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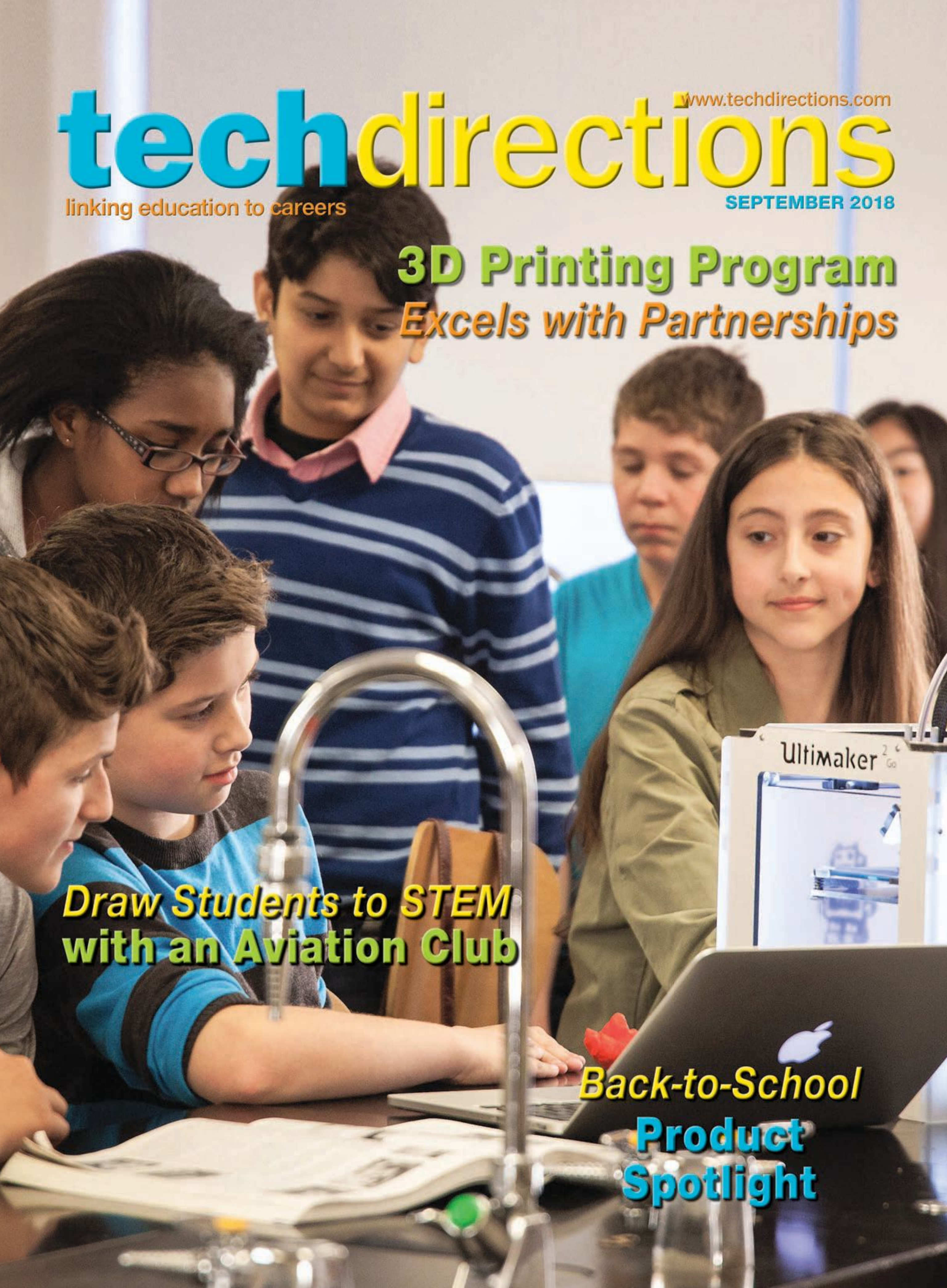

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technically speaking

Vanessa Revelli vanessa@techdirections.com

Welcome back to another school year, readers! Our 3D printing issue once again sent me on a research adventure. A lot has changed over the last year is this field. Some of it amazes me with the potential to help people, and another change made me take pause.

According to sculpteo's "State of 3D printing 2018" (https://www.sculpteo.com/en/get/report/state_of_3D_printing_2018/), prototyping (55%), production (43%), and Proof of Concept models (41%) are the three most popular 3D printing applications in 2018. One amazing example of prototyping in the medical field has me very excited. University of Toronto researchers have created a handheld 3D printer, which looks kind of like a white-out tape dispenser, that prints layers of skin tissue. The printer deposits the tissue, and sets it in place, in 2 minutes or less. The printer prints strips of "bio ink" which consists of protein-based biomaterials including collagen and fibrin which aides in wound healing. This amazing improvement on pre-existing technology would be able to be tailor tissue to specific patients and wounds. To see the device in action, and to read more, visit: https://www.utoronto.ca/news/u-t-researchers-develop-portable-3d-skin-printer-repair-deep-wounds.

Another fun search took me to Vermont to read about a 3D printing competition for middle and high school students. Each team had to create a 3D model of a historic building. The challenge was to "Identify a local building of historical interest, then model it. Buildings included libraries, post offices, hotels, prisons, churches, schools, and homes. Students had to research the site, which meant digging into primary source materials (period blueprints, journals, newspapers, letters), reading into secondary sources (books, articles, web documents), interviewing people (building owners, historians, architects), and exploring the site directly (an interesting number of students never got inside their objects)." From there they had to build digital models, and eventually 3D printed models of the buildings. To see photos and read more about this competition visit: https://bryanalexander.org/education-and-technology/middle-and-high-school-students-doing-history-with-3d-printing/

A final side of 3D printing took center stage this summer in the form of plans for a 3D printed gun. This created a lot of fear that a largely plastic weapon would be undetectable, and that anyone with access to a 3D printer could make one which would derail safety measures put in place like background checks. If you want more information about what is currently going on with this case in Texas, visit https://kristv.com/news/state-news/2018/08/14/texas-man-in-3d-printed-firearms-case-welcomes-legal-battle/. I am not going to take on this debate in our magazine, because I don't believe it is the place for it, but I do hope that this conversation makes people pause and think about our responsibility with the technology we possess, and how we are going to use it in the future.

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About the cover: Students watch as a 3D printer prints a model. Cover design by Sharon K. Miller.

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the news report

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Virtual Campus Brings Real-World Scenarios to More Students

A proof of concept is underway in the South Central Coast Region to embrace and actuate the California Community College Chancellor's Strong Workforce Program objectives to increase enrollment and facilitate more student completions. Stakeholders throughout the region are working together to bring cloud-based labs to eight community colleges. The region spans Northern Los Angeles, Ventura, Santa Barbara, and San Luis Obispo counties. See the full case study at https://ict-dm.net.

This effort allows students to access labs for a variety of Information Technology (IT) and cybersecurity classes at any time and from anywhere. It also significantly reduces faculty workload thus allowing them to serve more students and increase the number of trained professionals in the workforce to fill the thousands of open IT positions in California and across the United States.

Traditionally, students have practiced computer networking and security skills at a centralized physical lab (and equipment) or a limited virtual lab appliance at their educational institution. Physical labs and college-based data centers have high costs associated with the maintenance and repair of the hardware and software.

An external service providing a turn-key virtualized environment that is identical to the corresponding physical environment will decrease the need for high-cost physical labs yet provide open virtualized environments that let students experience the real-life scenarios that are critical in educating for technical careers. Virtual lab platforms must serve students with on-demand, 24×7×365, access to a virtual lab environment from anywhere there is an internet connection. Virtual labs must also represent the full functionality of a real-world setting.

The project is being coordinated by SynED, a non-profit organization dedicated to promoting innovation in education, at all levels, through research and providing higher education professional services to facilitate the development of new models of curriculum, industry alliance, service, and delivery.

Jerry Buckley, Chief Instructional Officer at College of the Canyons, one of the region's colleges, sees the conversations happening around this project as reminiscent of the discussions that took place as the first computer labs were being built in the 1990s.

"Virtual labs provide a great opportunity to completely reimagine how students engage with technology on and off campus. This opens up educational resources to students and to faculty, who now have access 24×7. You couldn't say that five years ago," Buckley said. "There will still be computer labs, but they will become more specialized and represent a different set resource to a different group of students."

Focusing on the finished solution allowed the team to delve into the heart of the problem they were trying to solve by selecting appropriate technology, rather than choosing a technology first then finding a problem for it to solve. Free from bureaucratic constraints, the team was able to create a vision for better serving students, enabling faculty while still being institutionally and financially sound.

Early results from the virtual labs proof of concept are positive. The pilot project will continue throughout the upcoming academic year. If this proof of concept is successful, the virtual lab service can be expanded to include other sectors and K-12 schools.

Ed Garcia, an IT faculty member at Moorpark College, began using virtual labs in his courses this summer and has already been able to increase his class capacity from 25 students to 40 without adding any additional lab space, hardware, or work to his already full plate. He estimates that his workload will be reduced by half, which will allow him more time to focus on training adjunct instructors and developing the curriculum for a new associate degree in cybersecurity.

"I really believe this is a new digital divide because the training is at a whole new level of sophistication and student confidence and experience will be off the charts," Garcia said.

Utilizing a virtual lab service has the potential to bring equality of access to students across the region. Smaller colleges and those in economically-disadvantaged areas can offer their students first-rate opportunities without incurring any additional overhead costs. Since access to labs is browser-based and requires relatively low-cost computers, colleges may also be able to shift funds from maintaining physical computer labs into purchasing inexpensive laptops, tablets, or other devices that students can use to access virtual labs—something that will benefit students who are not able to purchase these devices on their own.

Mark Peterschick, an IT instructor at Allan Hancock College, said virtual labs provide a critical missing piece necessary for students to complete A+ certification. Students can work at their own pace and gain the skills necessary to complement what they learn in the classroom and ultimately become workplace-ready technicians.

If the proof of concept in the South Central Coast Region is successful, the project team will begin the RFP process for a long-term production contract for all eight of the region's colleges. td

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Vanessa Revelli is managing editor of **techdirections**.

technology today

Alan Pierce
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WattUp®—Charging from 15' without Wires or Pads

Currently, wireless charging requires the placement of your smartphone or other electronic device on a special charging pad. The pads used to charge your devices transfer electricity using an MIT breakthrough called magnetic resonant coupling. This technology demands physical contact between the transmitter and the receiver in your device. What we are going to explore today is a new technology that will allow your devices to charge just by being in the same room as the transmitter.

The WattUp charging-at-a-distance transmitter fills the area where it is installed with low power radio frequency (RF) waves. These RF waves are converted by a proprietary chipset into a low-voltage DC charging current. For this new technology to take off, the chipset, or one with a similar design, must be installed inside the device it is going to charge (Photo 1).

A WattUp transmitter can charge many devices at the same time but this is a slow charging system (Photos 2 & 3). The concept is that your devices will always be topping off their charge when they are in range of a transmitter; these transmitters could eventually find their way into every location where you now find free WiFi.

Just like the resonant magnetic coupling technology mentioned above, for this technology to take off it needs to meet stringent safety standards. Because it is transmitting a frequency that is a part of the electromagnetic spectrum, it also needed Federal Communications Commission (FCC) approval for it to be used in the United States.

In December 2017 the FCC granted Energous, the company that created WattUp, approval for their near field transmitters to transmit at 900 MHz for wireless charging at a distance of up to 3'. In April 2018 the distance between the transmitter and the embedded receivers that would need to go into phones, tablets, earphones, hearing aids, and other electronic devices was raised to 15'. You can explore the FCC 2017 approval online at: https://fccid.io/2ADNG-MS300, and the 2018 ruling to raise the charging distance at https://bit.ly/2LuGB6Z.

The FCC was one of many roadblocks that this technology needed to pass before it even stood a chance of becoming a ubiquitous charging-at-a-distance reality. It has now also passed stringent Underwriters Laboratory testing so it now meets all U.S. requirements for commercial use. Before manufacturers adopt this

Photo 1—This extremely tiny chipset can convert RF waves into electricity to charge your electronic devices.

Photos courtesy Energous WattUp®

Alan Pierce, Ed.D., CSIT, is a technology education consultant. Visit www.technologytoday.us for past columns and teacher resources.

Photo 2—These devices could be charged at a distance when this technology is adopted by their product's manufacturers.

technology and build the receiver directly into their products, the chipset could be built into an accessory charging case. This would be similar in design, but much flatter, than backup battery cases now sold for smartphones. This kind of introduction into the marketplace would be taking a page from the roll out of magnetic resonant charging.

Since we live in a connected world Energous has also filed for international approval with all the necessary regulatory organizations throughout the world. The last hurdle will be to get the different manufacturers to include the necessary chipset in their products. This Energous video can further your understanding of this new technology: www.youtube.com/watch?time_continue=53&v=6INH8o6GLec.

Taking it a Step Further

1. What is the electromagnetic spectrum and is it safe for us to be bathed in its waves of energy?

2. At this point in time it appears that Energous is the leader in charging-at-a-distance technology. Research the other companies that are exploring other parts of the electromagnetic spectrum to bring energy to our smart devices.

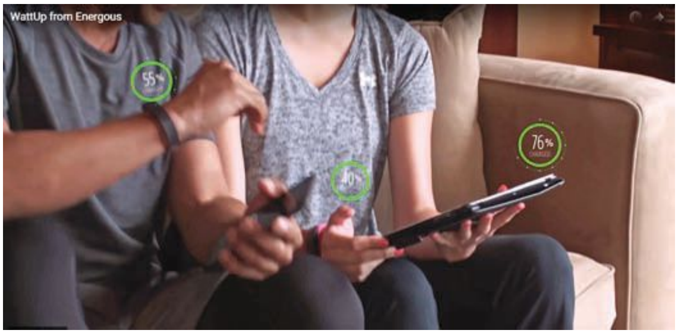

Photo 3—Your devices will constantly refill their battery slowly even when you are wearing or using them. The chipset will automatically stop charging when your device is fully charged.

Dennis Karwatka
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Paul Revere Williams—Architect to Hollywood Stars

Architects often specialize in certain areas of construction. They might work on private houses, government buildings, hospitals, or airport terminals. One person from the mid-20th century designed over 2,500 of those structures but is best known for his residential architecture. Several Hollywood film stars of the past employed the services of Paul R. Williams.

Paul R. Williams

Williams was born in Los Angeles, CA, in 1894. His father owned a small fruit market; his parents died of tuberculosis before he was four years old. Both he and an older brother were raised by foster parents.

Williams demonstrated an artistic talent in elementary school. His high school offered architecture classes and he took all he could. He entered a 1914 design contest for a neighborhood civic center and won first prize.

Williams and seven others studied architectural engineering at the University of Southern California for two years. He used a telephone directory to identify architectural firms as potential employers. He visited several in 1919 and accepted a job at one that offered him $3 per week. He married Della Givens in 1917 and they had two daughters.

Williams worked at various companies until winding up at one that specialized in designing upper-middle-class homes. A high school friend introduced him to a developer who was building houses near Pasadena in 1921. The architectural contracts Williams received earned him enough money to open his own office the next year. Even at that early point in his career, his work showed the grace and elegant proportion often associated with America's best architects.

One important client was E. L. Cord, manufacturer of the 1930s classic Cord automobile. Cord was uncertain about Williams and asked when he might complete a set of preliminary plans for a huge 15-bedroom residence. Williams calmly said, "Would tomorrow at four o'clock be soon enough?" Cord was amazed because other architects had required three weeks. By working nonstop for 22 hours, Williams met the deadline and received the assignment. The Cord house was completed in 1933 but taken down in 1963 for a newer development.

Williams went on to design homes for movie stars of his era including Lon Chaney (1930), Bill "Bojangles" Robinson (1939), Lucille Ball (1954), and Frank Sinatra (1957; torn down in 2006). All his clients appreciated Williams's ability to sensitively integrate his structures with the surrounding landscape.

Williams participated in other architectural projects, like the space-age design style of the Los Angeles International Airport Theme Building (1961). His work also included the Los Angeles County Courthouse (1958) and extensive modifications to the Beverly Hills Hotel (1951). He designed the St. Jude Children's Research Hospital (1962) in Memphis, TN, at no charge. Williams had earlier designed Langston Terrace (1936) in Washington, DC. It

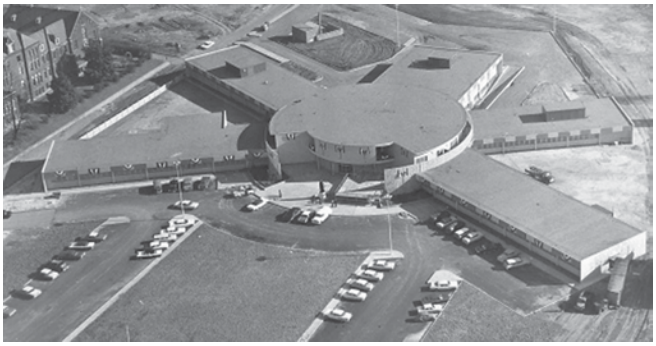
Above, house designed for E. L. Cord

Left, house designed for Lon Chaney

House designed for Frank Sinatra

Dennis Karwatka is professor emeritus, Department of Applied Engineering and Technology, Morehead (KY) State University.

The Los Angeles International Airport Theme Building



St. Jude Hospital

was the first federally funded public housing project in the U.S. Eight of his buildings are listed on the National Register of Historic Places.

Williams had a large staff with offices in Los Angeles and Washington, DC. In 1923, he was named the first African-American member of the American Institute of Architects (AIA). Along with legendary house designer Frank Lloyd Wright (1867-1959) and others, Williams was the first African American to receive the AIA Gold Medal in 2017 (posthumously), one of the profession's highest honors.

Williams was an impeccably dressed, pleasant, and approachable man who always kept the needs of his clients in mind. He once said that he had a lot of fun spending other people's money. Many of his early papers and photographs burned in a building fire during the 1992 Los Angeles riots. Williams died in 1980.

Modern Hollywood stars Denzel Washington, Ellen DeGeneres, and Andy Garcia have lived in his homes. Williams-designed houses occasionally come up for sale and command high prices. One 2018 listing was recently offered for over $16 million.

References

Block, Maxine (Ed.). (1941). *Current biography.* H. W. Wilson Co. Publishers.

Hudson, Karen E. (1994). *The will and the way: Paul R. Williams, Architect.* Rizzoli Publications.

Six Steps to Building ROI into Your Curriculum

How to Partner Your School with Local Businesses

By Stratasys

THE first time Mike Bruggeman understood the power of business partnerships for his engineering students was when he had them work on a project for Klean Kanteen, a Northern California company that makes reusable water bottles and food containers. The owners were attending a community college class Bruggeman was teaching to learn how to use AutoCAD so they could develop sippy cup lids for a "kid canteen" line.

Bruggeman suggested they let his students at Chico High School in Northern California tackle the project. With a day of effort, the high schoolers had come up with potential designs, and a day after that, they had created prototypes on their 3D printer. The Klean Kanteen team brought their bottles into the school, tested out the lids and, impressed, agreed to sponsor the high school's conversion from its education license for SolidWorks into a commercial version that would let them legally share their CAD files.

"That launched us," says Bruggeman. From that moment on, the high schoolers could go to other businesses and offer similar services, giving students real-life experience in 3D design and prototyping, interaction with clients, and other skills that have proven valuable in college and careers.

Student Dillon Silverman and instructor Mike Bruggeman set up the Stratasys 3D Printer.

The Chico Unified School District program is unique, a model program that many school systems would like to emulate for their students. Here are six rules of practice to set up a business partnering operation in your school district in order to create a career-focused learning environment for your students.

1. Pursue Partnerships Only after You Have Ample Experience.

You can't expect your first- or second-year students to be able to tackle professional design jobs. Save those for the older students.

In fact, advises Bruggeman, if you don't have at least several years of teaching on the design software and working with 3D printing, it may be premature for you to go hunting for business partnerships. Why? Because "you can't fail on these people, or they'll get impatient with you and they won't call you back," he says.

Chico Unified School District has two high schools, Chico High and Pleasant Valley High,which have a combined attendance of about 3,700 students. Bruggeman and fellow instructor Tom Phelan teach nearly 500 students a year in their industrial technology courses—the biggest elective program in the district—and run regional occupational programs (ROP) in CAD drafting and architecture for juniors and seniors. Unless they're part of an internship out in the field, ROP students meet for class two hours a day, and that's when the commercial work is done.

TIP: Follow a zero-failure policy. That applies to the internships Bruggeman's students have as well as the design and prototyping jobs they tackle. "When a project comes in the door, we won't take on another one unless we've completely satisfied that customer."

2. Work Your Contacts.

Selling student 3D printing services in your local community requires a huge effort by you and your students. Expect to hit up your own network, ask your students to talk with their family contacts, and go to your school's supporter network to make inroads into the offices of decision-makers.

Bruggeman says he "put a lot of miles" on his truck, visiting local companies, knocking on doors and talking to business owners. Although they'd say, "'We'll get back to you on that,' we would never hear from them again," he recalls.

Bruggeman struggled to parlay the success with Klean Kanteen into additional projects—until a local salesman and installer who worked for MJB Welding Supply, a company that serves the Chico region, offered to take him around to meet clients. "He had seen what we'd been doing. He saw the skill sets and the type of software and equipment we had. He felt comfortable enough to do that for us," explains Bruggeman.

Armed with that salesman's recommendations and introductions, Bruggeman and Phelan finally found the traction they needed to gain more work from the business community.

TIP: Local companies look good when they support local schools. Be prepared to allow them to publicize the work they're doing with your students and make sure to give them upbeat press in your own school communications to amplify the news about the kinds of projects your students are doing with them.

3. Provide In-Person Service.

The advantage of working with local businesses is that they can visit the school in person to present the objects they want accessorized or modified with new components. This is important because it lets the students get involved at the beginning of the project. They become a part of the initial planning phase and can begin to do whatever reverse-engineering they require and study the setting where their parts will have to fit.

As an example, recently a new client came into Chico High with his Can-Am Spyder, a three-wheeled motorcycle. He had designed a prototype for a wheelchair carrier that would fit on the motorcycle. What he wanted was a SolidWorks design file. The students set to work taking photographs and measurements from which to start their work.

"Most of the time people who walk through the door don't have much in the way of drawings or sketches. That's why they're coming to us. Our students are very talented with computers," notes Bruggeman. During the design process, if there's a part that just doesn't seem to be working, they'll redesign it and print it on the 3D printer to give the client a better idea of what's needed.

In another example, Woodzee, a wooden sunglass company based in Chico, was going to get its own3D printer until the cofounder's high school-age son convinced him to use the services of the ROP students. Now he brings his staff in to try on the sunglasses the students have prototyped, mark them up and tweak the drawings. "We keep going at it until they're happy," says Bruggeman.

TIP: The interactions between students and design clients are as important as the computer and 3D printing work, because these meetings teach students what kinds of questions to ask, how to record the information, and how to approach a new design problem.

4. Be Conservative about Timing.

Use your industry experience when estimating how much time a project will take for students to finish. What you don't want to do is give business partners less than they're expecting.

When a job comes in, Bruggeman is upfront about finding out just how fast turnaround needs to be. "Things do go slowly at a school. We only meet for two hours a day," he says. "I don't want to be the one to hold them up. If I don't think we can meet their deadline, we don't take it."

If a project runs longer than the estimate, he won't take on any additional projects until it's finished. "Sometimes I have a waiting list. People will say, 'Hey, no problem! If you guys can get to us, we would love to have you do it. Just let us know.'" Involving students in the timeline creation and holding them to it is one way to make sure projects are completed on schedule. By enforcing deadlines students learn the importance of delivering on a business agreement in a reasonable amount of time.

Silverman reverse engineered Briggs & Stratton small engine parts and printed physical models on Chico Unified's Dimension 3D Printer.

TIP: The use of professional-grade 3D printers pays off for Chico Unified by producing higher quality parts than hobby-grade 3D printers—particularly important when the project involves business partners, says Bruggeman. Currently, he runs Stratasys® 3D Printers for client work. "The Dimension® 3D Printer has offered legitimacy to my programs," he says. "And the way I see it, it was well worth the money as far as motivation for the students. It encourages them to do higher quality work from the start, and has been the catalyst for teaching them how to communicate technology with our industry partners." ▶

5. Create a Bartering System.

Don't expect monetary payment from your business partners. There's something much more valuable than money that they can provide for your program: class mentoring and supplies.

Bruggeman estimates that the work his students are doing saves their clients "thousands" by producing 3D printed prototypes and parts. In return, "All we ever really ask is to keep supporting the students, give them the chance to learn and materials to do it with."

For example, the students have worked extensively with Tim Dexter, whose company, Westside Research in nearby Orland, CA., creates designs for automotive cargo gear. When they're developing projects for Dexter (such as fasteners or collapsible mud flaps), he comes into the classroom weekly. His focus is twofold: to help the students improve their engineering skills by learning how to do research and rework 3D parts to work better together; and to help them improve the product's functionality, look, and safety to better satisfy the ultimate consumer.

The personal mentoring time is invaluable to students who can interface with a professional who is running a successful business—a kind of learning that students are not always able to get in a classroom setting.

Besides mentoring, Dexter also supplies material—filament—to keep the 3D printers running. That extra material lets Bruggeman's younger students—the ones not yet in ROP— practice their design and prototyping skills as well.

TIP: Internships are the ultimate payoff as far as Bruggeman is concerned. "My approach is, if we can do something for you, will you do something for the students—give them a chance?" Probably the ROP's number one supporter is Thomas Manufacturing in Chico, which keeps two interns working in their engineering department "around the clock, all year long." There's always one senior and one junior, the older student training the younger one, and both are paid for their hours. The welding company, which fabricates agricultural equipment, has already hired Chico Unified students as interns for five years. "We've pretty much become an integral part of their engineering department," Bruggeman says.

6. Prime Your Students to Work with Businesses.

The results of engineering classes cry out to be contained in a student portfolio, preferably online in digital form and maintained in a way that it can grow as a student moves through high school.

One of the first assignments freshmen at Chico Unified must complete is to write a resume. That starts their portfolio, which grows as they complete work samples.

Bruggeman has turned to website builder WIX, a service that lets people create sites for free. There, he maintains his own website (chsitech.wix.com/chsitech) and his students create their websites. Now, when students go to an interview related to their ROP work, they take a laptop computer and share their digital portfolios. "Business owners see that, they go 'that's impressive.' They like that a lot," he says.

He also has them document the processes they follow in their design and prototyping work, serving two purposes: That "tutorial" is used as curriculum by the next student to come along and tackle the same assignment; and it provides more portfolio fodder.

"We have turned the writing over to the students so they learn how to do technical writing," explains Bruggeman. One recent project required a team of students to create a "functional hinge" in SolidWorks and then print it out "with the proper tolerances to accept the pin and perform correctly." Once they've created a working prototype, they have to write up the process to help other students "achieve a successful outcome."

A prototype for a local manufacturer designed by Silverman

Every one of the students in ROP for industrial technology at Chico Unified for the last three years has gone to college. Before they head out the high school door, they've already earned up to nine college credits. On top of the technical skills students have gained, adds Bruggeman, they've learned how to be dependable, communicate with adults, and "get the job done."

Even as schools are putting a bigger emphasis on project and competency-based learning in their academic programs, Bruggeman believes partnering with local businesses can give students the extra boost they need to succeed. "The students who only have academics—they're a dime a dozen. They really don't have anything tangible to apply to their learning. They don't know why they're doing it," he says. "The best students are the ones who combine their academics and a career pathway."

TIP: Be prepared to modify your curriculum as you get feedback from your business partners. Bruggeman maintains an informal advisory board to stay on top of new skills companies want students to have. And then make sure those skills are reflected in the projects profiled in student portfolios.

Other Educational Uses for a 3D Printer

The process of working with business clients to develop designs, prototypes, and products will provide your students with real-world skills that will serve them their entire college and professional careers. But there are other invaluable educational uses for 3D printing in the classroom as well:

- Drive student engagement with 3D printed objects that would typically only be seen in photos. Picture passing 3D-printed bones, organs, molecules in science, or historical artifacts in social studies.
- When something breaks in the classroom, put your students' problem-solving skills to the test by printing replacement parts.
- The use of 3D printing in art and multimedia classes allows your students' imaginations to soar. Artists create their own masterpieces in three dimensions.

The Hunt for Good Curriculum

Chico Unified School District's Mike Bruggeman maintains a website (chsitech.wix.com/chsitech) where he posts the entire curriculum that he and colleague Tom Phelan have developed for classes in their industrial technology program. To find them, choose the "Resources" link in the main menu and pick either "Teacher Curriculum" or "Tutorials."

Bruggeman says he makes the content freely available to help other teachers "build a sequential set of classes that provide the skills necessary to be able to approach businesses." Working through those tutorials will give the teacher "evidence" that the students "are capable of doing this kind of work."

How to Acquire a 3D Printer for Your School

Wondering how to obtain the kind of professional grade 3D printing gear that will impress potential partners? Chico Unified's Bruggeman cobbled together money from multiple sources: grants from the federal Perkins Career and Technical Education Improvement Act and the state's Regional Occupational Centers and Programs, as well as "a little district funding." Besides pursuing grant funding, you can supplement those options with other sources:

- Partner with your local community college or state university for access to their printing equipment. Let them know also that you're interested in acquiring their high-end quality equipment when they choose to upgrade.
- Team up with other school districts in a consortium sharing arrangement. That's how Campbell-Tintah Public School in Minnesota does it. For $3,000 a year, the high school gains access to 3D printers and other maker-gear for a scheduled period, then it goes off to the next district.

6 Rules for an Excellent Business Partnership

1. Do persist. It's going to be tough to get your program off the ground.

2. Don't go into a business partnership before you and your students are really ready for it.

3. Do take advantage of face-to-face contact with clients to help your students learn how to work with customers.

4. Don't take on more projects than your students can complete with absolute success and total customer satisfaction.

5. Do help your students build up their professional portfolios by documenting the projects they work on.

6. Don't think you're going to get rich; business partnerships are about adding real-life experience to your curriculum.

Which 3D Printing Material Should I Use?

By Nicola Popplewell

WHEN it comes to 3D printing, the filament you use can have a big impact on your final product. Each material has different properties that you can choose to suit your specific needs. Here's a handy guide to help you figure out which is which.

Things to Consider When Choosing Your Material

Deciding on a material requires a bit of thought. What are you designing? Will it be used indoors or outside? Would you like it to be flexible or extra durable? Is it a complex shape that needs additional support to print? These are all questions that can ultimately influence your decision.

For example, printing something to showcase a concept probably won't require a filament that can take a lot of wear and tear, while a functioning prototype like a tool or spare part might. If your design contains large bridges or overhangs, you'll need a material than can support this. Looking for something to demonstrate a concept like new packaging? A material that comes in a variety of colors can help your team visualize it better and distinguish prototype versions.

For Easy Printing

If you're just getting started or need something that prints quickly and consistently every time, you should start with a filament like PLA (polylactic acid) or Tough PLA. For larger prints, PLA is the most reliable and serves a wide range of applications, such as concept models and functional prototypes. They also print quickly, which is useful if you need a fast turnaround or require multiple iterations.

Tough and Durable

Because of its good mechanical properties, ABS (acrylonitrile butadiene styrene) is one of the most popular filaments for prints that require toughness. More durable than PLA, ABS offers other qualities, such as heat resistance up to 85°C, which can be useful if the print is going to be used in day-to-day operations. When heat resistance is not important, Tough PLA is a good alternative. ABS can also handle a bit of post-print processing, so you can sand and paint it if necessary. Another material that should be explored for its durability is Nylon. With a high strength-weight ratio, anti-corrosion properties and low friction rates, it's ideal for applications like tooling and end-use parts.

Heat Resistant

Being able to withstand high temperatures is a property required by many different applications, such as manufacturing aids, and there are a number of filaments that present this. Although ABS has good heat resistance, it is limited and can be prone to UV sensitivity. If a print is going to be exposed to sunlight and temperatures higher than 85°C, you might want to consider something like PC (polycarbonate), which is heat resistant up to 110°C. The CPE (co-polyester) family is another group of filaments with a good heat resistance (up to 70°C for CPE and 100°C for CPE+), and has the added benefit of chemical resistance.

Ultimaker materials cover a wide range of applications and ensure the highest print quality.

Visual Appeal

For 3D prints that hold high visual appeal, something with an extensive range of colors gives you plenty of choice. PLA has a broad spectrum of colors and can print the intricate details needed in functional prototypes. Another useful material for this is CPE, which offers translucency as a property—this is especially relevant for items that will be used in lighting applications. It also has the capability to print detailed surfaces with a high-quality finish. PP (polypropyl-

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Nicola Popplewell is Content Marketing Specialist, Ultimaker. Article courtesy of Ultimaker.

ene) is also translucent and, as one of the most widely used plastics in the world, is the go-to material for many product development applications.

Strong, but Flexible

PP is also a semi-flexible material and, with a high fatigue resistance, is exceptionally useful in creating things like living hinges, especially those on bottles. Over time, continuous use can weaken a material, but PP retains its structural quality. However, if you require something that has the same strength and flexibility as rubber, an alternative is TPU 95A. With a Shore-A hardness of 95 and up to 580° elongation at break, it's versatile enough to suit most short-run manufacturing needs, as well as creating tools and guides to help you in your business.

Complex Prints

3D printing is beneficial in that it allows you to push the boundaries of design and come up with alternative solutions. Intricate geometries may be easily created using CAD software, but the reality is that printing can be limited. This is where support materials can play a huge role. PVA is a water-soluble material to support large overhangs and deep cavities. Printed using dual extrusion, it dissolves easily in water, leaving you with a finished print that is smooth and precise. It works best for delicate prints that cannot withstand a lot of post-print processing. For a print that's more durable, another option is Breakaway. It prints faster than PVA and can be easily removed using a set of pliers. It is specifically designed give you more freedom and a high-quality finish on your print. td

Volkswagen Autoeuropa 3D prints manufacturing aids that are used daily on the assembly line.

Materials like polypropylene and TPU 95A are versatile when manufacturing tools and guides.

Aviation Club students with a Coast Guard helicopter pilot who came in as a guest speaker and presenter.

Introducing Students to STEM Through an After-School Aviation Club

By Thomas Hendrickson
Thomas.Hendrickson@wjccschools.org

THE fields of aviation and aeronautics encompass a significant body of knowledge, all deriving from science, technology, engineering, and mathematics fields. Thus, aviation and aeronautics are perfect fields to get students interested in STEM and STEM-based careers.

One way to wholly introduce students to aviation and aeronautics is through the formation of an after-school aviation group. Such a group will attract students interested in becoming civilian and military pilots, engineers, mathematicians, mechanics, and those interested in working in aerospace. It can also help to ignite an interest in careers in such fields in students who are just generally interested in STEM. An aviation club allows for endless opportunities and potential to get students at all levels into aviation and STEM.

For the past four years I have conducted an after-school aviation club at the middle school where I am a special education math teacher. In addition to teaching, I am a licensed commercial pilot and fly sightseeing rides for Bay Aviation in Topping, VA, as well as fly a private business airplane for a company. I am also a licensed advanced and instrument ground instructor and teach the classroom portion of flight training at the flight school at Bay Aviation.

With my background and experience in aviation, I felt I could offer students a lot of insight into the field, as well as give them an advantage by providing them with ground school early on. My aviation group meets once a week during the school year for two hours each session; each session, on average, is divided into two hour-long portions. The first hour is comprised of formal ground school instruction; the second hour is comprised of students working on projects and taking turns on a flight simulator I have pieced together over the years.

Ground school is like the classroom portion of flight instruction, where students are instructed on topics they must be familiar with in order to obtain different levels of pilot licenses. Topics taught include aerodynamics; airports, air traffic control, and airspace; aircraft engines and instruments; aircraft design; aircraft navigation, map reading,

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Thomas Hendrickson is a special education math teacher at Toana Middle School, where he also runs their after-school aviation club. In addition, he instructs at the Bay Aviation flight school, and has flown and instructed there since April 2015.

and flight planning; aviation weather; aircraft performance characteristics and calculations; weight & balance and center of gravity calculations.

All of the concepts taught align with concepts tested on the private and commercial pilot FAA written exams, although some concepts may not be taught as intensively due to the level of students with which I work. However, for high school students, it would be appropriate to teach material as in depth as what students will be tested on. In addition to aligning with FAA test standards, many of the concepts taught align with state public school learning standards established in science, history, geography, and mathematics.

After each lesson that covers concepts tested on the FAA written exams, students take a test comprised of sample questions from such tests to measure their comprehension of concepts, as well as to better prepare them for taking actual written exams.

Beyond teaching concepts tested on the FAA private pilot and commercial pilot exams, one can branch out into other areas of STEM during the ground school lessons. I conducted a series of lessons this year under a grant from the Virginia Department of Aviation that focused solely on the mathematics of aviation. Students were taught the mathematics of aerial navigation, which introduced various aviation applications of algebra and trigonometry, all at a level appropriate for middle schoolers.

NASA has an array of free resources available online which are designed for teachers to introduce various scientific and mathematical applications in aviation and aerospace, most of which align with different state learning standards and are designed for various academic levels. Other areas we have delved into during our ground school lessons include emerging trends of solar and green energy in aviation; aircraft maneuvers; aeronautical decision making and scenario-based questions; the aerodynamics of birds; jet and rocket propulsion; and spacecraft design and aerodynamics.

The second hour of my aviation club is comprised of students working on projects and taking turns on a flight simulator. Over the years, we have done the following during our project time:

- Made balsa wood airplane models;
- Assembled plastic airplane models;
- Disassembled a push-lawnmower so students could see and learn about the inner workings of an engine in a hands-on fashion;
- Made complex paper gliders and flown them;
- Written reports on aircraft and pilots (in agreement with students' English teachers, reports counted as extra credit);
- Researched careers in the aviation industry; and
- Worked on planning cross-country flights. In the future, I plan on building a functioning wind tunnel, building rockets, and introducing aeronautical/aerospace modeling software such as Kerbel Space Program to students.

An Aviation Club student practices interpreting aircraft instruments on the club flight simulator.

While students work on projects, they take turns flying our flight simulator. Our flight simulator is equipped with X-Plane 10 software, a throttle quadrant, yoke controls, and rudder pedals. Equipping an aviation club with a simulator may seem cost prohibitive, but some schools may be willing to pay for a simulator, or one may be purchased with grant funds.

The simulator allows students to apply and experience flying concepts they've learned during the ground school portion of the club. On the simulator, students can practice interpreting aircraft instruments, flying various maneuvers, flying under various weather conditions, flying with various aircraft performance characteristics programmed, and applying navigational procedures such as flying a compass heading and using geographical features for navigation in different types of aircraft ranging from a basic Cessna-172 all the way to a Boeing-747.

Beyond the ground school and project/flight simulator portions of the aviation club, we have had various guest speakers who work in aviation come in to talk to students and have even had a weekend trip to an airport where students toured the airport and viewed historic and modern aircraft. In all, the club lends itself to endless enriching possibilities for students to get into aviation and other STEM careers.

Being as I am a special education math teacher, I strive to get students receiving special education services at my school interested in the group each year. Some of these students may not have an interest in attending college after high school, and through the exploration of aviation and related STEM careers that do not require a college education, they gain valuable insight into emerging careers they may be interested in pursuing such as automotive and aviation maintenance, machining/mill work, computer-aided drafting, welding/metal fabrication, and green technology. Some special education students who otherwise would not have wanted to attend college may find through this group that they do want to pursue a post-secondary education in an aviation or STEM field.

This group offers many applied learning opportunities in math and science to students receiving special education services, as well, which

Aviation Club students visit a local airport and tour vintage aircraft on display.

can enhance their interest and performance in general education math and science classes, and also allows for further application of concepts they are learning in their general education classes.

Beyond the career insight and the learning benefits, there is the social aspect of the club that I find most valuable to students receiving special education services. This group allows students to learn, work, and collaborate on projects with other students who share a common interest in aviation and STEM, and further teaches collaborative and team building skills, skills which will benefit them in future careers and in life, in general.

To make the after-school group that much more beneficial and enriching to students, you may consider becoming a licensed basic or advanced aviation ground instructor. This is a Federal Aviation Administration issued license which allows the holder to teach the ground school or classroom material required for an individual to obtain a light sport, private pilot, commercial pilot, and/or airline transport pilot license.

Obtaining your ground instructor license is a relatively easy process and it doesn't require you be a pilot or have any flight experience. In fact, many pilots will attest that some of the best ground instructors they have ever had were not even pilots.

All that is required is an understanding of the material taught in aviation ground school and a passing score of 70% or higher on two FAA exams: the Fundamentals of Instructing exam and the basic or advanced Ground Instructor exam. If you possess a teaching license that allows you to teach at the 7th grade level or higher, or if you are employed as a teacher at a college or university, the requirement for the Fundamentals of Instructing exam is waived.

The basic and advanced ground instructor exams test you on areas such as aerodynamics, weather, aerial navigation, aircraft performance calculations, and aviation law and regulations; all areas that you will be teaching to students to become licensed pilots. You can purchase a self-study book to familiarize yourself with the concepts tested, but I advise you to get with an instructor at a local flight school for instruction on some of the more complicated concepts tested. By obtaining this certification, you can sign off the lessons you teach in the aviation group as formal ground instruction for students, which counts towards their pilot training. You can also be certified to teach ground school at a local flight school, which is not a bad way to pick up some extra money.

A club like this can be the first stepping stone for students into a career in aviation or a STEM field. Not only can it provide students with enriching learning opportunities, it can provide them with valuable insight as to how to best pursue careers in aviation and STEM, and what careers may be available to them in the coming years.

To maximize learning benefits, I recommend aligning concepts taught in the group with concepts being taught in students' math and science classes. For example: when 6th grade science classes are learning about weather, I introduce and teach aviation weather and weather services in my group; when 8th grade math is learning to work with equations, I introduce time/speed/distance and correlating fuel calculations. Even if some students are in a different grade level and learning material that differs, the math and science concepts taught in the aviation group will serve as a primer for future math and science concepts, or as a review for students.

Consider starting a group like this and explore available resources to help get it going. Your school may have available funds to help, or there may be grants available from your state's Department of Aviation. Also, contact your local airport and make them aware of your club and see how they can help in ways of offering tours and guest speakers. A club like this should be well received by your school and students, and the STEM learning opportunities for students are limitless. Make it fun, enriching, and valuable for students and remember, the sky is no longer the limit. td

NASA Resources

https://www.grc.nasa.gov/www/k-12/airplane/

https://spacemath.gsfc.nasa.gov/books.html

CTE Success Stories:

How the Best Programs Move Students Forward

By Ginny Mumm

CAREER and technical education (CTE), an important component of U.S. education for more than a century, has undergone both a renaissance and a resurgence over the past 10 years. According to research by the Brookings Institute, “In 2015 alone, 39 states instituted 125 new laws, policies, or regulations relating to CTE, many of which increased state funding for such programs.”

The impact of designing successful CTE programs cannot be overestimated. The U.S. Chamber of Commerce’s Institute for a Competitive Workforce notes that, “In well-designed models of CTE, students have lower dropout rates, higher test scores, higher graduation rates, higher postsecondary enrollment rates, and higher earnings than students who do not enroll in CTE.”

While both students and society benefit from CTE programs that are well designed and implemented, each successful program has its own unique features. When, where, and how CTE programs are implemented, who they reach, and where students go after graduation are all important factors in measuring success. We spoke with several educators in standout programs to find out what makes their CTE program successful.

Reaching Higher in High School CTE

Colorado has invested heavily in CTE education, and its investment is paying dividends. One example of its many successful high school CTE programs is the STEM Academy at Castle View (CO) High School. Rob Hazlehurst is a former aerospace engineer who has been a technology teacher at Castle View since 2009.

Ginny Mumm is a freelance writer working with Roland DGA.

Aligned for Success

Hazlehurst credits a large part of the success Castle View’s program has achieved to its intentional alignment with higher education and industry. Castle View’s STEM program has an advisory board that includes members from local colleges and industry to help ensure that students are developing skills relevant to continuing education programs and employers.

Industry partners on Castle View’s advisory board have helped Hazlehurst’s students get plugged into the local SolidWorks User Group, while also arranging field trips to corporations and in-class presentations by industry experts.

In addition, like many successful programs, Castle View offers internship opportunities to students in their senior year. They have placed many of their students at local engineering firms, architecture firms, and related businesses.

STEM Academy students from Castle View High School (CO) design and produce projects like this colorful stock car that are entered in statewide TSA competitions.

Castle View’s curriculum is also carefully aligned with its community college courses. For example, Castle View’s Engineering III course not only provides college credit, it also aligns with local community colleges’ Computer Aided Design (CAD) courses.

Career-Oriented Technology Choices

In addition to incorporating curricular alignment, Castle View also focuses on using tools that students will find in the workplace. For instance, Hazlehurst teaches electronics, programming, and control systems using robots based on Arduino microcontrollers—the same microcontrollers that are used by many colleges and in the "maker" community.

They also use SolidWorks for engineering CAD, and Revit for architectural CAD, both of which have a large market share in the fields of engineering and architecture. Hazlehurst plans to introduce students to MatLab, software that is commonly used by college engineering programming courses, and by industry for testing and simulation.

To improve the skills and marketability of its students, Castle View offers SolidWorks Certifications at both the CSWA (Associate) and CSWP (Professional) level.

Educators at Castle View are encouraged to keep their skills current by taking classes in robotics and software classes offered through the school's resellers. They have also attended SolidWorks World for the past three years.

Maintaining Strong Student Interest

"Our students are most passionate about robotics and rapid prototyping of CAD designs," said Hazlehurst. "We make STEM relevant by encouraging our students to apply math and science to solve real engineering problems." Castle View coursework teaches students how to fabricate projects such as mousetrap dragsters, CO2 dragsters, and catapults, among others.

Upper-level students also work collaboratively on a capstone project. After agreeing on a single project to pursue, the class breaks the project down into subsystems. From there, smaller groups use their skills to develop, test, and integrate their subsystem with the other subsystems to form the final solution. Past years' projects have included a sensor package on a quadcopter drone that sent real-time telemetry data to a laptop where it was displayed on a "cockpit" display, and a flying RC model of a P-47 Thunderbolt built from scratch.

Providing a Platform

Another component of Castle View's program's success is the opportunity for students to use their skills to develop projects for the statewide Technology Students Association (TSA) competition events. "We've historically done well as a school at these competitions," said Hazlehurst. "Our students really enjoy the opportunity to compete."

To support students in their journey to the TSA podium, Castle View also established a TSA club where industry partners mentor students on their projects.

Setting the Stage in Community College

Glen Stevenson, manufacturing department head at Saddleback College (CA) sees a bright future for his students. "Our students are building skills from hands-on, real world experiences and industry collaborations," he said.

Leveraging Innovation

Integral to the success of the CTE program at Saddleback are innovative collaborations and outreach, such as the "Enable Hands" program, where students create upper limb assistive devices from CAD files of pre-designed hands and arms for those in need. Under the guidance of industry mentors, students in math, science, and manufacturing courses are also creating their own robotic hands. They are integrating Arduino Uno technology with a sensor that detects electrical activity of muscles to control robotic hand movements, and are developing a silicon mold around the device to improve its aesthetics and gripping function.

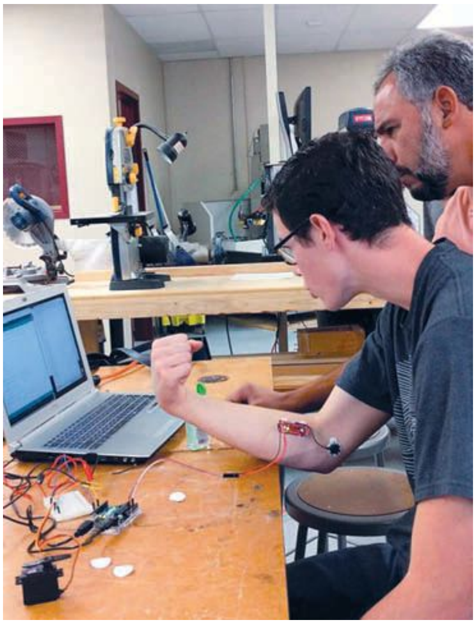
Partnerships with industry, said Stevenson, have resulted in increased enrollment, internship opportunities, and job placement. Saddleback invites industry participation on its Program Advisory Committees and in its workforce training. They also partner with local industry to provide a variety of internships.

In one of many cross-curricular collaborations, the Saddleback College departments of Biology, Advanced Manufacturing, and Art are currently working on a public art project commissioned by the city of Mission Viejo. The wall mural will showcase two prehistoric dolphins' skulls that were found in the city. Stevenson's students, who are 3D scanning and 3D printing the 13-million-year-old fossils, will test out artistic effects in CAD modeling for the art project and print true replicas for future biology research.

Educator Education

At Saddleback College, funding is available to support CTE faculty professional development activities, such as attendance at leadership and subject-matter content conferences and workshops. The college also organizes biannual professional development weeks filled with activities and workshops to address the professional, personal, and organizational needs of faculty. Educators are encouraged to share what they've learned with other educators in "train the trainer" sessions held on the Saddleback campus.

Professional development funds can also support various school projects, including the development of innovations in instructional and administrative techniques and program effectiveness, teaching improvements, or online course development.



Students at Saddleback College work closely with industry mentors to develop components for use in the production of robotic hands.

Measuring outcomes

Saddleback measures its success based on total enrollment, continuation in the program, completion of the program, transfer to four-year institutions, and job placement. To ensure it continues to provide a standards-aligned education that is focused on high-demand careers, Saddleback has an annual Program Advisory meeting and a biannual program review.

Saddleback College also offers its students the opportunity complete industry–relevant certifications with companies such as SolidWorks and Microsoft, along with certifications relevant to the real estate, culinary, and nursing fields.

Saddleback bolsters the effectiveness of its STEM teaching with cross-disciplinary curriculum and activities, and by specifically designing transfer programs that align curriculum with STEM and CTE programs at four-year colleges.

Passion-fueled learning

Like students everywhere, Stevenson notes that Saddleback students are most passionate about hands-on applications. "It's been great to see the growth that a rapid prototyping curriculum can foster both in the students and in our program overall," he said.

Maximizing CTE Opportunity for Lower Income Areas

While well-funded districts can provide CTE program enhancers such as cutting- edge technology to their students, other districts may need to get creative to provide the same opportunities. Blue Ridge High School (AZ) has developed a unique partnership between its district and the University of Arizona Cooperative Extension 4-H program to provide a Fab Lab/Makerspace for students.

Blue Ridge physics teacher Kevin Wooldridge, who is also a volunteer 4-H leader, proposed the collaboration as a way to provide math, science, physics, and computer learning in one place. The facility is available to K-12 students in the district, and to 4-H members in Navajo County and across the state.

Students, faculty, and industry partners celebrate the grand opening of the Blue Ridge 4-H University of Arizona Fab Lab.

Fabrication inspiration

Woolridge, the director of the new facility, notes, "Students in poor urban and rural areas don't lack ability or initiative, they lack opportunity. And teachers don't lack the desire to teach 21st century skills, they lack the 21st century tools to teach."

The Fab Lab's equipment includes vinyl printers, UV flatbed printers, and a high-precision benchtop CNC machine that engraves printed circuit boards and soft materials—all of which were donated by companies such as Roland, Ultimaker, and Epilog. Teachers use Roland's project-based learning (PBL) tutorials to help train students on the equipment as they fabricate projects such as a wooden yoyo. "The learning modules were really important to us," said Woolridge. These ready-to-teach tutorials make it so we don't have to reinvent the wheel on projects, and they help ensure that we're providing our students with the best possible instruction on how to use Roland's digital devices."

Roland product manager Adam Sebran is enthusiastic about the potential for sites like the Blue Ridge–University of Arizona 4-H facility. "With passionate educators, advanced technology, and a series of projects that teach the rudiments of digital fabrication, students can incorporate prototyping techniques into a wide variety of coursework," he said.

Measuring achievement

The facility's grand-opening ceremony was held in January 2018. In its first month, the Fab Lab welcomed 344 students. CTE classes in additive and subtractive manufacturing are set to begin this fall. The facility will help the school meet the Next Generation Science Standards' heavy focus on engineering/engineering design.

Eventually, facility organizers hope to spread the influence of the Fab Lab to all of Navajo County, integrating it with a network of 4-H clubs and mini labs. Woolridge explains, "Our goal is to have a mini lab in every county cooperative extension office within the next two years and in every 4-H community in the next five years."

Blue Ridge is also arranging collaborative programs so that, for instance, Agro Science students can have STEM students fabricate, assemble, and test projects in the 4-H Fab Lab. "Extending the reach of our facility simulates the work environment, where companies often outsource production and testing of prototypes," said Woolridge. "We hope to do the same with our minilabs in the future."

Keeping current

In addition to "train the trainer" courses offered by the Fab Lab staff, Blue Ridge plans to enroll its educators in the Fab Foundation's online

Continued on page 26.

Colleges Are Adding Programs in a Once-Decimated Industry—Manufacturing

But Few Young People Are Seeking Out the Skills to Fill These Jobs

By Delece Smith-Barrow

WITH vertical mills, lathes, and flat screen monitors at their disposal, members of Vermont Technical College's Fabrication Club are hard at work in Morrill Hall.

Jacob Walker is stationed at a Dell computer working on a 3D design for what will be a decorative stainless-steel maple leaf. To get from design to actual product involves using advanced computer software plus a waterjet, a traditional manufacturing machine.

Walker, 19, is in the school's two-year mechanical engineering program, a first step on the road to study manufacturing in the college's new bachelor's degree program. "You can learn to build something, but the manufacturing behind it to be able to produce it, I think that's very important to have an understanding of how it works," he says.

The students at Vermont Tech aren't preparing to build products through physically demanding factory work as much as they are studying to up their technical skills. Manufacturing undergrads take classes in calculus, 3D printing, and a slew of other specialized subjects.

3.5 million manufacturing jobs will need to be filled by 2025.

Manufacturing, which shed nearly a third of its workforce between 2000 and 2010, is rebounding as a solid path to the middle class. The industry has taken a more tech-intensive twist, making skills like practice in 3D design—like the work Walker is doing—critical for future employment. Schools are taking notice.

Despite President Donald Trump's campaign vow to revive manufacturing, the industry isn't expected to rebound to its heyday. At its peak in the late 1970s, it employed 19 million people. Today, the sector employs roughly 12.4 million; the Bureau of Labor Statistics predicts that number will fall slowly over the next decade to 11.6 million.

But the strong economy, and the return of manufacturing operations to the United States as labor costs rise abroad, have led some companies to add jobs. There were about 360,000 hires in January 2018,

Wes McEntee uses one of several manufacturing machines at Vermont Technical College.

Photos by Oliver Parini for The Hechinger Report

Delece Smith-Barrow is a senior editor for higher education at The Hechinger Report. *This article was originally published on* The Hechinger Report *website, www.hechinger report.org.* The Hechinger Report *is a nonprofit, independent news website focused on inequality and innovation in education.*

an increase of 52,000 over the year before, according to the Bureau of Labor Statistics.

Businesses are seeking workers whose profile is different from that of decades past, when a high school diploma was more than enough. As robots take over much of the manual labor in factories, the new jobs being created tend to require computer and engineering skills and advanced training.

That's helped to fuel a boomlet of college investment in manufacturing programs. In November 2017, Washington state's Shoreline Community College announced a new two-year degree in mechatronics—which prepares students to work with manufacturing systems.

In Illinois, Chicago's College to Careers initiative is prepping local students for careers in manufacturing. The city will spend $75 million on a new manufacturing training facility, to open in fall of 2018, one of many initiatives planned through College to Careers. This year Alabama became the first state to offer certification from the Manufacturing Skill Standards Council at all its public colleges.

Vermont Technical College, a rural college with about 1,600 students that specializes in hands-on learning, recently started a bachelor's degree program in manufacturing engineering technology. Its first class—of nine students—graduated in June 2017. The 2018 graduating class had 11 students, and the school is planning for larger classes in the future, says Christopher Gray, assistant professor for manufacturing and mechanical engineering technology at the school. But getting teens and young adults to study manufacturing, an industry that may seem more gritty than glamorous, isn't always easy, say industry experts.

Professor Christopher Gray teaches students at Vermont Technical College in one of the school's manufacturing lab spaces.

During Manufacturing Processes 1, Gray guides about a dozen students as they work on fine-tuning basic manufacturing skills. Half the group is learning to turn items on a lathe and the other half is learning to use vertical milling machines.

There's buzzing and whizzing and safety goggles and white boards.

Gray is on one side of the class with the lathe-turning students. "In an emergency how would you stop it right now?" he asks one as a lathe runs. Within seconds the student calmly powers off the machine, and Gray continues his rounds.

Most of these students are in their second year of school and studying automotive or diesel technology, Gray says, but the class is also for manufacturing majors.

Gray spends the nearly three-hour lab going from student to student, helping them with tasks like creating a piston and showing them how to safely and effectively use the manufacturing machines.

Every student is learning skills that can set them on a path to a manufacturing career. Students with the right training can work in a variety of areas, such as product design, operations management, welding, machining, or engineering.

Vermont is looking to increase employment and production at manufacturing companies throughout the state. One such company, Logic Supply, a Vermont-based international business that builds computers, recently signed an agreement with the state to open a new manufacturing and warehouse facility, creating 83 new jobs by the end of 2020. In February 2017, the Vermont Economic Development Authority approved $7.1 million in economic development financing for manufacturing, agricultural, energy, and small business projects. Through this program, Vermont's Rhino Foods, for example, was approved for $294,176 in financing to purchase new machinery and equipment and other manufacturing needs.

"Right now, in the state of Vermont, I'd estimate there's probably upwards of a thousand open positions in manufacturing that we can't fill 'cause we just don't have the people," says Gray. "Anywhere you go, you can walk into a manufacturing company and they're looking to hire."

Manufacturing jobs can pay between $26,000 to more than $100,000, with those who earn a college degree more likely to command a competitive salary. "Most of my students will leave my courses and make more money than I make now," says Gray.

70% of manufacturing executives say their current employees don't have the right technology and computer skills for modern manufacturing work.

Many of the fastest growing jobs in the state are in manufacturing, according to a 2016 report from Vermont's department of labor. Nationwide, about 3.5 million manufacturing jobs will need to be filled by 2025, according to a study by the consulting firm Deloitte and the Manufacturing Institute, a trade group. ►

A wave of baby boomer retirements in the industry—expected to total 2.7 million by 2025—is contributing to that gap.

But these manufacturing jobs are nothing like those depicted on black-and-white television shows from the 1950s and 60s. Some may still think manufacturing is like "the old Lucille Ball comedy when she's [in] the chocolate factory and she starts to lose her place in the factory and her chocolates start getting all mixed up," says Neil Reddy, executive director of the nonprofit Manufacturing Skills Standards Council. Or, he says, they may think of low-tech labor jobs where manufacturing workers repetitively do a single task all day, such as sewing the same pattern for the sole of a shoe. But those visions bear little relationship to manufacturing now.

At its peak in the late 1970s, manufacturing employed 19 million people. Today, the sector employs roughly 12.4 million.

Today, that work is largely done by machines. Humans are needed to program the computers that run those machines, Reddy says—and those skills are in short supply.

In the Deloitte-Manufacturing Institute study, 70% of manufacturing executives said their current employees didn't have the right technology and computer skills. The executives also said their workers lacked problem solving skills (69%), basic technical training (67%) and math skills (60%).

While some economists predict that automation will continue to wipe out manufacturing jobs, Reddy and others in the industry suggest that these technologies could actually generate employment. As robots help improve the efficiency and quality of products, Reddy says, demand will increase, leading to the opening of more plants.

But in Vermont, and around the country, getting more students to take manufacturing courses and work in this industry is a challenge.

"There's not enough kids interested," says Jeannine Kunz, vice president of Tooling U-SME, a branch of what was once called the Society of Manufacturing Engineers. "We need to grow the pipeline."

About 27% of manufacturing workers are 55 or older.

Schools with top-of-the-line technology, like 3D printers, can be a draw for millennials, Kunz says. But if a school doesn't have these resources, manufacturing can be a tough sell.

Plus, getting Mom and Dad to forget what they think they know about the industry can also be difficult. "One of the barriers is helping parents understand what manufacturing is," says Patricia L. Moulton, president of Vermont Tech. Sometimes, Moulton says, a young adult may want to study manufacturing but parents disapprove because they think manufacturing requires little-to-no skills and can quickly lead to unemployment. Her message to those parents: "It's not your father's manufacturing anymore … It's innovative, it's new, it's different."

It's also more academically rigorous than parents might think. At Vermont Tech, students learn about physics in addition to metrology inspection and computer-driven manufacturing.

Deema AL Namee came to Vermont Tech to study in the two-year mechanical engineering technology program, she says, but "when they started the manufacturing program, it was a clear choice for me to go into that." AL Namee expects to graduate in May and is the only woman in her graduating class.

"I love all of the hands-on work that we do," says the 21-year-old. "Overseeing a process from a start of a design until a full end product. That's really exciting to me."

AL Namee doesn't see a shrinking industry; she sees growth and opportunity. "I'm quite excited to get out there in the workforce." ⓣ

CTE Success, continued from pg. 23.
learning course "How to Make Almost Anything." The Blue Ridge facility is also working with the Fab Foundation under its What Is SCOPES-DF program (Scaling a Community of Practice for Education in STEM through Digital Fabrication). Through this program, Blue Ridge educators have access to the knowledge and resources of the Fab Foundation.

Passion for prototyping

"Students enjoy learning functional, real-world skills that they can put to work today and that give them post-graduation skills," said Woolridge. His curriculum emphasizes the engineering design process, teaching digital prototype design, production and testing, and allowing time for several iterations.

Within the Fab Lab, students have access to tools for making everything from wooden yoyos to printed circuit boards. Before their official coursework even begins, high school and junior high students are using the facility to create engineering and art projects such as customized phone covers.

Woolridge is also encouraging emerging cross-disciplinary collaborations, including one between the school's Spanish language students and students in Mexico, to digitally design an art project that will be produced in the Fab Lab.

Showcasing success

To provide an opportunity for students to share their projects and prototypes with other students and the community at large, Woolridge is pushing to have a STEM category included in the County Fair. "Our goal would be to spread beyond Navajo County to the State Fair," he said.

Blue Ridge School District is the first public school in Arizona to have a digital fabrication facility like this. "We are trying to create a STEM model that allows access regardless of which school you go to," said Woolridge. "We want our facility to be open door, open source. Our goal is to help as many students as possible learn these skills." ⓣ

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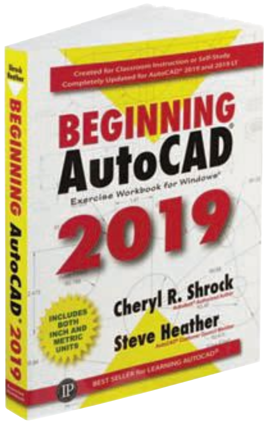
Continued on page 28 ▶



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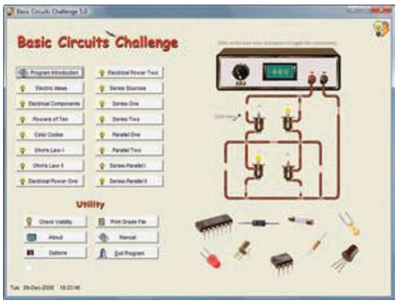
Electronics/Electricity Training Activities



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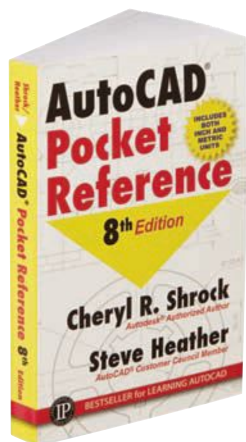

The 8th edition of the *Pocket Reference* has been improved by featuring both inch and metric measurements throughout to appeal to a more global audience, as well as updated screenshots of all the AutoCAD 2018 and 2019 commands readers need. And with the inclusion of special "CAD Tips" scattered throughout, this is the perfect "cheat sheet" reference to make the most of AutoCAD’s features and strengths.

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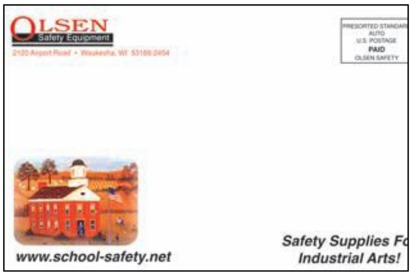

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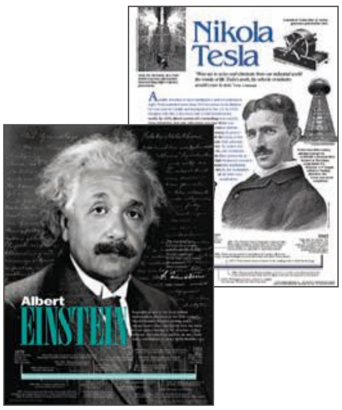

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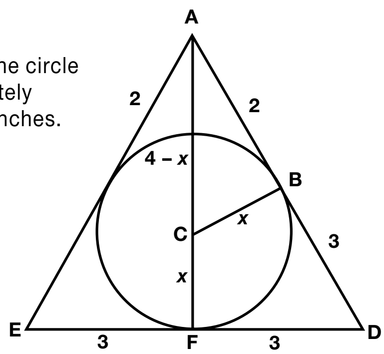
More than Fun Answers

A Closer Look at the Deathly Hallows

The area of the circle is approximately 7.07 square inches.



Triangle AED is isosceles with EA = AD.
From geometry, we know that BD = DF = EF = 3".
We also know that triangle ABC is a right triangle, as is triangle AFD.
In triangle AFD, FD = 3 and AF = 4.
Using the Pythagorean Theorem, AD = 5.
Since BD = 3, then AB = 2.
Let x = length of the radius of the circle.
Then AC = 4 - x.
Using the Pythagorean Theorem in triangle ABC,
$(4 - x)^2 = 2^2 + x^2$
$16 - 8x + x^2 = 4 + x^2$
So, $8x = 12$ and the radius $x = 3/2$".
Therefore the area of the circle is 7.07 square inches.

Around the World

1.59' off the ground!
Let x = the new height of the string
and r = the radius of the Earth
$C = 2\pi r$
$C + 10 = 2\pi (r + x)$
$C + 10 = 2\pi r + 2\pi x$
$C + 10 = C + 2\pi x$
$10 = 2\pi x$
$x = \frac{10}{2\pi}$ or 1.59 feet

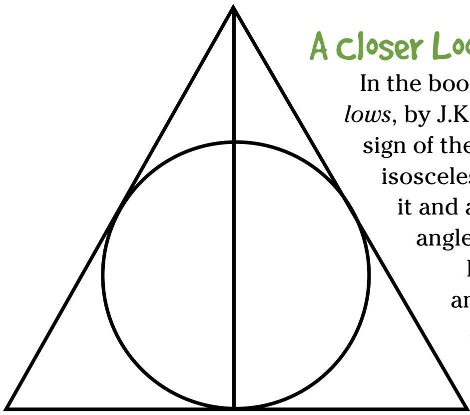
Where Did Napoleon Keep His Armies?

In his sleevies

How Far Will You Go?

The Prius gets 56.4 mpg and the Accord gets 31.2 mpg.
Let x = mpg of the Accord and let y = mpg of the Prius.
Then the Accord can go 17.12x miles and the Prius can travel 11.9y miles.
Set up two equations:
$11.9y + 17.12x = 1205$
$11.9y - 17.12x = 137$
Solving, we get $23.8y = 1{,}342$ so $y = 56.4$ mpg and $x = 31.2$ mpg.

more than fun



A Closer Look at the Deathly Hallows

In the book *Harry Potter and the Deathly Hallows*, by J.K. Rowling, Harry learns about the sign of the Deathly Hallows. The sign is an isosceles triangle with a circle inscribed in it and an altitude drawn from the vertex angle.

If the base of the triangle is 6" long and the altitude is 4" long, what is the area of the circle?

Puzzle devised by David Pleacher, www.pleacher.com/mp/mpframe.html

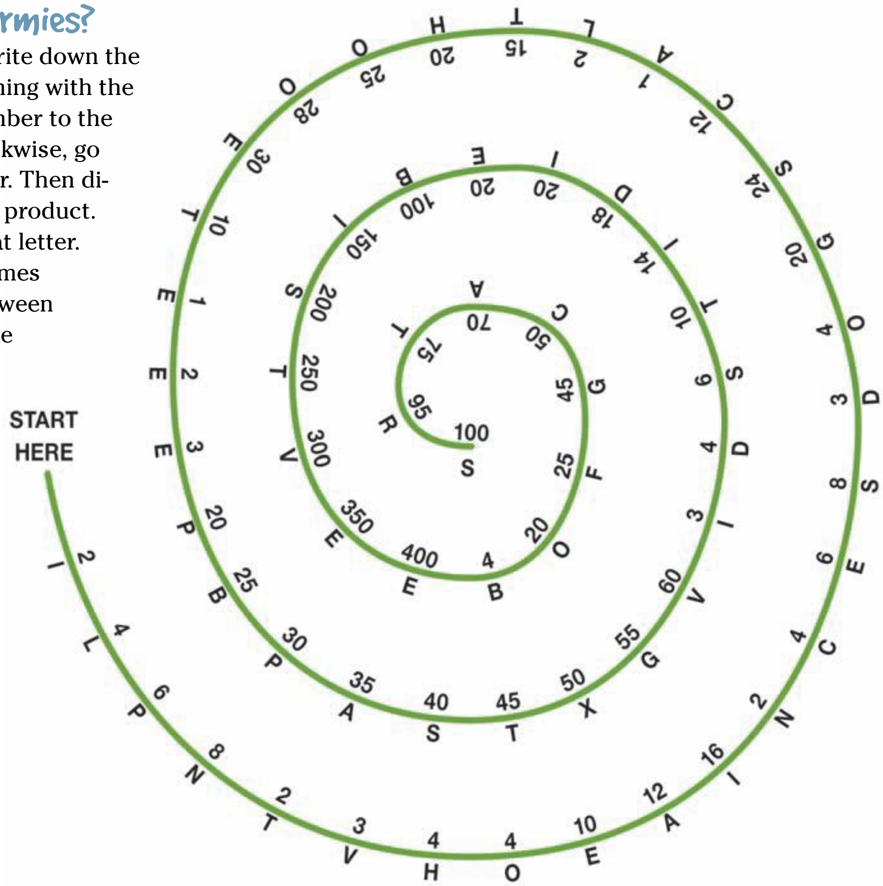
Around the World

A string is tied tightly around the Earth's equator. An additional 10' is spliced in. If the slack is evenly distributed, how high off the Earth's surface will the string be?

Puzzle devised by David Pleacher, www.pleacher.com/mp/mpframe.html

Where Did Napoleon Keep His Armies?

To solve this math spiral puzzle, write down the first letter at the starting point. Beginning with the first number, multiply it times the number to the right of it. Always moving counterclockwise, go to its product and write down its letter. Then divide by the number to the right of the product. Go to the quotient and write down that letter. Then, look to the right and multiply times that number. Continue alternating between division and multiplication to solve the riddle and figure out where Napoleon kept his armies.



How Far Will You Go?

Mr. P's 1998 Honda Accord has a capacity of 17.12 gallons and Mrs. P's 2010 Toyota Prius has a capacity of 11.9 gallons. If the Prius has a range of 137 miles more than the Accord, and the sum of the ranges of the two cars is 1,205 miles, determine the average miles per gallon for each car.

Puzzle devised by David Pleacher, www.pleacher.com/mp/mpframe.html

See answers on page 29.

We pay $25 for brainteasers and puzzles and $20 for cartoons used on this page. Preferable theme for all submissions is career-technical and STEM education. Send contributions to vanessa@techdirections.com or mail to "More Than Fun," PO Box 8623, Ann Arbor, MI 48107-8623.

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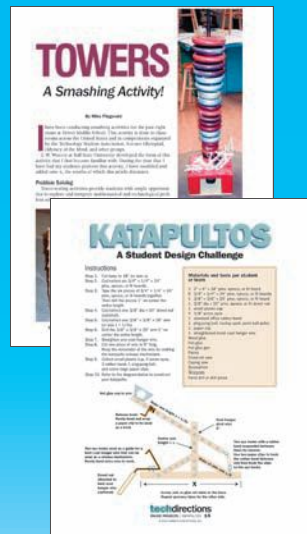

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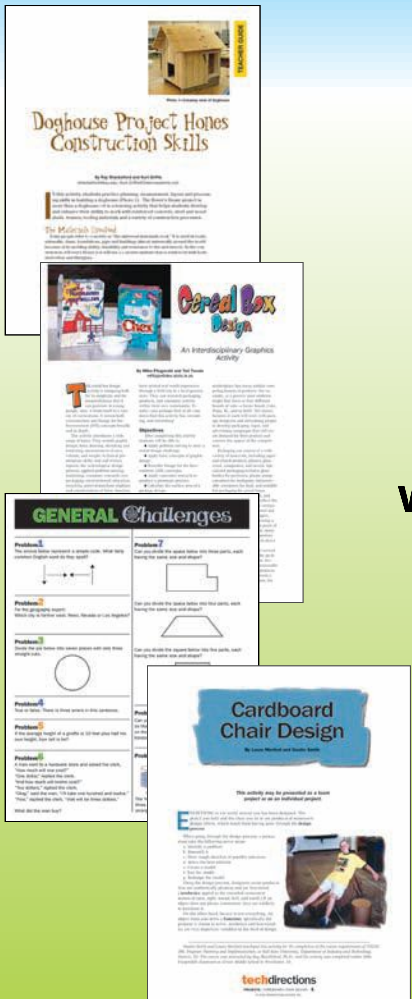

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