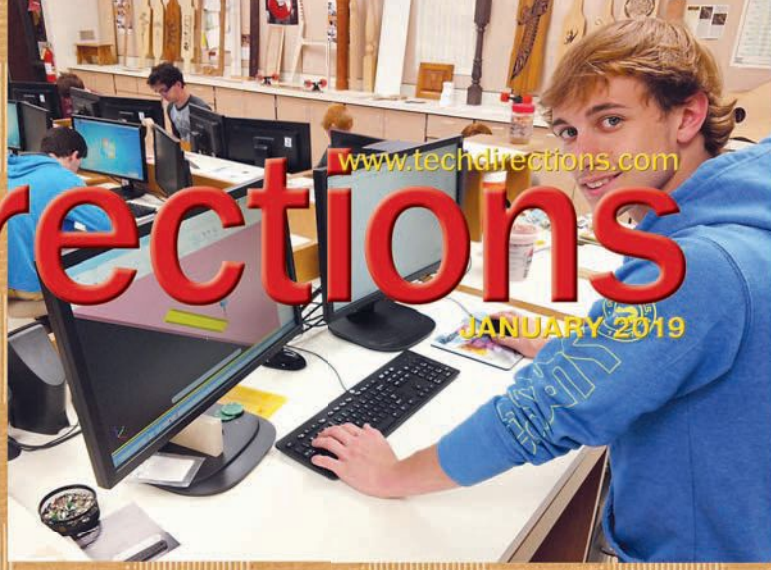
www.techdirections.com

techdirections

linking education to careers

JANUARY 2019



CAD/CAM Strikes a Positive Chord

Students Invent for First Responders

Double the Fun

technically speaking

Vanessa Revelli vanessa@techdirections.com

As we continue to talk about the looming skills-gap, I wanted to share an interesting approach that Express Employment Professionals is taking. They stress the importance of early intervention work-study programs.

An effective way of closing the skills gap is to provide students with real-life work experience before they graduate. Having high school students learn early on about workplace culture, how their educational experience translates into the real world, and what educational disciplines are the most sought, will help ensure students are graduating with the skills and education employers need.

Express Employment Professionals is committed to partnering with local entities to provide early education and work-study opportunities for high school students to help raise a workforce prepared to fill the shortage of skilled workers.

One way Express helps connect educators with the needs of businesses is through Job Genius, a free video-based program created by Express to successfully prepare students to enter into the workforce. With parent and facilitator guides for teachers, Job Genius explores everything from job market forecasts, postsecondary education requirements, and resume creation to career pathing to help students make informed choices for their future.

To help further early intervention workforce education, Express International Headquarters is currently hosting several interns as part of the Cristo Rey Network's Corporate Work Study Program. The network of high schools serves students who are from inner-city economically limited backgrounds and the work-study program allows them to intern one day a week at a local business, earning money towards tuition.

"Not a lot of kids get this opportunity," said Cinthya Bolado of her internship. "I think it's going to open up doors everywhere."

Elvira Quinones, Cinthya's mother, says Cristo Rey and the opportunity to work is a "blessing."

"Working once a week has helped her in having a better understanding of the experience of being employed … and helped her realize the importance of communication skills, time management, and how to be more proactive," she said.

Express franchise owners see the importance of similar efforts in their local communities.

"Our team has started to be more active in participating in high school job fairs," said Terri Greeno, an Express franchise owner in Crystal Lake, IL. "We are educating students, and their parents quite frankly, that you don't need to have a four-year degree to build a successful and rewarding career. Manufacturers are desperate for people who are hungry to learn and excited to be trained. A high school student who has limited economic means or experiences is just as trainable and promotable as other students, as long as they have the work ethic and desire to learn and grow."

techdirections
A Prakken Publications Magazine

Digital Tech Directions (ISSN 1940-3100) is published monthly, except June, July, and August, by Prakken Publications, Inc., 251 Jackson Plaza, Suite A, Ann Arbor, MI 48103-1955. Executive, editorial, and advertising offices are at PO Box 8623, Ann Arbor, MI 48107-8623, telephone 734-975-2800; fax 734-975-2787. Vol. 78, No. 5.

Subscriptions: individuals: $30 per year; Canadian and foreign: add $20 per year. Canadian GST #R126213487. Single copies $3. Group rate for students in teacher-training institutions available upon request.

Periodicals postage paid at Ann Arbor, MI, and additional mailing offices. Printed in U.S.A.

POSTMASTER: Please send change of address information to Tech Directions, PO Box 8623, Ann Arbor, MI 48107-8623.

Manuscripts should be addressed to: Editor, Tech Directions, PO Box 8623, Ann Arbor, MI 48107-8623. Manuscripts become property of Tech Directions upon letter of acceptance to author and signed copyright release form. Payment made on publication. Electronic copies of back issues available from ProQuest Information and Learning, www.il.proquest.com. Microform copies available from NAPC, www.napubco.com

January 2019

techdirections

This issue of **techdirections** is brought to you **free** by these leading companies. Let them know you saw their advertisements or listings in **techdirections**.

Company	Page	Web Address	Phone
All Electronics Corp.	29	www.allelectronics.com	800-826-5432
Electronix Express	25	www.elexp.com	800-972-2225
ETCAI Products	28	www.etcai.com	800-308-0154
Forest Scientific Corp.	11	www.forestscientific.com	800-956-4056
Hobart Institute of Welding Technology	28	www.welding.org	937-332-9500
jds Products	29	www.jdsproducts.com	916-933-2699
John Deere Publishing	7	www.johndeere.com/publications	800-522-7448
Kelvin	29	www.kelvin.com	800-535-8469
Roland DGA	21	www.rolanddga.com/edu	800-542-2307
ShopBot Tools, Inc.	17, 28	www.ShopBotTools.com	888-680-4466
Tech Directions	4, 27	www.techdirections.com	800-530-9673
Tech Directions Books & Media	9, 29, 32	www.techdirections.com/products	800-530-9673
Techno Education Division	6, 28	www.techedcnc.com	631-648-7481
Test Equipment Depot	23	www.TestEquipmentDepot.com	800-517-8431

techdirections is a magazine for career/technical and STEM educators. Designed for the involved educator, **techdirections** brings to life today's technology and provides a wealth of engaging student activities. To receive a free subscription at your school address, please visit us online at techdirections.com/subscribe or use the form below.

Subscribe to techdirections for FREE!

techdirections is free to educators at their school address.

Use this form or visit www.techdirections.com/sub

Your type of school (check only one):

- (A) ☐ Fed./State/School District Headquarters
- (D) ☐ College/University
- (E) ☐ Community/Jr. College
- (F) ☐ Vocational/Technical School
- (J) ☐ Sr. H.S. (9-12)
- (K) ☐ Jr. Sr. H.S. (7-12, K-12)

Check all subjects you teach or supervise:

- (Y) ☐ 3D Printing
- (X) ☐ Aeronautics/Aviation
- (A) ☐ Agricultural Tech
- (5) ☐ Appliance Repair
- (I) ☐ Applied Math/English
- (B) ☐ Automotive (incl. Auto Body)
- (C) ☐ Bldg. Trades/Construction Tech (incl. HVAC&R)
- (F) ☐ CAD/Drafting/Design
- (V) ☐ Careers/Technical (incl. Vo-Ed, School-to-Work)
- (7) ☐ CNC/CAM/CIM/FMS
- (S) ☐ Communications
- (3) ☐ Computer Tech
- (G) ☐ Electricity
- (H) ☐ Electronics
- (1) ☐ Engineering/Pre-Engineering
- (K) ☐ Forge/Foundry
- (Z) ☐ Green Technology
- (J) ☐ Hydraulics/Pneumatics
- (E) ☐ Information Technology
- (M) ☐ Machine Shop
- (N) ☐ Manufacturing/Production
- (P) ☐ Metals
- (Q) ☐ Plastics
- (R) ☐ Power/Energy (incl. Diesel)
- (6) ☐ Robotics
- (8) ☐ Safety
- (D) ☐ Science/Appl. Sci.
- (2) ☐ Small Engines
- (L) ☐ STEM
- (W) ☐ Technology Ed
- (4) ☐ Tech Prep
- (9) ☐ Transportation
- (T) ☐ Welding
- (U) ☐ Woodworking

Please print

Name _____

Title _____

School _____

School Address _____

City _____ State _____ Zip _____

E-mail _____

E-mail address information is for in-house use only and will not be shared or sold!

Subscribe online:
www.techdirections.com/sub

FAX: 734-975-2787

Mail: Tech Directions Requests
P.O. Box 8623
Ann Arbor, MI 48107-8623

contents

January 2019
Vol. 78, No. 5

CAD/CAM/CNC

page 15

ENGINEERING

CTE

page 18

SPECIAL FEATURE

COLUMNS

About the cover: Reed-Custer students build custom guitars in their advanced hands-on woodworking class. Read the article on page 12. Cover design by Sharon K. Miller.

the news report

Vanessa Revelli
vanessa@techdirections.com

Women in STEM Can Mitigate $2.5 Trillion Impact of Worker Shortage

A new report by Deloitte and The Manufacturing Institute estimates 2.4 million U.S. manufacturing jobs may go unfilled between 2018 and 2028, risking $2.5 trillion in economic output over the next decade. The study cites a need for advanced technology skills, yet government data shows that few females are pursuing relevant education—less than one in five engineering, computer, and information sciences bachelor degrees are earned by women.

Monica Eaton-Cardone, a FinTech executive specializing in risk management and fraud prevention, emphasizes the importance of increasing the number of women in technology and believes young leaders can help get more girls interested in STEM fields.

Manufacturing executives indicated the top five skill sets they will need in the coming years are: technology/computer skills, digital skills, programming skills, expertise in tools and technology, and critical-thinking skills. National Center for Education Statistics (NCES) data suggests a lack of women in science, technology, engineering, and math (STEM) may be contributing to the projected skills gap: as of the 2015–2016 academic year, just 19.7% of engineering bachelor degrees and 18.7% of computer and information sciences bachelor degrees are awarded to females.

Yet based on average National Assessment of Educational Progress (NAEP) scores, it's not necessarily a lack of ability that is creating this gender gap. In the latest (2015/2017) NAEP mathematics tests, girls in Grade 4 scored just 2 points lower than boys and those in Grade 8 scored only 1 point lower on a 500-point scale, while girls in Grade 12 scored 3 points lower on a 300-point scale. On 2015 NAEP science tests, which have a 300-point scale, girls in Grade 4 had the same average score as boys; girls in Grade 8 scored 3 points lower and those in Grade 12 scored 5 points lower.

"What this means is that national testing suggests girls and boys have a similar aptitude for math and science—however, girls tend to stray from STEM fields as they approach graduation and enter college. This could be due to a lack of interest or confidence; but either way, it's clear that female attrition needs to be addressed," asserted Eaton-Cardone,

---

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

who serves as Chief Information Officer (CIO) of Global Risk Technologies and Chief Operating Officer (COO) of Chargebacks911.

To overcome the projected technical skills gap and worker shortfall, Eaton-Cardone maintains it is critical to increase the number of women in technology—and she says this starts by encouraging girls to pursue STEM fields at an early age. While she has long advocated for companies and business leaders to support initiatives designed to boost women in tech, Eaton-Cardone is encouraged by the innovative new solutions that are being launched by young leaders.

As an example, she cites the Forbes 30 Under 30 Education 2019 class, which features young visionaries with an average age of 26. Among them are Dianna Cowern, a YouTube personality known as Physics Girl; Abigail Harrison, cofounder of a Student Space Ambassador program called The Mars Generation; Ruby Lee and Vivian Shen, founders of Juni Learning online coding classes; Grechen Huebner and Jon Mattingly, founders of computer education startup Kodable for students in grades K–5; and Jana Landon, a Google Outreach Specialist who is working to increase computer science enrollment at historically black and Hispanic colleges, and who has helped hire over 500 underrepresented students into Google STEM internships.

"Solving the STEM skills gap is a huge challenge that shouldn't fall to any single entity; it's going to require the combined efforts of schools, government agencies, employers, and individual leaders to change the status quo," stated Eaton-Cardone. She applauds those who are already contributing solutions, and encourages others to add their ideas and efforts to the mix.

Eaton-Cardone's own initiatives include founding the Paid for Grades incentive program, which is designed to support and motivate underachieving students, and spearheading Chargebacks911's efforts to expand young women's access to business and networking opportunities with technology leaders. She aims to have women account for at least 25% of the technical workforce at Chargebacks911 in the coming years, and hopes to exceed that goal in the not-too-distant future.

Calendar

Feb. 1. Contest. ACTE and NASA HUNCH Video Challenge. Deadline for submission is February 1. For more information, visit: https://www.acteonline.org/why-cte/cte-awareness/cte-month/cte-month-2019-and-nasa-hunch-video-challenge/

Feb. 11-13. Conference. CTAT Winter 2019 Conference. San Antonio, TX. To read about the conference, and to register, please visit: https://www.ctat.org/page/CTATWin

Mar. 25-27. Conference. 2019 National Policy Seminar. Arlington, VA. For more information, visit: https://www.acteonline.org/nps/

Mar. 27-30. Conference. ITEEA's 81st Annual Conference. Kansas City, MO. For full details, and to register, visit: https://www.iteea.org/ITEEA_Conference_2019.aspx

technology today

Alan Pierce
pierceaj@techtoday.us; on Twitter @ TechToday_US

Constructing Tall Buildings Using SpeedCore

Ron Klemencic is the 2018 recipient of the Engineering News Record (ENR) Award of Excellence for his team's development of their SpeedCore method of construction. Klemencic conceived the basic concept for this construction paradigm shift many years ago and started doing preliminary testing in 2006 at Purdue University. The first building to use the SpeedCore construction method to create a Composite Plate Shear Wall Core superstructure is now under construction in Seattle, WA (Photo 1). When it is completed, at 850', it will be the second tallest tower in Seattle, an area that is known for its earthquakes.

Wright Runstad & Company

Photo 1—The Rainier Square Tower, under construction in Seattle. The construction is using the new SpeedCore building system to construct the building's core superstructure. This technology will cut construction time by about 40%.

The methodology and structural integrity of this new construction technology had already been tested before it received final approval to move from the testing lab to the construction of the Rainier Square Tower. Under laboratory conditions, it has proven itself to be a superior earthquake-proof method of construction when compared to the current traditional concrete core system used today.

Photo 2 shows a prefabricated SpeedCore metal shell that was used during testing. Photo 3 shows one of the many testing machines that were used to test SpeedCore's ability to stand up to everything that nature might throw at it including the lateral loads of extremely high winds as well as the ground shaking and moving of earthquakes.

American Institute of Steel Construction (AISC)

Photo 2—During the original testing of the SpeedCore building system, prefabricated metal cavities like this one were used.

It is important to point out that the steel walls of the SpeedCore shells are extremely thick structural steel. The steel is so thick that all cutouts need to be created during fabrication, which means that each section's final resting place needs to be charted so that these openings end up in the correct location.

Photo 4 is a labeled diagram of a SpeedCore partially filled with concrete; here you can see how the cutout has a pipe sleeve that will be used to feed wires or pipes through the wall. The thickness of these SpeedCore shells removes the need to wait for the concrete to harden since the steel alone is strong enough to support the structure during construction.

Reports have called the Rainier Square Tower a proof-of-concept construction of this new building paradigm. The strength of the core has already been proven and the only thing that the architects, engineers, and the builder hope to prove is that this construction technology will reduce the time it takes to build a new building by about 40%.

The current method of building tall office buildings combines a steel frame with a traditional reinforced concrete core. To build a traditional reinforced concrete core superstructure, wood forms must first be assembled for the eventual casting of the concrete. After the forms are assembled, the steel rebar goes in using a labor-intensive procedure to cut, bend, and tie the different pieces of rebar into their proper locations.

Next the concrete is poured in; once it has had sufficient time to

---

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

American Institute of Steel Construction (AISC)

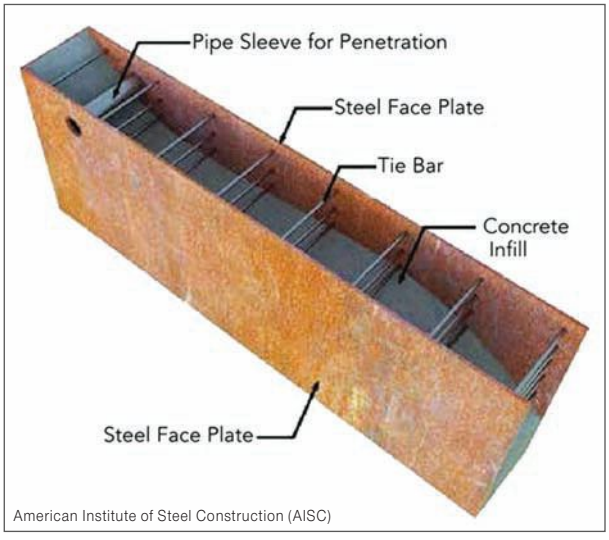
Photo 3—One of the many testing machines the engineering team used to determine if the SpeedCore construction system would be able to stand up to everything that nature might throw at it.

harden the wood forms are removed. This procedure is performed repeatedly floor by floor until the concrete core superstructure is completed. Basically, construction slows to a crawl during many of these steps especially while waiting for the concrete to harden enough to support the load of all the higher floors of the core.

SpeedCore does away with the wood forms and the custom bending and placement of rebar. These new prefabricated composite steel frame casting cavities, with all the necessary reinforcement built in (Photo 4), are assembled at the construction site and welded together. They do the job that was once done by the wood forms and rebar and add further strength since the steel that originally served as a casting form now remains as a permanent part of the structure.

Once the individual SpeedCore casting cavities are properly placed and welded together, they are instantly ready to be filled with concrete. Since the steel shell provides sufficient strength to support all the floors before the concrete fully hardens, construction moves forward very quickly.

The added cost of the prefabricated SpeedCore casings are easily absorbed by the money saved by the speed of construction and reduced labor costs. Quicker occupancy of the building is obviously another plus of this technology. In the end the building goes up faster and is better prepared to survive the mega storms that global warming might throw at it during the building's lifetime.



American Institute of Steel Construction (AISC)

Photo 4—Each casting cavity has all the necessary reinforcements built in. The steel cavities are welded together during construction; they are so thick and strong the entire core can be built without waiting for the concrete to harden.

The engineering firm Magnusson Klemencic Associates is responsible for the full development of this technology. They have created a YouTube video, *Rainier Square Core Side-By-Side Comparison,* to help people understand the advantages of the SpeedCore construction system. You will find it online at: https://www.youtube.com/watch?time_continue=21&v=_joMFRHgwCg

Taking It a Step Further

1. Tech Challenge: Your mission, if your teacher assigns it, is to build the tallest tower possible. (Materials and amount of each material that can be used to construct the towers will be determined by your teacher.)

2. To further test the different towers that the class builds, design a testing procedure to see which groups' tower is most wind resistant and best able to withstand the shaking of an earthquake.

Dennis Karwatka
dkarwatka@moreheadstate.edu

Oliver Winchester and His Rifle That Won the West

As people moved into the American West during the 19th century, they often felt an increased need for self-defense. Farmers, merchants, and other productive workers began to populate unmapped regions of a new nation. They wanted some assurance they could protect themselves and provide food for their families. That environment encouraged the development of the Winchester lever-action repeating rifle. It was named for Oliver Winchester, who produced the first one in 1866 in New Haven, CT.

Oliver Winchester

Winchester was born in Boston, MA, in 1810 and had little formal education because of his father's early death. He became almost self-sufficient at the age of seven and worked on various farms and in small shops until he was 20.

Winchester moved to Baltimore, MD, where he did construction work and saved enough money to open a successful clothing store. He married Jane Ellen Hope in 1834 and they had two children. Winchester partnered with others to involve himself with the broader aspects of importing and manufacturing men's shirts. They opened a shirt factory in New Haven in 1850 to manufacture clothing according to a technique Winchester had patented. He bought out his partners in 1855 and was still wealthy enough to look for a new venture.

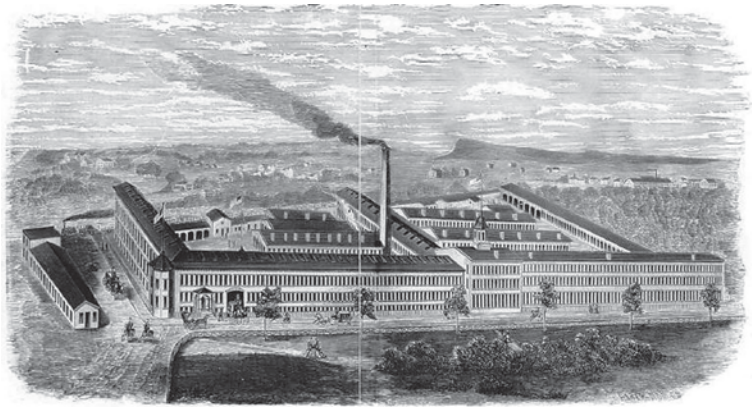
New Haven was an important firearms manufacturing city. Winchester decided to invest in the Volcanic Repeating Arms Company. The company soon became unsuccessful and Winchester acquired it in 1857. He also obtained the services of Benjamin Tyler Henry (1821–1898). Henry had been working on repeating rifles at Volcanic for several years. Winchester made him factory superintendent and gave Henry the freedom to experiment with rifle and ammunition improvements. The Henry repeating rifle was introduced by Winchester in 1862.

A metal tube under the rifle's barrel held 16 cartridges, but the Henry was troublesome to load and the tube attracted dirt. Winchester purchased a patent in 1866 for loading cartridges into the side of a rifle. When this improvement was added, the first Winchester rifle was born and the company's name changed to the Winchester Repeating Arms Company. Henry left about that time.

The 1866 rifle held 15 cartridges and was so popular that it required two new factories to keep pace with the demand. Winchester did little personal work on his rifle designs. His expertise was in factory organization, attracting skillful employees, and identifying useful patents for purchase.

Winchester rifles were named according to the year they entered production. Manufacture of the 1866 Winchester ended in 1898 after a total run of 170,000 rifles. Other popular rifles included the 1873 and 1892 models. The $20 1873 model introduced the "one of one thousand" engraving on those that were partic-

An 1862 Henry (top) and an 1866 Winchester (bottom). Note the cartridge-loading gate on the side of the Winchester.



The Winchester plant, around 1876

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

An 1873 Winchester refinished model said to have been made in 1878 with a "one in one thousand" engraving

ularly accurate. Of the 720,000 produced through 1923, only 136 had the engraving. Rugged, reliable, accurate, and moderately priced, the 1873 rifle was advertised as "The Gun That Won The West."

The Model 1892 has been popular in Hollywood westerns. Movie star John Wayne (1907–1979) introduced the oversized saddle ring in 1939's *Stagecoach*. It was a large metal loop attached to the repeating lever. Wayne used 1892 Winchesters in at least 13 of his movies. Another user was Chuck Connors (1921–1992).

His 1892 saddle ring Winchester appeared in 136 television episodes of *The Rifleman* in the 1960s. Also a favorite of Annie Oakley (1860–1926) and Buffalo Bill Cody (1846–1917), Winchester 1892s are still in production and over a million have been manufactured.

Oliver Winchester served as a town councilman in 1864 and was elected lieutenant governor of Connecticut in 1866. He shared his wealth with others and was called an "active philanthropist." Yale University used his $100,000 gift to establish its observatory. Winchester died in 1880.

References

Garraty, John A., et al. (Eds.). (1999). *American national biography.* Oxford University Press.

Kirkland, K. D. (2008). *America's premier gunmakers: Winchester.* World Publications Group Publishers.

Actor John Wayne with a saddle ring 1892 rifle in *Stagecoach*

Student Matt Jurak holds his completed guitar.

CAD/CAM Strikes a Positive Chord for Reed-Custer

By Barry Van Name

STUDENTS enrolled in the Industrial Technology/Advanced Manufacturing Program at Reed-Custer High School are immersed in a course of study that brings their woodworking abilities to a high skill level desired by prospective employers. Their teacher, Mark Smith, is a devotee of the woodworking arts with many years of teaching this subject at both the college and secondary school levels.

Smith immerses his students in hands-on operations, a learn-by-doing method that helps them gain confidence in performing each step required to bring pieces of wood into a beautifully finished product. "If I show them how to do something and they do it once or twice and move on to the next step, they really haven't learned the operation," he says. "But doing it until it becomes second nature, and the next time that operation is called for, they do it quickly and easily, leading to much better results in their final product."

In addition to stressing repetition to build confidence, Smith also promotes variety in student projects to encourage interest in his program. His classes have created wood frames for the sunglasses industry, skateboards for pleasure, kitchen cabinets for neighbors, and even professionally finished guitars for themselves and family.

Reed-Custer student Justin Read works on a Mastercam program in the school's CAD/CAM lab.

The school's facilities for the program include a classroom with 16 seats of Mastercam® for programming CNC toolpaths, a room for assembly of various projects, and a shop that measures approximately 100' × 40' that is filled with traditional woodworking tools and a Thermwood® model 43 CNC router with a 4' × 8' table.

"Our freshman students start out with Orientation to Technology, where they begin by learning all the safety rules for handling the equipment they'll find in a typical shop and then proceed to basic CAD/CAM operations," says Smith. "I let them design logos and artwork for longboards that they will demo with pride at the skateboard parks, and

---

Barry Van Name is an editorial associate with Lynn Gorman Communications LLC, specializing in technology education and industry topics.

show them how to transfer the designs into Mastercam to program the CNC router.

"The student checks each piece of geometry using Mastercam's chaining option that has the software examine their design, one chain at a time. They're checking for things like double entities because when kids are learning to draw, they often put geometry on top of geometry. They also look for places where the geometry is not a closed loop, because they are going to be engraving their design on the router and all designs must be comprised of closed loops. They clean up their geometry, making sure corners are correct and that lines do not overlap or fall short."

As sophomores, the students can take a guitar-making course called STEM I. The acoustic guitar materials are provided to the class by Taylor Guitars®. In the process of building their guitars, the students learn how to work with hand tools and power tools, along with more advanced operations using a CNC router.

"Taylor Guitars has been wonderful to us over the years," says Smith. "They contact me in advance to find out how many students will be in next year's class. Then, in August, they deliver shrink-wrapped pallets of guitar components to the school. There will be cartons with sides, backs, tops, bracing, kerfing, necks, ebony fret boards, and so on, all roughed out and ready for hand- and machine-finishing and assembly."

Beginning with the sides, students pick out the components that strike their fancy. Some of the choices are mahogany and others are more exotic, such as ovangkol, and each has its own distinct grain design, with no two alike. This allows each student to build a guitar that is unique to his or her personal taste.

Student Daniel Fierro works on the sides of his guitar in a special fixture.

The students place their rough-shaped guitar sides into special jigs to create the true form and glue in some blocks in the head and tail, along with some kerfing and set them aside to cure. "Then they choose the top section, which is usually a Sitka spruce," says Smith. "Then they select the back section, which is in the same material they have chosen for the sides, whether mahogany, ovangkol, or other.

"Taylor Guitars provides us with jigs for positioning the bracing on the back side of the top and back side of the back of the guitar. The top has a very slight convex shape to it, while the back has a more noticeable radius.

"Our students glue all the front, side, and back components together and place the resulting 'sandwich' in a VacuPress® vacuum pressing bag system that completely envelopes the woodwork. As air is drawn out of the cells in the surface structure of the wood, glue is sucked into the cells for a tight, consistent bond." After about thirty minutes, the guitar body is removed from the vacuum bag and any glue traces on the outside are cleaned up. Glued-on reinforcing structural members that now stick out of pre-cut slots on the top and back are also machined off.

"While we are building these guitars, we have the students in a classroom at least once a week for math lessons," continues Smith. "Even though most high school students wouldn't be able to do the kind of math needed to determine where the metal frets go in the neck of the guitar, we show them the math and

Working on their guitars are (left front to back) Max Leper, Anthony Mancilla, Chandler Norton (and, right front to back) Justin Read, Josh Passafiume and Vincent Vercelote.

how it works to create an instrument capable of such pleasant music.

"It's a little mind-bending for them to watch all these calculations going on in the video presentations, but they realize that because somebody knows how to do the math, we have these awesome guitars. They see the value in learning math, from basic arithmetic all the way up to advanced algebra equations. We're also exposing them to the science behind abrasives, finishing, wood preparation and all the steps that go into a fine wood product."

A guitar neck after CNC machining at Reed-Custer

At this stage in construction, students will use a special jig and router tool to prepare a space all around the face and bottom of the body, where they meet the sides, to receive an attractive edging material that hides the structural member slots and give the body a finished 'look'.

"We built our own humidity chamber for the guitar bodies to reside while we work on the rest of the components," says Smith. "It keeps the interior of the chamber at between 35% and 50% relative humidity because the thin wood of the bodies might crack if subjected to the 20% humidity of our Midwest climate during the winter before the guitars are finished."

The students now turn to the necks of their guitars. "They come to us pretty much as a stick of wood with a slight bend at one end where the tuners will eventually be located," says Smith. "If you didn't know what it was, you'd probably never guess it was for a guitar neck.

"The students have a lot of measuring, machining, and finishing ahead of them. They pick out the material that will complement what they have chosen for the body, as well as the truss rod, the ebony fret board, and the veneer that goes on the tuner head. Here, too, Taylor has given us the jigs for positioning all the registration marks for the frets and other components.

"In our plans for more advanced work, students will have the opportunity to use the CAD/CAM software and the CNC router to create more than the usual round 'dots' you see on the average fret board. The materials for these inserts, such as stars and unique icons, will also be programmed and machined on the router."

Student Justin Read machines a guitar component on the school's CNC router.

An important function for Mastercam and the router is to machine the opening in the neck that allows access to the truss rod so the guitarist can adjust it with an Allen wrench to compensate for changes due to age, humidity, and other variables. The oval opening is sealed with an attractive cover.

The fret board is then glued on using the registration points as a guide and the back of the neck, along with the tuner holes, is machined to precise specifications. "These are operations being assigned to Mastercam and the CNC router," says Smith. "The more we can do using automated manufacturing processes, the more time we can spend teaching the various sciences that deal with woodworking, whether it be for guitars or any of the many other projects we have our students doing. We're looking forward to adding a CNC laser cutting machine next year to expand our automation capabilities within the curriculum."

Of Smith's 80 or so students each year, 20 are involved in producing their own guitars. "I've been including guitars in my woodworking program for the past eight years both here and in other schools," he says, "so there are a lot of kids that have benefitted from this course.

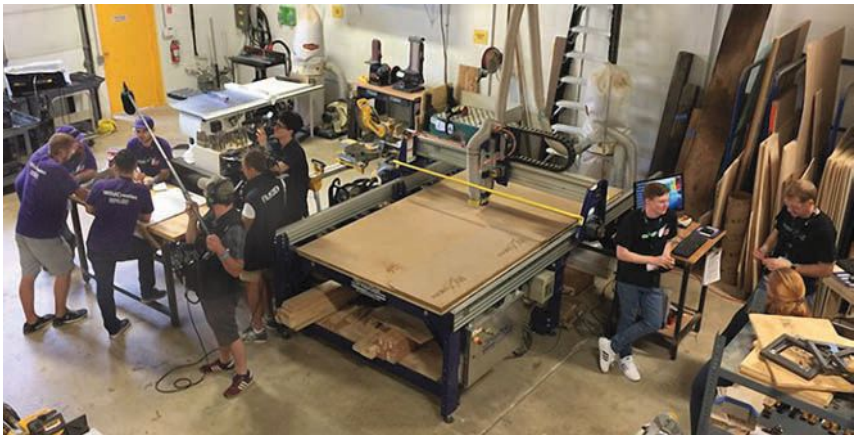
"I have to thank Taylor Guitars, Mastercam, Thermwood, and the dozens of manufacturers who contribute supplies and advice to our program every year. Our graduates are well prepared to tackle a wide range of manufacturing operations and companies, both large and small, are inviting them onto the payroll."

48 Contestants. 48 Hours. One Winning Idea.

By Sarah Burns

AS a product design student walking into an event where teams are tasked with designing a product, I didn't quite know what to expect. Every day at school we brainstorm ideas, sketch them out, prototype them over and over, and then at the end of the project, market and present a finished prototype to our peers.

As I looked around the empty shop in the quiet hours before the competition began, I wondered how closely what I was about to witness would resemble the process of product development that I had grown so familiar with. I was in Towson, MD, at the Stanley Black & Decker Makerspace for Season 3 of the TV show "Make48" in which 48 contestants have 48 hours to develop a product, produce a working prototype, create a short promotional video for that product, present it to a panel of judges, and do it all within the given challenge category and specific budget constraints. Sounds easy enough, right?



Make 48 film crew at work

This year, the contestants were college students from universities all over the country—but I wasn't there as a contestant. I was invited as a tool tech for ShopBot Tools, there to help the teams realize their ideas through physical prototypes and to guide them through the process of 3D modeling and 2D vector design for CNC machining.

Once the contestants began to arrive and I had a chance to talk with them a little, it became apparent that the competition drew a heavily engineering-based crowd. Of course, there were outliers who didn't fit into this category, and there was one team that didn't have a single engineering or design-based member. Those were the teams I was most interested in following. Sometimes throwing people out of their element and having them do things they wouldn't normally do can yield surprising and positive results.

Right before noon on Friday, we all gathered around the huge stop clock at the front of the room, eagerly waiting for the 48 hours of chaos to begin. The giant steam whistle blew loudly, like the start of a factory workday in days gone by. It was then time for the teams to get down to business and time for the tool techs

Bryan and Sarah Burns alongside judge and fellow Shopbotter Jimmy Diresta

---

Sarah Burns is a third-year product design student at Appalachian State University, Boone, NC. She works at their Makerspace in the library.

The team from the Kansas City Art Institute

Cutting prototypes for the TV camera

to stand at the ready once the prototyping begins.

Straight out of the gate, each team tackled the brainstorming phase in different ways. Within the first two hours, one team had created a model and 3D printed a rough prototype while many other teams struggled to narrow down the category of products that they wanted to focus on. Some teams immediately turned to sketching out their thoughts, while others pulled their ideas together into ordered lists, and one team had a mess of notes scattered across the table with no rhyme nor reason.

Unfortunately for me as a tool tech, I was merely a spectator in these first few hours as teams decided what they wanted to create. It wasn't until they began thinking about prototyping that my expertise came into play. One-by-one, the teams began to send their members out to the tool techs to begin fabricating their ideas.

For me, that was when the most rewarding part of the whole weekend began; the first contestant came to us with their idea, and we helped them translate their idea into a real, tangible product. We worked with them to create or edit their CAD files and guide them through the process of converting those vectors into a ready-to-cut .sbp file.

As the machine warmed up and we zeroed the axis to the new material, I watched the whole team gather around the tool. As the spindle began to cut away at the material, there was a visible change in their expressions as the magic of technology brought their vision into reality. Watching their faces light up with pride as they watched the ShopBot cutting out their product or their logo was rewarding.

If there's one thing I've learned about design in my time at school, it's that presentations matter. There were many rapid prototyping techniques available at this event to bring these teams' projects to life. In addition to the two ShopBot CNC machines, there were twelve Ultimaker 3D printers, an Epilog laser cutter, a large vinyl cutter, a Bridgeport mill, and a CNC plasma cutter, as well as a well-stocked wood and metal shop filled with many Stanley Black & Decker power and hand tools.

Although several universities

The team from University of Nevada-Reno watching the ShopBot PRSalpha at work

Aluminum cam lever being cut on a ShopBot Desktop

represented have ShopBot tools in their programs, the teams unfamiliar with CNC technology found some machines intimidating. Once we cut out a few things on the ShopBot ourselves, you could see the curiosity and confidence in the faces of the contestants begin to grow as teams got excited about the potential of prototyping on CNC.

On the last day, as I looked out on the stage as each team presented their products to the panel of judges, I admired all the work we'd done with the ShopBot. Without our ShopBot Desktop and large PRSalpha 5' ×10' gantry, or any of the other digital manufacturing machines, the outcome of this competition would have been very different, and certainly would have taken longer than 48 hours. In the world of design, an idea is nothing if you can't see it through to a working product.

I really wish that I could tell you more about all the incredible products that the teams produced, but I'm not allowed to share that information until the show is released next year, so you'll have to wait until then. For more on the show, including what channels the first two seasons can be viewed on, visit Make48.com.

A prop created by one of the teams for their presentation

Parts cut with one of the ShopBot tools

University of Connecticut team members with parts cut on the PRSalpha

Invention Education Students Solve First Responders' Needs

By Emma McNamara

ENGINEERING students at Hopkinton High School (MA) often ask, "What's your problem?" as they engage in Invention Education with a focus on beneficiaries in their local community. Each semester, students receive a unique opportunity to work directly with their local fire and police departments. The students work through not only an engineering design process, but also the invention process which helps them identify a problem and discover what current technologies exist through patent research.

Hopkinton High School engineering teacher Doug Scott worked directly with the USPTO (United States Patent and Trademark Office) as a Learning Institute Ambassador and currently serves as a Master Teacher with the Lemelson-MIT program. He describes Invention Education as "a teacher-facilitated experience in which students learn the process of how to clearly define a real problem that has beneficiaries in their local and/or global communities. This process includes research that leads to the ideation of potential solutions and the fabrication of a prototype while documenting, communicating, reporting, and receiving critical user feedback throughout the process."

The partnership between students and first responders builds a strong relationship between the two groups as well as with the school community. This unique, interactive learning environment has been available to HHS students for several years.

The wide variety of problems, potential solutions, and revisions the students incorporate into their projects show how truly versatile and open-ended this collaborative project is for students of all abilities and backgrounds. Hopkinton High School student Cole C. named his inventive device "Fire Scout." It is "a robot that you can send into a structure

Hopkinton Firefighter Tom Poirier discusses visibility issues with HHS engineering students.

Photos contributed by HHS Engineering

Emma McNamara is a 17-year-old national award-winning writer from Hopkinton, MA.

if it's on fire, and it will search to find where the fire is and sense potential dangers before any actual firefighters go in... this makes it so that the injury risk is lessened." Firefighter Paul Finneran found the working prototype of this invention particularly intriguing, noting that "The Fire Scout is a well-thought-out design."

Hopkinton High School senior Cole G. describes his invention, created with teammates Emma and Davin, as "a cooling system to prevent the body from getting hot and skin pores opening up, because when the pores open up while you're in a fire, there are carcinogenic chemicals that can get into your skin and can cause cancer, so we invented a way to cool down the body and help prevent these chemicals from getting into the skin."

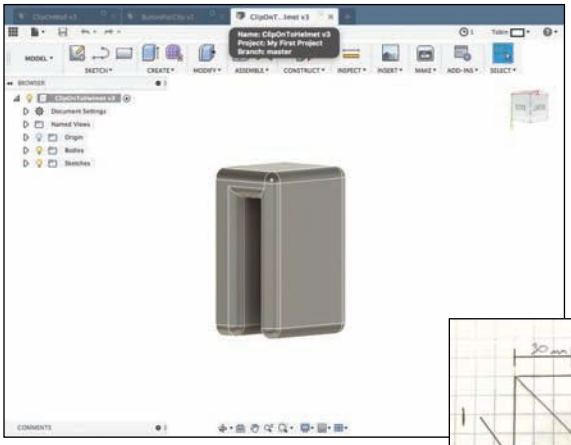
Cole plans on being an architect and has used the resources available in HHS engineering classes to build towards this goal, noting that "We get to experience a design process which is something architects definitely use a lot and we get to see how things are made and use computer-aided design (CAD) software which I wasn't familiar with before, so that helps prepare me for the college courses I will take in the future."

Hopkinton police officers review and rate student prototypes during an invention showcase.

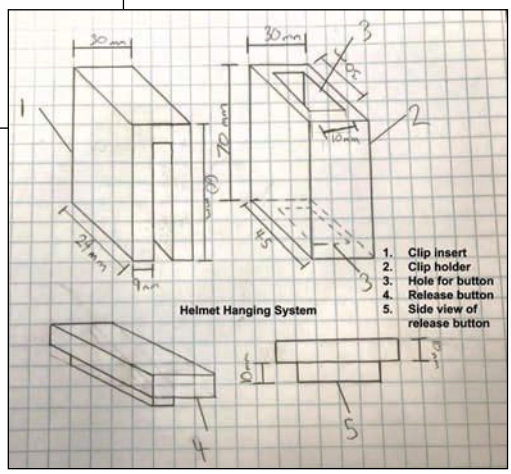
Hopkinton Firefighters test a student prototype in a controlled burn.

Students in the class fabricate prototypes in various ways, demonstrating the versatility and scalability of Invention Education projects. Students like Jacob, Shayna, and Aya learned sewing skills while developing a storage system that used elastic straps mounted to the walls and roof of a fire truck. Another team of Tobin, Eliza, and Peter utilized Autodesk Fusion 360 to design a simple yet effective clip system for hanging fire helmets that often fall off the wall inside the fire truck. Those students, along with others, exported their designs as STL files, sliced them using Cura software, and 3D printed them on inexpensive but effective 3D printers.

The range of tools and materials that can be used for fabricating inventive prototypes is wide. Scott's students entered the ideation phase of the project with sticky note brainstorming to allow each student to express his or her own ideas. Teams then developed three rapid prototypes out of cardboard and tape. The ideation phase culminated with teams making a group decision about which solution or combination of solutions to pursue. A school without fabrication tools could utilize simple office supplies to prove concepts. Ultimately Scott's students file an in-



Above, HHS engineering students work on prototype designs for a helmet clip system in Autodesk Fusion 360 CAD.



Right, HHS engineering students work on prototype designs for a helmet clip system with technical drawings.

class patent application which is similar to a US Patent application.

Inventive Education projects take problem-solving abilities to higher levels with students having to identify a problem first. This in-depth research promotes thoughtful selection and transferable skills that are valuable in many fields and everyday life. Scott says, "Identifying a viable problem for a beneficiary is truly the most difficult part of Invention Education. At no time does anyone provide the problem directly to the student, it is up to them to dig deep to discover the true root cause of a problem that is creating an issue for the beneficiary.

"This is the difference between traditional project-based learning and what I refer to as 'problem-based learning' that is encouraged by Invention Education. Such an open-ended, free structure truly cultivates creativity and gives students an opportunity to take a leadership role in selecting the path their educational experience takes."

Barry Regan, an engineer at Dell, found it particularly impressive "when students started working on one problem or solution and then realized it just wasn't going to work and then started over with a different problem or solution," a realization that leads to "a difficult transition to make, and we run into that all the time (at Dell)." Regan compared this to the creation of the Dyson vacuum cleaner, an invention that went through hundreds of prototypes before one was created that functioned sufficiently.

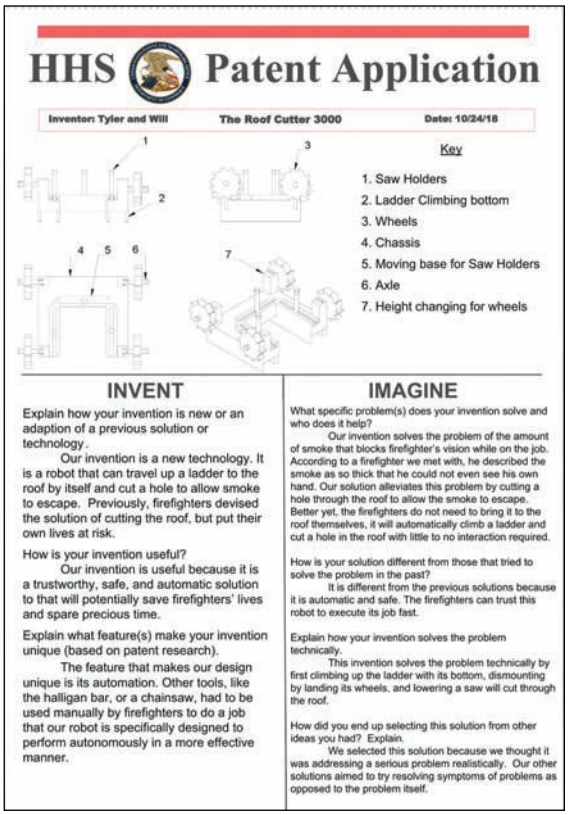
Tom Poirier, an organizer for the Hopkinton Fire Department and one of the first responders who participates in the project, advises students to "Try to find better ways to do the things that we do today. If you keep following the norm, you'll never be able to make changes." On having students at Hopkinton High School think about and work towards solutions for problems regarding his important work, Poirier commented, "It's very humbling. It's awesome to see the kids get involved in a project like this."

Phil Powers, a School Resource Officer/Patrolman of the Hopkinton Police Department, agreed with Poirier, "We have a lot of issues in law enforcement. One problem is when we're driving around eight hours a day and the seats in the cruisers really aren't made to support our backs. That was one of the problems that came up in (Mr. Scott's) engineering class, and students came up with solutions to fix that problem." While working with students on Invention Education, Officer Powers commented, "It's wonderful that the students have such great ideas that help us out."

When asked why it is important for students and teachers to experience Invention Education, Leigh Estabrooks of the Lemelson-MIT program answered that, "The experience helps students develop skills they will use throughout life. They gain experience in identifying real-world problems to solve through technological inventions through collaboration, communication, and creativity."

Joyce Ward of USPTO makes an important point that "Invention Education and inventions touch every aspect of our life, we experience it every day. Every product we use was invented by someone." Ward strongly believes that "it is important for all people to understand that their ideas matter and that they have the ability to transform their ideas into action and reality."

Not only are problems identified and solved, but the improved connection between first responders and students is clear to teacher Doug Scott, who notes, "You can see the students start out tentative to engage


HHS Patent Application

Inventon Tyler and Will | The Roof Cutter 3000 | Date: 10/24/18

Key

1. Saw Holders
2. Ladder Climbing bottom
3. Wheels
4. Chassis
5. Moving base for Saw Holders
6. Axle
7. Height changing for wheels

INVENT

Explain how your invention is new or an adaption of a previous solution or technology.

Our invention is a new technology. It is a robot that can travel up a ladder to the roof by itself and cut a hole to allow smoke to escape. Previously, firefighters devised the solution of cutting the roof, but put their own lives at risk.

How is your invention useful?

Our invention is useful because it is a trustworthy, safe, and automatic solution to that will potentially save firefighters' lives and spare precious time.

Explain what feature(s) make your invention unique (based on patent research).

The feature that makes our design unique is its automation. Other tools, like the halligan bar, or a chainsaw, had to be used manually by firefighters to do a job that our robot is specifically designed to perform autonomously in a more effective manner.

IMAGINE

What specific problem(s) does your invention solve and who does it help?

Our invention solves the problem of the amount of smoke that blocks firefighter's vision while on the job. According to a firefighter we met with, he described the smoke as so thick that he could not even see his own hand. Our solution alleviates this problem by cutting a hole through the roof to allow the smoke to escape. Better yet, the firefighters do not need to bring it to the roof themselves, it will automatically climb a ladder and cut a hole in the roof with little to no interaction required.

How is your solution different from those that tried to solve the problem in the past?

It is different from the previous solutions because it is automatic and safe. The firefighters can trust this robot to execute its job fast.

Explain how your invention solves the problem technically.

This invention solves the problem technically by first climbing up the ladder with its bottom, dismounting by landing its wheels, and lowering a saw will cut through the roof.

How did you end up selecting this solution from other ideas you had? Explain.

We selected this solution because we thought it was addressing a serious problem realistically. Our other solutions aimed to try resolving symptoms of problems as opposed to the problem itself.

A HHS engineering student submits a simulated patent application upon completion of their work before public disclosing their invention at a showcase with first responders.

Hopkinton Firefighters review and rate student prototypes during an invention showcase.

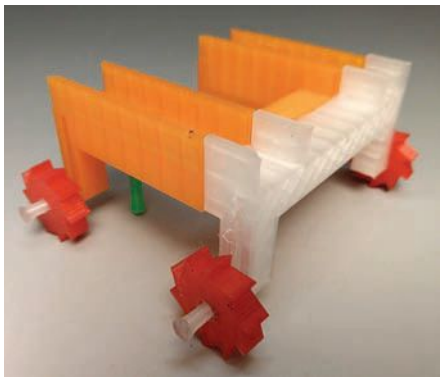
with the first responders, but by the end of the project, the students are partners with the first responders, with both engaging in a process to improve the working conditions of many."

On mentoring the students at Hopkinton High School in Invention Education, Barry Regan commented, "I keep coming back because I keep having a lot of fun, and see the students having a lot of fun. It's been a great experience for me, and all my coworkers are jealous."

A student's prototype for a helmet hanging system designed in CAD and 3D printed.

Junior student Neel reflected on his QR code system to bring up floor plans for first responders, stating that he was "proud of effectively solving the dangerous problem of disorientation during an emergency, in order to make practices safer and time efficient for first responders".

Dr. Leigh Estabrooks of Lemelson-MIT best summed up the experience of all involved, "Inventing is just plain fun!"



A student's prototype for a roof cutting system designed in CAD and 3D printed.

Resources for Invention Education

Lemelson-MIT: http://lemelson.mit.edu/

USPTO: https://www.uspto.gov/kids/

PBS NewsHour Extra Invention Education Lesson Plans: www.pbs.org/newshour/extra/lessons-plans/5-engaging-lesson-plans-celebrating-invention-and-innovation/

High-Paying Jobs Go Begging while High School Grads Line Up for Bachelor's Degrees

Huge shortages loom in the skilled trades, which require less—and cheaper—training

By Jon Marcus

LIKE most other American high school students, Garret Morgan had it drummed into him constantly: Go to college. Get a bachelor's degree.

"All through my life it was, if you don't go to college you're going to end up on the streets," Morgan said. "Everybody's so gung-ho about going to college."

So he tried it for a while. Then he quit and started training as an ironworker, which is what he's doing on a weekday morning in a nondescript high-ceilinged building with a cement floor in an industrial park near the Seattle-Tacoma International Airport.

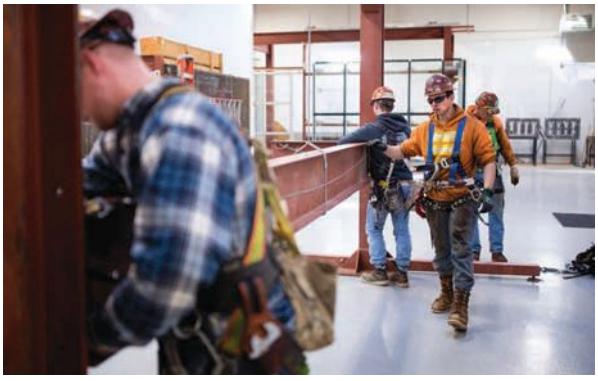
Clipped to safety harnesses, Morgan and several other young men and women in work boots, hardhats and Carhartt's, and with heavy wrenches hanging from their belts, time each other wrestling 600-pound I-beams into place. Others are rigging pulleys to a scaffold or outside weaving rebar.

Morgan, who is 20, is already working on a job site when he isn't here at the Pacific Northwest Ironworkers shop. Seattle is a forest of construction cranes, and employers are clamoring for skilled ironworkers. He'll finish with enough college credits to earn an associate degree after four and a half to five years. In the meantime, he gets benefits, including a pension, from employers at the job sites where he's training. And he's earning $28.36 an hour, or more than $50,000 a year, which is almost certain to steadily increase.

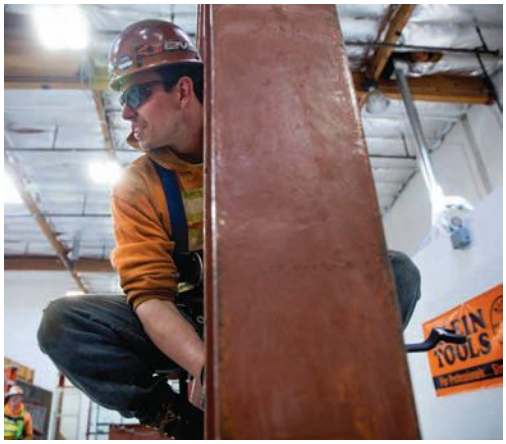
As for his friends from high school, "they're still in college," he said with a wry grin. "Someday maybe they'll make as much as me."

In fact, while a shortage of workers is pushing wages higher in the skilled trades, the financial return from a bachelor's degree is softening, even as the price—and the average debt into which it plunges students—keeps going up.

Yet so effectively have high school graduates been encouraged to get



Photos by Sy Bean for The Hechinger Report



Garret Morgan is training as an ironworker near Seattle, and already has a job that pays him $50,000 a year.

Jon Marcus is higher-education editor, The Hechinger Report. *This article was originally published on* The Hechinger Report *website, www.hechingerreport.org.* The Hechinger Report *is a nonprofit, independent news website focused on inequality and innovation in education.*

one that high-paid jobs requiring shorter and less expensive training are going unfilled. This not only affects them, but has become a growing threat to the economy.

"Parents want success for their kids," said Mike Clifton, who teaches machining at a technical college near Seattle called the Lake Washington Institute of Technology. "They get stuck on [four-year bachelor's degrees], and they're not seeing the shortage there is in tradespeople until they hire a plumber and have to write a check."

Other people are seeing it, however, and raising alarms.

In a new report, the Washington State Auditor found that good jobs in the skilled trades are going begging because students are being universally steered to bachelor's degrees. Among other things, the auditor recommended that career guidance—including about choices that require less than four years in college—start as early as the seventh grade.

"There is an emphasis on the four-year university track" in high schools, said Chris Cortines, who co-authored the report. Yet, nationwide, three out of 10 high school grads who go to four-year public universities and more than one in five who go to four-year private colleges still haven't earned degrees within even six years, according to the National Student Clearinghouse, which tracks this.

"Parents want success for their kids. They get stuck on [four-year bachelor's degrees], and they're not seeing the shortage there is in tradespeople until they hire a plumber and have to write a check."

Mike Clifton, Lake Washington Institute of Technology

"Being more aware of other types of options may be exactly what they need," Cortines said. In spite of a perception "that college is the sole path for everybody," he said, "when you look at the types of wages that apprenticeships and other career areas pay and the fact that you do not pay four years of tuition and you're paid while you learn, these other paths really need some additional consideration."

And not just in Washington State.

Seventy-percent of construction companies nationwide are having trouble finding qualified workers, according to the Associated General Contractors of America; in Washington, the proportion is 80%. There are already at least 3,259 more jobs than Washingtonians to fill them in such skilled trades as carpentry, electrical, plumbing, sheet-metal work, and pipe-fitting, the state auditor reports. Many pay more than the Washington average annual wage of $54,000. Of 260,000 "career jobs" expected to become available here over the next five years, according to the Washington Roundtable, an association of

An apprentice ironworker practices attaching I-beams. Ironworkers in this program are already making around $50,000 a year while they train.

employers, one-third will not require bachelor's degrees.

The number of workers needed in the construction trades nationally is expected to rise 11% through 2026, far faster than other occupations, or by 747,600 new jobs, the Bureau of Labor Statistics says. Construction, along with health care and personal care, will account for one-third of all new jobs through 2022, the agency says.

It also predicts that, between now and 2022, there will be a need for 138,200 new plumbers. While 7,000 people become electricians every year, about 9,000 retire, according to the National Electrical Contractors Association; by 2021, the nation will have to turn out 17,557 new electricians annually. And as politicians debate a massive overhaul of the nation's roads, bridges, and airports, the U.S. Department of Education reports that there will be 68% more job openings in infrastructure-related fields in the next five years than there are people training to fill them.

"The economy is definitely pushing this issue to the forefront," said Amy Morrison Goings, president of the Lake Washington Institute of Technology, which educates students in these fields. "There isn't a day that goes by that a business doesn't contact the college and ask the faculty who's ready to go to work."

In all, some 30 million jobs in the United States that pay an average of $55,000 per year don't require bachelor's degrees, according to the Georgetown Center on Education and the Workforce.

Yet the march to bachelor's degrees continues. The number of bachelor's degrees conferred has more than doubled in the last five decades, from 839,730 in 1970 to nearly 1.9 million in 2014-15, the last period for which the figures are available, the U.S. Department of Education reports. And while people who get them still are more likely to be employed and make more money than those who don't, that premium appears to be softening; their median earnings were lower in 2015, when adjusted for inflation, than in 2010, the department says. Meanwhile, the number of students who borrow to pay for college has increased from half in 1989 to nearly 70% now, and their average debt has grown from $15,200 to $26,300.

"There's that perception of the bachelor's degree being the American dream, the best bang for your buck," said Kate Blosveren Kreamer, deputy executive director of Advance CTE, an association of state officials who work in career and technical education. "The challenge is that in many cases it's become the fallback. People are going to college without a plan, without a career in mind, because the mindset in high school is just, 'Go to college.'"

That was what landed Matt Dickinson at Washington State University, where he started toward a bachelor's degree in mechanical engineering. "Hey, everybody, go to college," he remembered being told repeatedly in high school. "Go to a four-year school! Get a degree and get a lot of money!"

But it wasn't for him, and now he's studying automotive repair at Lake Washington Institute of Technology, where he's reassembling a transmission in a corner of the auto shop while a classmate checks the specifications on a computer monitor.

Dickinson already has a part-time job at a dealership that specializes in expensive cars, and no worries about finding a full-time one when he's finished. The placement rate in his program is 94% and median pay in the industry is just under $40,000 a year, according to the Bureau of Labor Statistics; in the Seattle area, some automotive technicians make as much as $75,187, the salary research company PayScale reports.

Ironworkers climb rebar on the outside of a training center near Seattle. Ironworkers in this program are already making around $50,000 a year while they train.

"We have people coming in here every other week to hire," Dickinson said. "There's a huge demand for mechanics and people who know trades like this."

Meanwhile, one of his roommates who goes to the University of Washington is racking up thousands of dollars in debt, said Dickinson, who is 21 and wearing safety goggles and a "COLLEGE" sweatshirt inspired by the movie Animal House.

What people need to understand, he said, is that someone with a bachelor's degree "could be working as a

barista at Starbucks" while a skilled tradesperson "could be making six figures."

Some 30 million jobs in the United States that pay an average of $55,000 per year don't require bachelor's degrees.

It's not that finding a job in the trades, or even manufacturing, means needing no education after high school. Most regulators and employers require certificates, certifications, or associate degrees. But those cost less and take less time than earning a bachelor's degree. Tuition and fees for in-state students to attend a community or technical college in Washington State, for example, come to less than half the cost of a four-year public university, the state auditor points out, and less than a tenth of the price of attending a private four-year college.

People with career and technical educations are also more likely to be employed than their counterparts with academic credentials, the U.S. Department of Education reports, and significantly more likely to be working in their fields of study.

"There's fundamentally a lack of information," said Steve Mullin, president of the Washington Roundtable. "If you're a young person who's not inclined to go to a four-year institution," and wants to go into the trades instead, "the message is, 'Go for it.'"

Young people don't seem to be getting that message. The proportion of high school students who earned three or more credits in occupational education—typically an indication that they're interested in careers in the skilled trades—has fallen from one in four in 1990 to one in five now, according to the U.S. Department of Education.

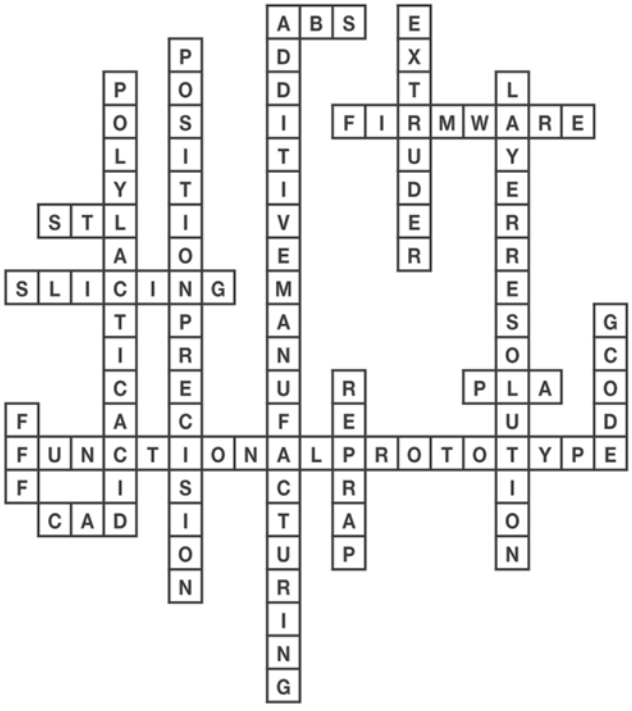
"There are more jobs, more opportunities in these kinds of fields, and they're requiring more skills, yet we have the same finite number of students," Kreamer said.

Washington is not the only state devoting attention to this. California is spending $200 million to improve the delivery of career and technical education. Iowa community colleges

Matt Dickinson started toward a bachelor's degree, but it wasn't for him. Now he's studying to become an automotive repair technician. The placement rate in his program is 94%.

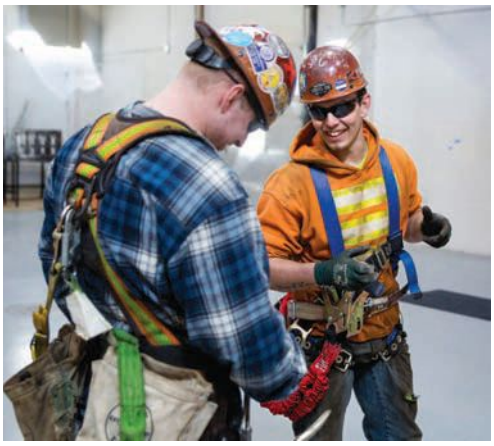
Even More Fun

3D Printing Crossword Answers



Let companies know you saw their ad in techdirections. They make your free subscription possible!

and businesses are collaborating to increase the number of "work-related learning opportunities," including apprenticeships, job-shadowing, and internships. Tennessee has made its technical colleges free.



Garret Morgan is training as an ironworker near Seattle, and already has a job that pays him $50,000 a year.

So severe are looming shortages of workers in the skilled trades in Michigan, Gov. Rick Snyder in February announced a $100 million proposal he likens to the Marshall Plan that rebuilt Europe after World War II. Using scholarships and stipends, among other things, it would prepare more people for the 811,000 expected job openings through 2024 in industries facing worker shortages, which Michigan officials say don't require bachelor's degrees and pay an average of $60,000 a year.

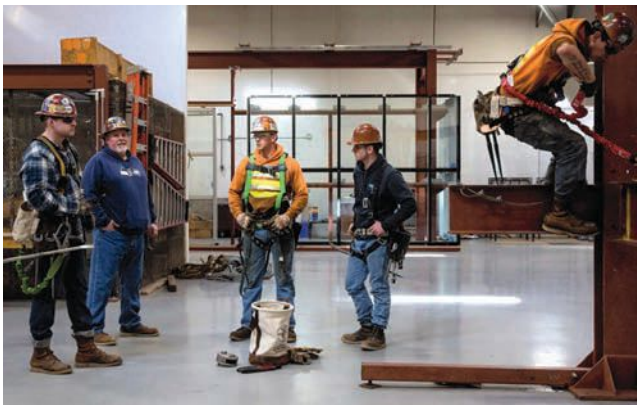
At the federal level, there's bipartisan support for making Pell grants available for short-term job training courses and not just university tuition. The Trump administration supports the idea.

Congress should "invest in workforce development and job training [and] open great vocational schools," President Donald Trump said in his State of the Union address.

For all the promises to improve vocational education, however, a principal federal source of money for it, called Tech-Prep, hasn't been funded since 2011, when it went from $103 million a year to zero; Trump's budget proposal sought to cut the remaining state grants for career and technical education by another $166 million, though Congress instead approved a $75 million increase. A quarter of states last year reduced their own funding for postsecondary career and technical education, according to the National Association of State Directors of Career Technical Education.

But money isn't the only issue, advocates for career and technical education say. An even bigger challenge is convincing parents that it leads to good jobs.

"They remember 'voc-ed' from what they were in high school, which is not necessarily what they aspire to for their own kids," Kreamer said.



Ironworkers chat as 20-year-old Garret Morgan, right, runs through a connector mockup drill at the Iron Workers Local Union #86 Administrative Offices, Tuesday, March 6, 2018, in Tukwila, Wash.

The parents "are definitely harder to convince because there is that stigma of the six-pack-totin' ironworker," said Greg Christiansen, who runs the ironworkers training program. Added Kairie Pierce, apprenticeship and college director for the Washington State Labor Council of the AFL-CIO: "It sort of has this connotation of being a dirty job. It's hard work—I want something better for my son or daughter."

Of the $200 million that California is spending on vocational education, $6 million is going into a campaign to improve the way people regard it. The Lake Washington Institute of Technology changed its name from Lake Washington Technical College, said Goings, its president, to avoid being stereotyped as a vocational school.

These perceptions fuel the worry that, if students are urged as early as the seventh grade to consider the trades, low-income, first-generation, and ethnic and racial minority high school students will be channeled into blue-collar jobs while wealthier and white classmates are pushed by their parents to get bachelor's degrees.

Already, 82% of parents with bachelor's degrees, and 86% who have advanced degrees, expect their kids to get bachelor's degrees, compared to 60% of parents who never finished college, according to the U.S. Department of Education. So do 72% of suburban parents, versus 63% who live in towns and 68% in rural areas.

"When CTE was vocational education, part of the reason we had a real disinvestment from the system was because we were tracking low-income and minority kids into these pathways," Kreamer said. "There is this tension between, do you want to focus on the people who would get the most benefit from these programs, and—is that tracking?"

In a quest for prestige and rankings, and to bolster real-estate values, high schools also like to emphasize the number of their graduates who go on to four-year colleges and universities. "We're always awarding great big banners of excellence to schools that send a lot of kids to

college," said Gene Wachtel, director of career and technical education for the Lake Stevens School District in Washington.

Students see that too. "I feel like everyone at the school has been told by their parents that you have to go to college to be successful," said Jack Wislen, a senior at Lake Stevens High School, who is still trying to figure out what he's going to do when he graduates but is thinking about careers that require less than a bachelor's degree. "They ask you what your plans are for college. They don't just ask you, 'What are your plans.' It's a little stressful."

His classmate, Hunter Vance, has a cousin who's a plumber. "He gets a lot of money for that," Vance said. "I do want to learn a trade where I can use my hands." But his parents, he said, "are definitely pressuring me" to go to college.

Angela Riebli, head of counseling at Lake Stevens High, remembers a student with a 3.7 grade-point average who "just really wanted to be an auto mechanic. It took a little bit of work, conversations with the parents to help them understand that this is your son and this is your son's life," said Riebli, whose office walls are hung with thank-you notes from students.

Most high school college counselors don't have that kind of time to talk about career options; the average public school counselor in the United States is responsible for 483 students, according to the American School Counselor Association and the National Association for College Admission Counseling, nearly twice the caseload the school counselors' association recommends. In California, it's one counselor to 760 students; in Washington State, one to 482.

Jessica Bruce went to college after high school for one main reason: because she was recruited to play fast-pitch softball. "I was still trying to figure out what I wanted to do with my life," she said.

Now she's an apprentice ironworker, making $32.42 an hour, or more than $60,000 a year, while continuing her training. At 5-foot-2, "I can run with the big boys," she said, laughing.

Amy Morrison Goings, president of the Lake Washington Institute of Technology, which changed its name from Lake Washington Technical College to avoid being stereotyped as a vocational school.

As for whether anyone looks down on her for not having a bachelor's degree, Bruce doesn't particularly care.

"The misconception," she said, "is that we don't make as much money."

And then she laughed again.

product spotlight

The newest and best for CTE and STEM classes

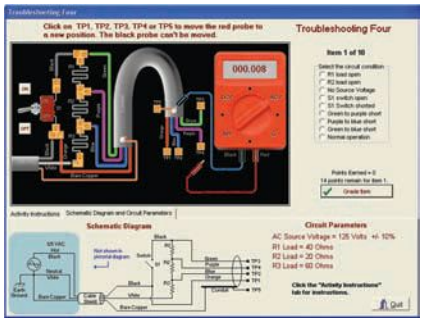
Industrial Skills Training Solutions

Techno CNC Systems Educational Sector offers high-speed, affordable, industrial-quality CNC routers, plasmas, and laser machines with work areas

available from 12" × 12" to 5' × 10'. All Techno machines are perfect for classrooms, offer endless STEM opportunities, and make it easy and exciting for educators to prepare students for technical manufacturing jobs. Every machine is installed and supported by local Techno CNC Systems representatives to ensure a successful startup.

Techno CNC Systems, LLC • Educational Sector
631-648-7481 • www.techedcnc.com
technosales@technocnc.com

Teach Electrical Troubleshooting



Go from boredom to fun. Students learn troubleshooting and meter use in a game-like environment. No dangerous voltages or burned-out parts. Use your current textbooks and curriculum. Activities provide immediate feedback and grading. Scores can be printed or stored on disks. Learning activities are constructed using random variables to assure varied experiences. Go to our website for a free trial.

ETCAI Products
901-861-0232 • Fax: 901-861-0233
info@etcai.com • www.etcai.com

Welding Training Curriculum

HIWT offers world-class curriculum materials on all major processes based on AWS® Entry Level SENSE criteria (QC10 and EG 2.0). Our complete training programs include DVDs, instructor guides, and student workbooks. Designed with input from instructors, video modules present core information and model proper technique so students can work independently with the aid of their workbooks and coaching from their instructor. Visit our website to see a complete line of offerings.

HOBART INSTITUTE OF WELDING TECHNOLOGY

Hobart Institute of Welding Technology
937-332-9500
www.welding.org

ShopBot Desktop CNC: Built to Perform Like a Big Tool

Our affordable ShopBot Desktop, with a 24" × 18" cutting bed, is a digital fabrication powerhouse. The Desktop delivers engraving level precision and has the power and rigidity to machine parts from wood, plastic, aluminum, and other materials. Not only can it perform a wide range of prototyping and production projects, the Desktop is also an agile platform to support your growing digital fabrication interests and needs.

ShopBot Tools, Inc.
888-680-4466
info@shopbottools.com
www.shopbottools.com

monthly marketplace

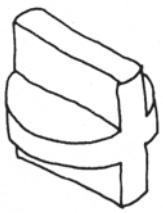
Your great ideas could be published in techdirections. To learn how, visit www.techdirections.com/guidelines.

More than Fun Answers

Funky Phrases

1. Back to square one
2. Deep rooted
3. Paint by numbers
4. Against all odds
5. Wait on tables
6. Times Square
7. Nothing to do with me
8. A finger in every pie
9. Too close to call
10. For Hire (four higher)
11. Custard pie
12. Task force
13. Grand stand
14. Y-intercept
15. On all fours
16. Close quarters
17. Positive attitude
18. Money is the root of all evil
19. Apple pie
20. Forever and a day

Design Challenge



Throttle Up!

It would take 40 minutes or 2/3 hour until we would average 60 mph. At that point, we would have traveled a total of 130 miles (80 miles plus an additional 50 miles) in a total of 2-1/6 hours (1.5 hours plus an additional 2/3 hour).

I solved this as a Rate-Time-Distance problem.

Let x = time traveled at 75 mph until we reach the 60 mph average. Then set up a table:

Rate	Time	Distance
----	1.5 hr.	80 miles
75 mph	x hr.	75x miles
60 mph	(1.5 + x) hr.	(80 + 75x) miles

Now, since Rate × Time = Distance, set up the equation:
$60\ (1.5 + x) = 80 + 75x$.
This yields $90 + 60x = 80 + 75x$
Solving, we obtain x = 2/3 hour (or 40 minutes).

TV Envy

Isaac's family TV has 4,784 square inches while Mr. P's TV has 165 square inches (using the rounded values for the horizontal and vertical lengths).

Let $16x$ and $9x$ be the horizontal and vertical lengths, respectively, of Isaac's TV. Then using the Pythagorean Theorem, $(16x)^2 + (9x)^2 = 106^2$

Solving, we obtain $337\ x^2 = 11{,}236$, so $x = 5.7741$.

Therefore, $16x = 16\ (5.7741) = 92.39$ or 92".

Likewise, $9x = 9\ (5.7741) = 51.97$ or 52".

The area is 52 × 92 = 4,784 square inches.

In a similar manner, let $4x$ and $3x$ be the horizontal and vertical lengths, respectively, of Mr. P's TV. Then using the Pythagorean Theorem,

$(4x)^2 + (3x)^2 = 19^2$

Solving, we obtain $25\ x^2 = 361$, so $x = 3.8$.

Therefore, $4x = 4\ (3.8) = 15.2$ or 15".

Likewise, $3x = 3\ (3.8) = 11.4$ or 11".

The area is 15 × 11 = 165 square inches.

more than fun

Funky Phrases

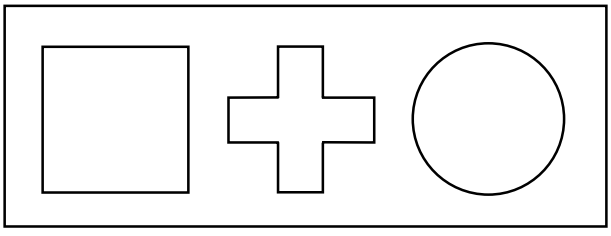
Can you figure out the familiar word, phrase, or saying represented by each arrangement of letters and/or symbols in the following puzzles?

1 OT 1^2	2 √DEEP	3 PAINT 123456	4 13579 ALL
5 WEIGHT 1x1=1 1x3=3 1x4=4 2x2=4 2x3=6 2x4=8 3x2=6 3x3=9 3x4=12 4x2=8 4x3=12 4x4=16	6 X □	7 0 TODOME	8 FINGER FINGER
9 2CALL	10 4 1 2 3 5 6 7	11 CUSTARD π	12 TASK 444
13 0 0 0 1 $	14 TERCYEPT	15 444444 ALL	16 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4 1/4
17 a++i+ude	18 $ =√SIN	19 APPLE 3.14159	20 EVER hour hour hour hour hour hour hour hour EVER hour hour hour hour EVER hour hour hour hour EVER hour hour hour hour hour hour hour hour

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

Design Challenge

Can you design a solid plug gage that will fit each of the shapes below exactly as it passes through each hole?



Throttle Up!

At one point on our trip from Fort Collins to Salt Lake City, I noted to my wife that we had gone exactly 80 miles in 90 minutes (so that we were averaging less than 60 miles per hour). At that point, we were on I-80 traveling on cruise control at the maximum legal speed limit of 75 mph.

How long would it take until we averaged exactly 60 mph from the beginning of the trip?

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

TV Envy

Isaac told Mr. P that his family had a 106" HDTV screen in his basement.The screen aspect ratio, that is, the ratio of the horizontal length of a TV screen to its vertical height, is 16:9 for HDTVs.

By contrast, Mr. P has a 19" traditional TV in his bedroom. Traditional televisions have a 4:3 screen aspect ratio.

The "inch size" of the TV refers to the diagonal measurement of the TV, so the 106" and 19" above would be the diagonal measurements.

Determine the viewing area of each TV. You may round the horizontal and vertical lengths to the nearest inch before finding the areas.

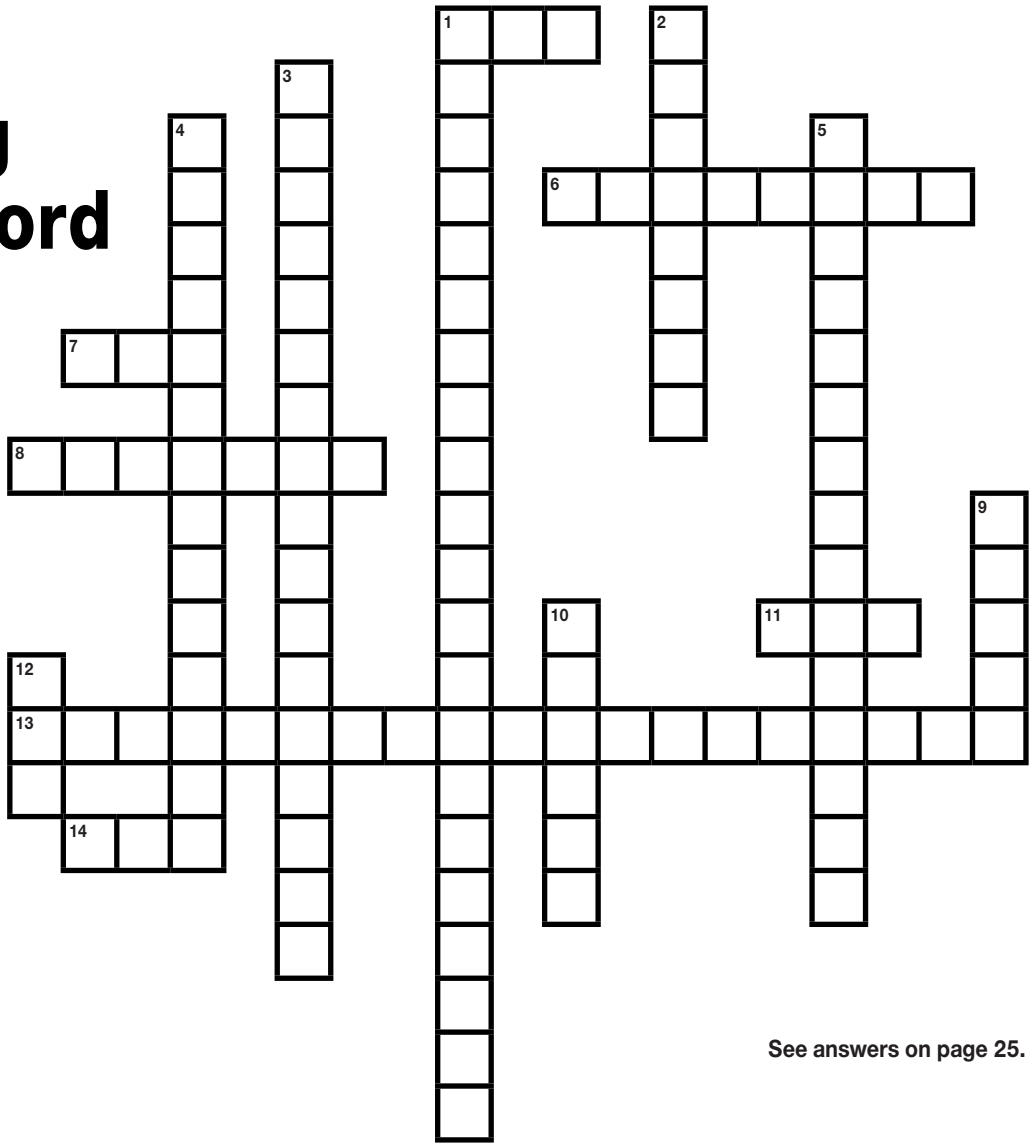
Puzzle devised by David Pleacher, www.pleacher.com/mp/mpframe.html

See answers on page 29.

We pay $25 for brain teasers 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.

3D Printing Crossword

By Cal LaFountain



See answers on page 25.

Across

1. A plastic well-known for its durability and industrial purposes

6. The software that runs on the electronics and controls the printer

7. A commonly used file format for 3D modeling

8. The process of converting a model into a printable file

11. A hard, odorless bioplastic with low environmental impact

13. A representation of a product created during the design process to evaluate the form and function of an object and its parts (two words)

14. Software that enables users to create models in either two- or three-dimensional formats

Down

1. The process of building up a three-dimensional object one layer at a time (two words)

2. A part that controls the extrusion of the filament

3. The accuracy with which the print head moves around the x and y directions (two words)

4. A biodegradeable plastic that's used as the build material or 'filament' in fused deposition modeling 3D printers (two words)

5. The thickness of one layer of a 3D print (two words)

9. A file that controls the movements of the printer (two words)

10. Machines which are open-source 3D printers utilizing the fused filament fabrication process

12. A manufacturing technology based on the principle of laying down material in layers

Celebrate Black History Month!

Inspire your students with posters of African Americans who have had a major impact on the course of American history, from the research lab to the battlefield to the courtroom.

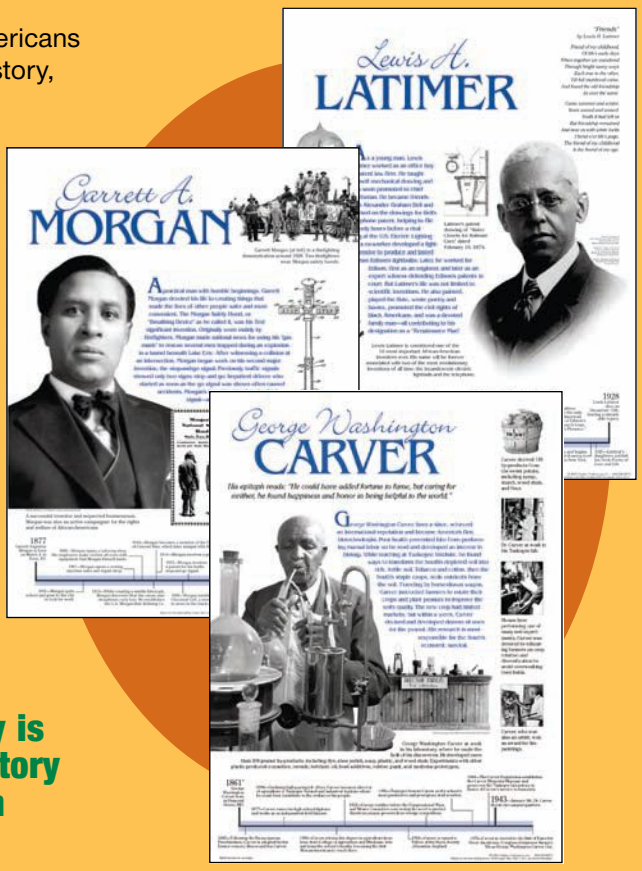
These posters will help educate your students as well as perk up dull classroom walls.

Each poster provides brief biographical information and a timeline of key life events—all designed around a stunning image of these notable black Americans.

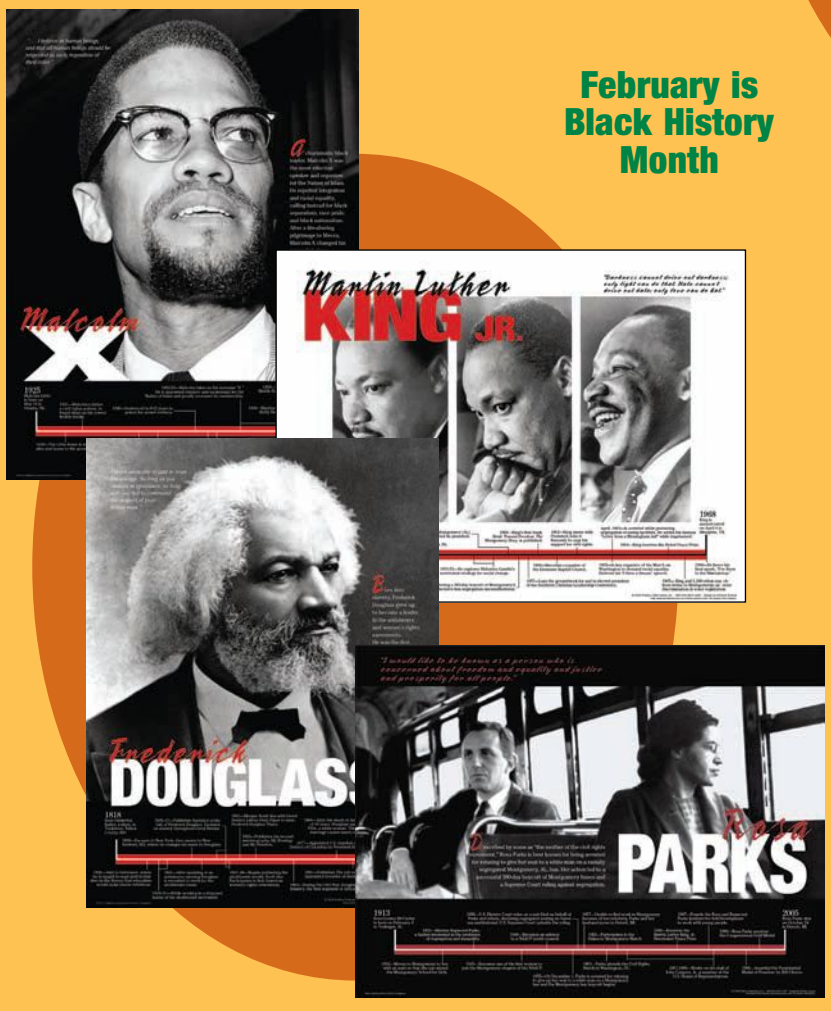
18" × 24" glossy poster stock **$12.95 each!**

Black Technologists posters–set of 3
Only $24.95! Save $13.90!

Black History Pioneers posters–set of 14
Only $119.95! Save $61.35!



February is Black History Month



Black Technologists:
George Washington Carver
Lewis Latimer
Garrett Morgan

Black History Pioneers series:
W.E.B. DuBois
Frederick Douglass
Martin Luther King, Jr. (Portraits)
Martin Luther King, Jr. (March)
Thurgood Marshall
Rosa Parks
Sojourner Truth
Harriet Tubman
Booker T. Washington
Malcolm X
The Buffalo Soldiers (Plains)
The Buffalo Soldiers (Uniform)
Montgomery Bus Boycott
The Tuskegee Airmen

To view all posters and order, visit: https://bit.ly/2Slv0Et • **FAX:** 734.975.2787
Phone: 800.530.9673 ext. 300 • **Mail:** Tech Directions Books & Media, PO Box 8623, Ann Arbor, MI 48107