the ribbon-cutting ceremony the Governor of Rhode Island was in one of the new STEM Center classrooms. From his room he was able to watch our fifth grade students in their technology education classroom as they worked on a robotics project. While the students were completing the project, the Governor was able to offer suggestions and ask questions directly to the students. For their part, the students were able to answer his questions, explain their methods, and provide demonstrations. All of this took place in real time. This simple example of our new technology provides a glimpse into what is possible. Both the professors at the college and the teachers at the elementary school are excited about the possibilities for collaboration presented by the technology.

Hand in hand with all of the wonderful technology in any school is another set of problems and questions. The concerns run from security of the hardware, to long-term and routine maintenance, to what to do when a projector blinks off in the middle of a lesson, to implementing
a replacement schedule as computers become worn out or obsolete. None of these issues are insurmountable, and with a little patience and understanding we will have corrective procedures in place. There will always be “bugs” to address, but schools have been solving similar issues since the “new” technology was defined as opaque projectors and hand-cranked mimeograph machines, and we will continue to do so. New technology means new problems, and new problems result in new solutions.

With all of this technology and all of the resulting instructional implications, we often ask ourselves whether the school is technology rich—perhaps not yet. As every educator knows, technology changes so quickly that it is impossible to keep abreast of it all. The next influx of technology into schools and classrooms should allow large-scale, real-time, two-way interaction among those in a school and those at other sites. (We can do this now, but on a limited basis and only in certain places in the school.) Imagine the possibilities when schools are able (and willing) to invite parents into the school via a secure Internet connection. A dad who can’t attend a parent-teacher conference because he is out of town on business can log on and contribute to the discussion. A mom who misses her child’s classroom presentation due to a morning meeting can log on and watch it that night with the family. If you want to see how your child really behaves in her mathematics class, then arrange it with the teacher and watch in real time from a home or work computer. As much as these ideas offer promises, they also raise a host of practical and ethical questions that must be resolved. I believe these questions will be satisfactorily answered and that education will be improved as a result.

For laboratory schools and for professional-development schools, the future implications of technology are just as bright for teacher candidates, their college supervisors, and for professors who are involved in educational research. The same technology that invites parents into a classroom can be used as teaching tools for methods and practicum classes. From their college classroom, teacher candidates could observe prekindergarten through high school master teachers and discuss the teaching strategies with their college supervisor in real time. Teacher candidates could be observed working in classrooms by their college supervisors, and the lesson could be recorded, enabling both to critique the presentation in their next class. The technology is available for this to happen even if the teacher candidate is in a study abroad program and is teaching in London while his or her college supervisor is in New England. The same technology offers a valuable window into classrooms for those interested in aspects of educational research. Using technology in these instances at the college level also raises practical and ethical issues, but these can also be overcome.

To be a technology-rich school it is not sufficient to simply purchase the newest technological advances. A technology-rich school will implement the technology in the classrooms on a regular basis and be willing to explore creative (and sometimes controversial) methods of delivery. The goal of using the technology should be the same as every educational innovation—the improvement of teaching to further student understanding and achievement. Just as it was in the days of the opaque projectors, whether we reach the goal and become a technology-rich school will depend more on the educators who implement the technology than on the technology itself.

Ron Tibbetts, Ed.D., is the Principal of the Henry Barnard Laboratory School on the Rhode Island College campus. He can be reached at: Rtibbetts@ric.edu.

This photo shows a preschool class with a camera rolling. They are recording different literacy teaching methods for early childhood.
The growing awareness of the STEM field has spawned numerous Internet sites. STEM provides many unique opportunities for interesting collaborations in schools. Teachers and students can work on fascinating and challenging projects where together they investigate and discover solutions to problems. Here are a few websites for teachers interested in the growing field of STEM studies.

www.currtechintegrations.com
“Where curriculum joins technology”—offering students an interactive approach to science and math through engaging hands-on challenges. It offers teachers technology training and custom curriculum development, integrating innovative instructional materials and performance assessments.

www.smarttech.com
SMART education solutions to help transform classrooms into centers of interactive learning. Offering a comprehensive collection of products and resources to create inspiring learning environments designed to best implement the teaching of science, technology, engineering, and math.

www.learning.com
This site offers teachers effective tools, technology-based activities, problem-solving challenges, and proven, easy-to-use strategies to supplement existing science, technology, engineering, and math curriculum. Flexible programs allow teachers to select what they want, when they need it. Students can access information and self-tutorials to support classroom instruction—a user-friendly site for both teachers and students.

www.explorelarning.com
Through interactive online simulations called Gizmos, this site offers students a fun and easy way to explore challenging math and science concepts. Gizmos partner textbooks with research-based teaching strategies designed to supplement existing curriculum.

www.vernier.com
Created by a teacher for teachers, this site offers a full line of materials, software, and curriculum to support lab teaching in math and sciences. Appropriate for every grade level, related links detail experiments, demonstrations, and resources for students and teachers.

www.childrensengineering.com
Focusing on activities to promote greater understanding and retention, children’s engineering implements technology to develop thinking skills and engage students in the learning process. Related links offer teacher resources, ready-to-use activities, and informational materials.

www.westlake.k12.oh.us
Emphasizing the importance of STEM subjects to all areas of learning, this site offers a comprehensive program to support the teaching of science, math, and technology. Ideas, lessons, and resources are available through a variety of related links that detail specific subjects.

www.engineeringk12.org
Compiling the most effective engineering education resources available to Grades K-12. For teachers, hundreds of classroom-ready resources. For students, a grade-specific outreach program database.

www.discoverengineering.org
Career-specific sites offer profiles and facts illustrating the importance of STEM education. Video activities engage the students with “cool” demonstrations and lessons. A Did you Know? section gives interesting facts and explanations. This is a kid-friendly and entertaining site.

by John D. Arango

John Arango is the elementary technology education instructor at the Henry Barnard Laboratory School on the Rhode Island College campus. He can be contacted at JArango@ric.edu.
One of the strongest connections available to technology teachers is the science teacher next door. While most historical technologies, like ships, were developed long before the science underlying them was well understood, today science and technology go hand in hand, one providing the inspiration for the other. Unfortunately, in some schools and districts, coordination is weak.

There is good news, however. We can teach science and technology together, which is actually directly called for in the national science education standards (see Table 1). We can reach our standards for technology and give students an opportunity to build their skills in scientific inquiry. In order to do this effectively, we need to know what the science standards call for, and we need to be clear with ourselves and with our students about the difference between science and technology.

A simple tool that can be adapted for this purpose was created by Marshall Herron, who first used it to look at the reform curricula of the 1960s (Herron, 1971). Today it is called the Herron scale, and here is how it works:

Problems are divided into three components: the question, the procedure, and the solution. These may be provided by the teacher or by the student.

As an example of a level-zero investigation, consider something like: “Follow these steps to confirm that water boils at 100 degrees Celsius.” The student has been given the question, the procedure, and the solution by the teacher. A savvy student could write “We got 98 degrees” without even attempting the activity, which is a poor approximation of how technology and science actually work.

An example of a level-two investigation might be “This liquid was found at a crime scene: identify it.”

While Herron did not discuss engineering himself, his scale can easily be adapted to engineering problems. Having students design a container that will safely transport an egg is clearly an engineering task, as is a larger-scale project like designing a car that will travel 100 miles on a single tank of gas.

The Herron scale is a quick, easy diagnostic tool that can easily be applied to your own curriculum. When Herron first introduced his scale, he found that most lab activities were at levels zero and one. Take a look at the projects and activities that your students will do this semester. Where would they fit on the Herron scale?

The national standards in both science and technology encourage you to offer a range of activities to your students. These are not radical changes and are often easy to implement. Give students a choice of materials, or make them ask for the materials they need. Give fewer directions (but keep safety in mind). Use an activity before students know what to expect as the result.

Hopefully, by integrating science and technology together, you will be able to make more efficient use of your classroom time, and prepare your students for the science and technology that will be a part of their future.

Table 1

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Rudy Kraus is an assistant professor in the Department of Educational Studies at Rhode Island College. He is the coordinator of the Secondary Education Science program. He can be reached at: RKraus@ric.edu.

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• Engineering Design for Human Exploration: Focus: Energy and Power. Level: HS.
• Lunar Growth Chamber: Focus: STS-118 Lunar Plant Growth Chamber. Level: HS.

EbD™-NASA STEM Design Challenge Middle School Units:
P238CD - $15.00 (Includes all four units – delivered on CD as interactive publications)
• Lunar Colonization: Focus: Energy and Power. Level: MS.
• Space Transportation: Reshooting the Moon: Focus: Transportation. Level: MS.
• Creating a Space Exploration Infrastructure: Focus: Transportation. Level: MS.
• Packing Up for the Moon: Focus: STS-118 Lunar Plant Growth Chamber. Level: MS.

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P239CD - $9.00 (Includes both units – delivered on CD as interactive publications)
• Moon Power: Focus: Energy and Power. Level: ES.
• Moon Munchies: Focus: STS-118 Lunar Plant Growth Chamber. Level: ES.

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summary

A Dinosaur Named Sue: The Find of the Century is suitable for children beginning to read chapter books (every two-page spread has at least one picture). After a two-page, scene-setting foreword, we’re put right in the action in Chapter 1 as Susan Hendrickson discovers some very amazing fossils. The sections following take us back, first about 100 years, then 67 million years before that, to introduce the tyrannosaurus species and changing views of dinosaurs and paleontology among scientists over time. One possible scenario is presented as to how the remains of Sue (the T. rex) may have been fossilized. The last two chapters return to the present, recounting Hendrickson’s careful exhumation of her namesake, the dispute over its ownership, and its preparation and display at Chicago’s Field Museum. The book ends with five questions about the dinosaur named Sue that were unanswered at the time of publication.

student introduction

You and your team are “preparators” at the Field Museum in Chicago, Illinois. You’ve just received a bundle of fossilized bones discovered in southeastern Montana. The paleontologists think that the bones are from a dinosaur. Not all the bones are there, and a few of them might be from a different animal. Finally, just like the “preparators” prepared Sue, this dinosaur’s skull will be restored and displayed separately.

design brief

Suggested Grade Level: 2-4

Prepare a model of a Field Museum display of the Montana bones. You must be able to take apart and reassemble the model.

- Be careful to preserve the “bones” as well as you can. Small indentations are all you should need.
- To bind pieces of the skeleton together, you may use wire or a “filler” material (clay). Try to use as little of these materials as you need to accurately display the skeleton.
- To hold the skeleton up, you will use posts (toothpicks). It is important to keep the skeleton from falling, but it is also important that the posts not look like part of the skeleton.
- Report to the Museum Curator, telling her how efficient your design is.

teacher hints

1. Prepare the “bones” before introducing the lesson. These can be made out of dowels and old metal clothes hangers (or other materials that can be connected to each other using wire and clay). Provide each group with about three feet of “bones.”
   - Quarter-inch dowel can be used for the spine and large leg bones.
   - Smaller bones can be made from eighth-inch dowel or from clothes hangers. Clothes hangers are especially good for ribs. Try to avoid sharp edges; use a file where necessary to dull the ends.
   - Always wear safety glasses when cutting materials, especially clothes hangers, the pieces of which often become airborne!
   - Make a spare set of bones that you can “embed,” like the picture on page 33 of A Dinosaur Named Sue. Use a piece of styrofoam to represent the rock in which the bones are encased.

2. You will need the following materials per group:
   - One set of “bones”
   - Modeling clay
   - About 4’ of floral (or similar) wire (good sizes are 24 or 20 gauge)
   - 10 to 15 toothpicks (the regular kind with pointed ends)
A piece of styrofoam for the display base (no larger than 9” x 5” x 1”)
One thumbtack (the kind with the cylindrical plastic “handle”)
You will also need a kitchen scale and a pair of pliers or another tool to cut the wire and toothpicks. It will also be very helpful (but not essential) to borrow a digital camera and a projector that can display the camera’s photos.

3. Issue the challenge to the class, showing them the “embedded” skeleton. Give each group its “bones,” one or two toothpicks, a few inches of wire, and a little clay. Have them experiment with the materials before they decide on a plan.

4. Whatever their plan, the bones should be as unaltered as possible. Warn them that, in fact, they will need to take their display apart and reassemble it in a later part of the activity. If necessary, explain the purpose of each material (of course, they may use them differently):
- The embedded bones are an almost two-dimensional, crumpled version of the dinosaur as it actually was. The bones will need to be joined together, probably using clay or wire, to recreate the three-dimensional skeleton.
- Toothpicks can be used as vertical “posts” to hold the skeleton up. One end of the toothpick should go into the base; the other end can go into a joint (the wire or clay) or a small indentation in one of the dowel “bones.”
- These indentations should be made using a thumbtack. This represents the small alterations preparators need to make to fossils in order to display them.

5. The groups should sketch out a plan, predicting how many toothpicks they will need to hold up the skeleton. When you have approved a group’s plan, they can begin assembling their display.

6. If you have a camera, take a digital photo of each display when this first phase is completed.

7. Have the students carefully disassemble their models and collect and record the following data: the mass of the bones, the mass of the wire and clay they used, and the number of toothpicks they used. They can then calculate the joint efficiency of their design by dividing the mass of the bones by the combined mass of the wire and clay, and the post efficiency by dividing the bone mass by the number of toothpicks.

8. Using the digital photos (or the reassembled models), conduct a classroom critique. Here are some assessment criteria:
- Is the skeleton realistically displayed? Do you agree with how the group placed each bone?
- Are foreign joint materials (string and wire) kept to a minimum? Are they efficiently used? Do they detract from the patron’s experience, or are they almost invisible?
- How many posts were used? What is the average weight each supports? Could the mass be distributed more effectively?

9. Finally, students should return to their groups and reengineer their designs in light of the class discussion.

extension ideas

Reading extension:
This book has chapters but no table of contents. Students can create an Annotated Table of Contents that includes a one-sentence summary of, or introduction to, the preface and each chapter. Alternately, have students pick out one sentence or phrase from each section to include on this page.

Research extension:
The book was originally published in 1999 and reissued with some changes in 2003. Have students identify which of the five questions in Chapter 6 have been answered. For older or more advanced writers, have them rewrite this part of Chapter 6 to include the answers. Have the class vote on one rewrite to send to the publisher or the Field Museum!

reference

Your school is surrounded with opportunities to demonstrate STEM occupations, whether you live in the most rural area or in an urban environment. The fact is, most occupations will require workers who have had STEM education. Students must be made aware of these occupations and be put in contact with people who occupy these professions. One scenario that worked well in an elementary school in a nearby community was an occupation fair. Teachers at that school invited professionals from occupations that were typically found in the community. Each professional created a small display related to the work that was being done at his or her business. Many of these people related the requirements for the jobs. Most of the presenters had information about the courses that students needed to take if they wanted to enter that career path.

Another strategy to make your students aware of STEM careers is to invite guest speakers to your class. Many companies and businesses take the time to perform outreach into schools so that teachers and students get to learn about what they do.

Perhaps practicing members of the professions listed below are in your community and could make themselves available for a visit to your school.

**STEM careers**

(The source for these career descriptions can be found at ONET Resource Center, U.S. Department of Labor: [http://online.onetcenter.org](http://online.onetcenter.org/).)

**Accountant**

This profession requires a sound mathematics and computer science background. If you are interested in figures and analyzing budgets, this is a great career. Most accountants prepare, examine, or analyze accounting records, financial statements, or other financial reports to assess accuracy, completeness, and conformance to reporting and procedural standards. They compute taxes owed and prepare tax returns, ensuring compliance with payment, reporting, or other tax requirements. Other duties include analyzing business operations, trends, costs, revenues, financial commitments, and obligations, to project future revenues and expenses or to provide advice.

**Agricultural Technicians**

These technicians work with agricultural interests to insure that animals and crops are raised humanely and without disease that could enter the food chain. The technician often receives and prepares laboratory samples for analysis, following proper protocols to ensure that they will be stored, prepared, and disposed of efficiently and effectively. They record data pertaining to experimentation, research, and animal care. The AG technician must be comfortable around animals and familiar with plants because they need to collect samples from crops or animals so testing can be performed. In the lab, they operate laboratory equipment such as spectrometers, nitrogen determination apparatus, air samplers, centrifuges, and potential hydrogen (pH) meters to perform tests.
Biomedical Engineers
These engineers apply knowledge of engineering, biology, and biomechanical principles to the design, development, and evaluation of biological and health systems and products, such as artificial organs, prostheses, instrumentation, medical information systems, and health management and care delivery systems. A biomedical engineer should have knowledge of design techniques, tools, and principles involved in production of precision technical plans, blueprints, drawings, and models.

Environmental Engineer
Design, plan, or perform engineering duties in the prevention, control, and remediation of environmental health hazards, utilizing various engineering disciplines. Work may include waste treatment, site remediation, or pollution-control technology. They collaborate with environmental scientists, planners, hazardous waste technicians, engineers, and other specialists, and experts in law and business to address environmental problems. These engineers inspect industrial and municipal facilities and programs to evaluate operational effectiveness and ensure compliance with environmental regulations. Environmental engineers prepare, review, and update environmental investigation and recommendation reports.

Mechanical Engineering Technician
Applies theory and principles of mechanical engineering to modify, develop, and test machinery and equipment under direction of engineering staff or physical scientists. They often prepare parts sketches and write work orders and purchase requests to be furnished by outside contractors. These technicians draft a detailed drawing or sketch for drafting-room completion or to request parts fabrication by machine, sheet, or wood shops. They must review project instructions and blueprints to ascertain test specifications, procedures, and objectives, and test the nature of technical problems such as redesign. People in this profession have knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.

Graphic Designers
People in this field design or create graphics to meet specific commercial or promotional needs, such as packaging, displays, or logos. Designers may use a variety of mediums to achieve artistic or decorative effects. This occupation requires knowledge of media production, communication, and dissemination techniques and methods. This includes alternative ways to inform and entertain via written, oral, and visual media.

Operations Research Analyst
These people formulate and apply mathematical modeling and other optimizing methods using a computer to develop and interpret information that assists management with decision making, policy formulation, or other managerial functions. They may develop related software, services, or products. The analyst concentrates on collecting and analyzing data and developing decision-support software. Their duties include developing and supplying optimal time, cost, or logistics networks for program evaluation, review, or implementation. A solid background of arithmetic, algebra, geometry, calculus, statistics, and their applications is required.

Charlie McLaughlin is the Field Editor for T&C. Charlie is the Chair of the Department of Educational Studies at Rhode Island College and the Coordinator for the Technology Education program. He can be reached at cmclaughlin@ric.edu.

Accounting and graphic design are just two STEM-related careers.
introduction

There is a push in American society to engage youth in Science, Technology, Engineering, and Math (STEM) related fields and career paths. The United States is currently experiencing a deficit in the number of professional engineers and technologists available to solve problems. The promotion of STEM topics in education could have far-reaching implications related to the nation’s stability and security. Steven C. Beering, the Chairman of the National Science Board, in a letter to Barack Obama, stated, “Our national economic prosperity and security require that we remain a world leader in science and technology.” With enthusiastic curiosity, elementary level students are generally eager and excited to learn about STEM topics. When presented with the right design-based activity, students are capable of excelling as they develop STEM-related knowledge and competencies. Many times, however, due to the constraints of time, it is often challenging for an elementary teacher to find or develop exciting, standards-based STEM curriculum suitable for the cognitive abilities of younger students.

why teach STEM?

The acronym “STEM” has become very popular in modern dialogue. Many times however, people don’t stop and think about the various disciplines represented by each letter of “STEM.” With this idea in mind, it is important to define the “T” and “E” in STEM. Math and science may be self-explanatory, but technology and engineering play very important, albeit distinct, roles in society. The National Center for Technological Literacy stated, “…technology has a long history—as long as human history. Technologies are solutions designed by humans to fulfill a need. Pens, water filtration, wheelchairs, and tunnels are all technologies. The process that creates technologies is engineering.”

According to ITEA’s Standards for Technological Literacy: Content for the Study of Technology (2000/2002/2007), the United States is becoming increasingly dependent on the use of technologies. As this dependence increases, however, public interest in STEM topics is dwindling. In relation to education, the National Science Board States, “In the next decade, the Nation is going to need 2.2 million new teachers in K-12 schools and community education settings. The greatest need now and into the future is for teachers in the STEM areas” (National Science Board, 2007, p. 1). Engineering your Future (Oakes, Leone, and Gunn, 2006) presents the fact that many students enter collegiate engineering programs without even a clear understanding of the meaning of engineering or its practice. Given these trends, it would naturally seem important to expose children to STEM topics at an early age, and reinforce these concepts steadily throughout the entire K-12 experience.

STEM education may seem a daunting and unrealistic task at the elementary level. The contrary is the case, however, as STEM topics can be easily integrated into core academic subject material. Engineering design curriculum uses math, science, and other core subjects to teach about technology and engineering, all while making schoolwork seem relevant to the young student. Several different engineering design curriculum models have been developed by various organizations. In this article, two curriculum models will be explored. Project Lead the Way (PLTW), offers several elementary lessons that are both exciting and appropriate for elementary level students. Engineering is Elementary (EiE), also featured in this article, strives to promote technological literacy and engineering skills.

two of the available curriculum

Project Lead The Way

Project Lead the Way is a national nonprofit organization offering extensive middle and high school curriculum featuring STEM topics. Project Lead the Way is the largest pre-engineering curriculum available at the secondary level. (Blais & Adelson, 1998, Bottoms & Anthony, 2005). Today, Project Lead the Way boasts serving over 1250 schools in 44 states, reaching over 160,000 students (McVearry, 2003). Project Lead the Way recognizes that, due to high rates of retirement of engineers today and high dropout rates of college engineering students, there is currently a void of over one million engineers in the United States, a huge deficit compared to the total population of the United States, about 304 million people. Project Lead the Way promotes STEM proficiencies through the use of hands-on, project, and design-based instruction. PLTW most
recently has been developing curriculum for elementary students.

Project Lead the Way elementary lessons range from five days to two weeks long. The number of lessons available at the elementary level is currently limited: one third grade lesson, two fourth grade lessons, and two fifth grade lessons are available to teachers. Although there is a limited number of lessons available at this time, they currently are free and will likely prove to be of great value in the elementary classroom. According to PLTW, research indicates that students engaged in problem-based learning, project-based learning, and activity-based learning will exhibit increased performance in their academic achievement, higher-order thinking skills, and cooperative learning abilities.

Obtaining Resources:
Teachers who wish to download the free PLTW curriculum may do so by logging in as a guest at: www.pltw.org/moodle and selecting Elementary Engineering Lessons.

Engineering is Elementary
The Engineering is Elementary curriculum strives to use a wholesome approach to teaching children engineering and STEM topics. EIE utilizes social studies and English skills as a base to promote the “engineering mind-set.” Through storybooks, students are introduced to a diverse set of characters with differing backgrounds. Students are challenged to read stories and design solutions, solving problems faced by the characters. With over one million students and close to 16 thousand teachers, respectively, studying and teaching the EIE curriculum, its influence is formidable. There is no need to be intimidated by this curriculum though; EIE provides professional development opportunities to teachers, providing teaching strategies and content related to engineering education. EIE strives to promote problem-solving skills in children through projects and activities-based learning. EIE provides more course material than Project Lead the Way, although the material does require modest monetary investment.

Obtaining Resources:
Overviews and pricing for storybooks, teacher guides, and material kits can be found on the EIE website at www.mos.org/eie.

example lessons
Project Lead the Way
The following are descriptions of selected lessons taken directly from the Project Lead the Way website: www.pltw.org/moodle.

Grade 3: Why is Air in Airplane?
This lesson uses hands-on experiences to introduce students to how aircraft vehicles fly. A fictional story line is interwoven within the lesson to foster reading and writing skills while students work in an “engineering” environment. Utilizing this approach, students come to understand how engineers work and, in particular, are introduced to aspects of the aerospace engineering field. Students also learn sketching techniques and use basic descriptive geometry as a component of design, measurement, and modeling their solutions. Using an engineer’s notebook and other forms of documentation, students create models and document their work to solve problems.

Grade 5: Designing My Rover!
Through hands-on projects, students explore the science of robots and wireless communication, which is the movement of information and objects using remote-control and sensing devices. Students acquire knowledge and skills in basic design and explore the impact of wireless communication in the field of aerospace engineering and on our lives. They design and prepare a prototype of a remote vehicle that will be built and programmed in a future lesson.

Engineering is Elementary
The following are examples of lessons, and are taken directly from the EIE website: www.mos.org/eie/20_unit.php.

Storybook: Leif Catches the Wind
This unit guides students to think like mechanical engineers as they use their knowledge of wind to design and create machines that can be used to capture wind energy. The storybook “Leif Catches the Wind” reinforces the science concept of air as wind, and introduces the field of mechanical engineering. The wind turbines found in Leif’s home country, Denmark, are used as an example of a renewable energy source and a machine designed in part by mechanical engineers. Students will look critically at several common machines (mechanical pencils, egg beaters, rolling pins) and diagram
how the parts of the machine interact with other parts of the machine and allow the object to function.

Students will then use their mechanical engineering skills to explore different materials and shapes conducive to catching the wind, first by designing sails for small boats, and finally for designing windmill blades.

**Storybook: Michelle’s MVP Award**

Michelle and her older brother, Tim, play on a hockey team together. Tim is one of the best players, and Michelle (who has Down syndrome) usually doesn’t mind getting help with hockey from her brother. Michelle contributes to the team in her own special way: by making a Most Valuable Player (MVP) award out of play dough, which is given to a team member after every practice.

When Coach tells the team that they have the chance to see the Toronto Maple Leafs play in a professional hockey game, everyone is excited—but they need to raise a lot of money to buy the tickets. The team needs a great sales idea for their booth at the school fair, and Michelle’s play dough might be it. With some help from her Uncle Adam, a chemical engineer, can Michelle become the team’s MVP by creating a fun, easy-to-follow play-dough process?

Readers are encouraged to design and improve their own play-dough processes. With some creativity and knowledge of the engineering design process, everyone can engineer!

**references**


**Standards for technological literacy:** Content for the study of technology. Reston, VA: Author.


Daniel C. Brenner is a graduate research assistant in the Department of Industrial Technology at Purdue University in West Lafayette, Indiana. He can be reached at dbrenner@purdue.edu.
Open Tech Lab first started during my year of student teaching. I was fortunate enough to student teach with Tom Pachera, DTE in his middle school classroom. As it came close to the end of the semester, many students wanted extra time to finish their technology projects, so we opened the technology lab after school to allow students this opportunity. So, I vowed to continue the practice once I had my own classroom.

I’ve now finished my second year teaching at Honey Creek Community School in Ann Arbor, where I am the school’s Technology Specialist. Honey Creek is a public charter school for students in Washtenaw County. We teach Grades K-8, with approximately 200 students. I teach technology classes for students in Grades 2-8 and oversee the school’s IT department (I wear many hats due to the small size of the school). For the past two years, I have offered Open Tech Lab as a way to provide our school’s students with more opportunities to engage with technology.

Open Tech Lab is structured as a once-a-week, one-hour after-school activity. It is limited to the first 10 kids to sign up each week. This is intentional: by limiting the group to 10 students, I am able to spend more time with each student; it’s not overwhelming for me (since this is my own time that I’m donating); and it gives the whole thing an element of excitement. Students want to make sure they get their names on the list, and it’s perceived as being a cool, exclusive opportunity, which builds its appeal among the school community.

So what do students do during Open Tech Lab? Whatever they want, within limits! Here are some examples.

As I mentioned, I teach technology starting at Grade 2, so there are a number of K-1 students who are really excited to have the chance to use the school’s technology resources. Open Tech Lab gives them an opportunity to get involved right away, and I get a chance to start building a relationship with them. Several first graders showed up the first weeks of Open Tech Lab this year, and they built great stuff out of Lego NXT and RCX hardware. One of the first graders built a working NXT claw during his first session, using two servos and the NXT brick. I’ve had middle school students who weren’t able to come up with a design as elegant and workable—and he built and programmed it in 20 minutes! An unexpected side effect is that I now have a great list of candidates for next year’s FIRST Lego League and Junior FLL teams.

Some students use Open Tech Lab for its original purpose—to finish technology projects outside of class time. Students used time in Open Tech Lab to finish making crayons for our Green Chemistry unit, work on 3D house models for the Sustainable House Design project, and edit audiobooks that are recorded for our building’s preschool program.

My hope is that students will use Open Tech Lab to do the sort of free exploration that they don’t necessarily get to do during school hours, and in large part this hope has been realized. Examples of this include students exploring Google Earth with a laptop, by Bill Van Loo.
WHAT WORKS

Building Lego creations, or using tools they haven't used before. One aspect of this program that I didn't anticipate but has proved wonderful is the way that students from different classes and grades interact. Since Open Tech Lab is open to students from Grades K-8, there is generally a wide mix of ages. Older students share information, tips, and ideas with younger students, and vice-versa.

While the kids are building and exploring, I find myself doing the same things. This is a nice chance to try out that unformed project idea, or practice taking pictures of student work, or program a new Web page...the list goes on and on.

In summary, Open Tech Lab has proved to be well worth my one-hour-per-week time investment. It builds my relationships with a wide range of students, helps build my program, and inspires children. It's hard to ask for more than that.

Bill Van Loo is the Technology Specialist for Honey Creek Community School in Ann Arbor, Michigan. He can be contacted at bill@billvanloo.com or www.billvanloo.com.

EDITORIAL

Continued from page 2

Economy. It would worthwhile to invite representatives of local business and industry to participate in developing interesting scenarios to investigate in your classes. Certainly, the exposure to your program could stimulate necessary and valuable relationships between the school and STEM professionals. Imagine special projects in which engineers, scientists, mathematicians, and technologists could work side-by-side with you and your students. The relevance of what students were learning would be hammered home in such projects. Such collaborations would also make a wonderful bridge between the STEM occupations and the work of the school.

A dimension of STEM programs that needs to be in place to ensure success is that of professional development. Teachers, candidates, and veterans alike need to have a solid foundation in the content and methods of STEM. Only high-quality preparation will insure that STEM programs remain vital in our schools. Schools and local post-secondary institutions can collaborate to improve the teaching of STEM materials. In several states, STEM centers have been created. These centers offer teachers and teacher candidates opportunities to develop cutting-edge materials and practices that they can bring back to their classrooms. The benefit of these centers is that they often showcase best practices. Much of this work is done in collaboration with "expert" faculty and teachers. Interested teachers can find centers online where lots of cutting-edge materials and practices are available at no cost.

Teachers who participate in STEM professional development have extraordinary opportunities to create partnerships with community business and industry leaders. Professional development also strengthens communication between stakeholders. All elementary teachers ought to take advantage of STEM professional development opportunities that STEM centers or their school systems offer. Not only will they benefit, but their students will also have the advantage of being taught with best practices and up-to-date materials.

Charlie McLaughlin is the Field Editor for T&C. Charlie is the Chair of the Department of Educational Studies at Rhode Island College and the Coordinator for the Technology Education program. He can be reached at cmclaughlin@ric.edu.

Bill Van Loo is the Technology Specialist for Honey Creek Community School in Ann Arbor, Michigan. He can be contacted at bill@billvanloo.com or www.billvanloo.com.
We hear it over and over…the world continues to increase its reliance on experts in the fields of science, technology, engineering, and mathematics. But statistics show a dramatic void in the number of Americans going into these occupations. In order for our country to keep up with the world, STEM education must begin in elementary school. So…here are some ideas to get you started!

**language arts**

- On April 27, 2009 President Obama spoke at the 146th Annual Meeting of the National Academy of Sciences. His speech emphasized the importance of science, technology, engineering, and math and was a turning point for STEM education. [www.nas.edu/morenews/20090428.html](http://www.nas.edu/morenews/20090428.html) (speech/video/transcripts)

- As a class, discuss how government and legislation can help or hinder education. How might the new STEM Ed laws change things? How did the NCLB laws change education? Why is it important to have a national focus or standards for education? What was our country like before standardized education? Brainstorm historical examples and how they changed our country—not just in education—but bigger impacts.

**math**

- What if YOU were in charge or could write educational legislation? Have your students interview each other in writing, video, or podcast. Sample interview questions: What would you change? What would be your focus and why? What would the impacts of your legislation be?

- Teach your students the tools of the trade! Mathematics is a crucial tool for construction. First decide on an age and experience-appropriate construction project. If construction is brand new to your students, start with an assembly kit, then move on to include the full design process to develop their own project.

**During the design stage:**

Discuss scale and actual size. Have your students label their designs with measurements before construction. If measurements change during actual construction, record the final measurements on the designs.

**During the construction stage:**

Students should measure and mark all construction material that needs resizing. For safety,
Robotic programming is all about math and logic! You can purchase programmable robots for around $100. With these robots, your students learn how to logically breakdown movements into measured sequence. If your robot actually “travels,” your students can also measure distance and turning in degrees of circle. A fun way to introduce basic commands is to have your students “be a robot” and act out each command that you, the “programmer,” call or write. If buying a robot is not in your budget, you can try “Bots” for virtual programming: www.iknowthat.com/com/L3?Area=BattleBot_Puzzle.

Learn the language of robots!

- Learn the language of robots! Robotic programming is all about math and logic. You can purchase programmable robots for around $100. With these robots, your students learn how to logically breakdown movements into measured sequence. If your robot actually “travels,” your students can also measure distance and turning in degrees of circle. A fun way to introduce basic commands is to have your students “be a robot” and act out each command that you, the “programmer,” call or write. If buying a robot is not in your budget, you can try “Bots” for virtual programming: www.iknowthat.com/com/L3?Area=BattleBot_Puzzle.

- Catapult your students into STEM! Build a Trebuchet! First, review the physics of forces and simple machines—www.neok12.com/Simple-Machines.htm. Then get your students all fired up with some footage of real trebuchets in action. http://pbskids.org/dragonflytv/arentsteachers/tguide_rebuchet.html or www.youtube.com/watch?v=Z-O_b4Oy054

- Ready to launch the trebuchet!

- STEM at its best—building a trebuchet!

- Wheelbarrow construction – success!

science

- We use the scientific method to systematically discover and yield an end result or solution; but innovation requires something more. It requires multiple pathways of plausible solutions revealed through the design process. Integrating both of these methods invites your students to engage in their learning through real-world application.


  ✓ (Scientific Method) www.stuperb.com/wp-content/uploads/2009/03/overview_scientific_method2.gif

TECHNO TIPS
✓ **Research:** Now it’s time to form the trebuchet teams and embark on interactive research for a design. In this online simulation, teams will experiment with variables of counterweights, lever and sling length, fulcrum placement, and structure base to destroy a castle. Teams should record all successful combinations and use this information in their team design. [www.pbs.org/wgbh/nova/lostempires/trebuchet/destroy.html](http://www.pbs.org/wgbh/nova/lostempires/trebuchet/destroy.html)

✓ **Design:** Should be research-based and include measurements (can be added after final construction).

✓ **Construction:** Teacher decides scale, building material, and projectile before start of project. Good projectiles: fresh marshmallows, ping-pong balls, H₂O balloons. Easy build—use balsa wood kits. More difficult build—and more fun—use donated scrap lumber and junk. Follow the construction safety and procedures stated earlier in “math” section.

✓ **Testing:** Designate a launch site to test the trebuchets. (Use a “squishy ball” to test H₂O balloon). Teams may need to repeatedly modify and repair designs. Teams should record and average three distance tests.

✓ **Launch:** Have the class draw a castle and place at end of launch area. Teams can compete for longest distance. Wearing safety goggles, teams can also launch the fresh marshmallows or H₂O balloons at each other or, depending on bravery, the teacher!

### Social Studies

- Some of the most promising career opportunities are and will be found in the areas of science, technology, engineering, and mathematics (STEM). Search your community for people who work in these areas, then invite them in to show and tell! Also, for some real excitement, invite NASA for visit! Contact the NASA-Ames Education Outreach Center: [www.nasa.gov/centers/ames/education/speakersbureau.html](http://www.nasa.gov/centers/ames/education/speakersbureau.html).

- These days, we live in a global community—so get your students involved! Students can raise money for a global cause by designing, manufacturing, marketing, and selling a product. Some ideas for mass-production: homemade candy, formed plaster/plastic pendants/duct tape accessories, etc. Be sure to search online for any cause-related, reputable organizations. If contacted, they will sometimes match your donations.

- If you’re looking for more, go to: [www.iteaconnect.org](http://www.iteaconnect.org)

Krista Jones is a teacher of elementary technology education, Grades K-5, at Bellevue Elementary School, Bellevue, Idaho. She can be reached via email at kjones@blaineschools.org.
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