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JOBS AVAILABLE!
Welders Needed Everywhere

ITEEA Conference Preview—
Bringing STEM to Life

technically speaking

Vanessa Revelli vanessa@techdirections.com

In December the Committee on STEM Education of the National Science & Technology Council released a report titled *Charting a Course for Success: America's Strategy for STEM Education*. I would like to share a few excerpts, so you understand why it was created, and what they hope it will achieve.

The pace of innovation is accelerating globally, and with it the competition for scientific and technical talent. Now more than ever the innovation capacity of the United States—and its prosperity and security—depends on an effective and inclusive STEM education ecosystem.

The Federal Government has a key role to play in furthering STEM education by working in partnership with stakeholders at all levels and seeking to remove barriers to participation in STEM careers, especially for women and other underrepresented groups. Accordingly, this report sets out a Federal strategy for the next five years based on a vision for a future where all Americans will have lifelong access to high-quality STEM education and the United States will be the global leader in STEM literacy, innovation, and employment. It represents an urgent call to action for a nationwide collaboration with learners, families, educators, communities, and employers—a "North Star" for the STEM community as it collectively charts a course for the Nation's success.

This vision will be achieved by pursuing three aspirational goals:

- Build Strong Foundations for STEM Literacy
- Increase Diversity, Equity, and Inclusion in STEM,
- Prepare the STEM Workforce for the Future

The Federal strategy is built on four pathways representing a cross-cutting set of approaches, each with a specific set of objectives and priority Federal actions for achieving these goals.

Develop and Enrich Strategic Partnerships

This pathway focuses on strengthening existing relationships and developing new connections between educational institutions, employers, and their communities.

Engage Students where Disciplines Converge

This pathway seeks to make STEM learning more meaningful and inspiring to students by focusing on complex real-world problems and challenges that require initiative and creativity.

Build Computational Literacy

This pathway recognizes how thoroughly digital devices and the internet have transformed society and adopts strategies that empower learners to take maximum advantage of this change.

Operate with Transparency and Accountability

This pathway commits the Federal Government to open, evidence-based practices and decision-making in STEM programs, investments, and activities.

You can find the report in its entirety here:

https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf

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. 6.

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.

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contents

February 2019
Vol. 78, No. 6

WELDING

page 16

CTE

CONFERENCE PREVIEW

SPECIAL FEATURE

page 27

COLUMNS

About the cover: Staff Sgt. Nicole Lomax uses a gas metal arc (GMA) welding machine to weld a t-joint. For more, see page 12. Photo courtesy of American Welding Society. Cover design by Sharon K. Miller.

the news report

Vanessa Revelli
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The Future of Autonomous Vehicle Technology

Compare-autoinsurance.org has launched a new blog post that presents the main technologies that are currently tested and will soon be available to the general public.

Numerous research projects are currently under development in laboratories and on test tracks all over the world. Researchers are looking for new technologies that will improve safety and prevent car theft. The most important technologies likely to be implemented soon are:

Fully autonomous vehicles. Industry giants are competing for developing the best driverless car. Replacing the human driver with Artificial Intelligence (AI) will eliminate the risk of accidents. When self-driving cars replace the driver, radical changes will happen. From changing the laws to changing our lifestyle, the self-driving car is the most significant innovation that can affect the auto market and insurance industry.

Driver override systems. The car's AI will decide when to stop the vehicle. As soon as the sensors detect a possible collision, the car will apply the brakes, no matter how hard the driver tries to accelerate.

Augmented reality windshield and dashboard. In the future, windshields and dashboards will be capable of displaying different data about the car and local area. Collision warnings and lane departure alerts will be directly displayed on the windshield.

Health monitoring assistance. Future seatbelts and steering wheels will come fitted with health sensors. Cars will wirelessly pair with these devices in order to monitor the driver's health. In case of a heart attack, the vehicle can pull over and call an ambulance.

Biometrics-accessed cars. In order to increase vehicle security, biometric access keys are being developed. The car owner will unlock and start the car using only his fingerprint or a retinal scan; even face recognition is being developed. All these technologies already exist in order to unlock our smartphones and some car models already use them.

New SAE Competition Recognizes Student Research

The SAE Student/Young Professional Technical Paper Competition will honor outstanding work done by active SAE student members or active SAE young professional mem-

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

bers (18-34 years old)—those at the forefront of the transformation of mobility engineering.

Winners of this exclusive competition—only the top two student and two young professional papers will be chosen—will receive an all-expenses-paid trip to present their papers at the inaugural SAE Innovations in Mobility event, which will be held Oct. 28-31, 2019, in Novi, MI.

All accepted applicants for the competition will have their technical papers published by SAE International.

Technical papers will be accepted in the following automotive technology areas:

- Advanced Manufacturing
- Advanced Materials
- Advanced Propulsion
- Automated/Autonomous and Connected Vehicles
- On-demand Mobility

Submissions will follow standard SAE event paper review and publishing practices. Final technical paper submissions will be reviewed and judged by the Competition Review Panel.

Members are invited to submit their abstract online by no later than March 25, 2019 at https://www.sae.org/attend/innovationsinmobility/techpapercompetition.

SAE International's Innovations in Mobility event is the industry's most forward-thinking event for engineers, executives, business development professionals, entrepreneurs, OEMs, suppliers, and decision-makers who need knowledge, insight, and solutions in the ever-changing mobility industry. Through three days of expert-led technical education, peer-to-peer networking, and a technology-driven exhibit floor, this hallmark event addresses the fundamental issues faced by the mobility industry amid the rapidly advancing technology marketplace in the critical areas of Smart Manufacturing, Next Gen Materials, Advanced Propulsion, Smart Mobility and Infrastructure, and Automated and Unmanned Mobility.

SAE International is a global association committed to being the ultimate knowledge source for the engineering profession. By engaging nearly 200,000 engineers, technical experts, and volunteers each year, they drive knowledge and expertise across a broad spectrum of industries. They act on two priorities: encouraging a lifetime of learning for mobility engineering professionals and setting the standards for industry engineering. They strive for a better world through the work of their philanthropic SAE Foundation, including programs like A World in Motion® and the Collegiate Design Series™. More details are available at https://www.sae.org/attend/innovationsinmobility.

February is CTE Month®!

This is a great time to promote your program! ACTE has some great ideas on how to do this. From participating in their video challenge to hosting a school visit for members of your community. Visit https://www.acteonline.org/why-cte/cte-awareness/cte-month/ for more ideas and details.

Dennis Karwatka
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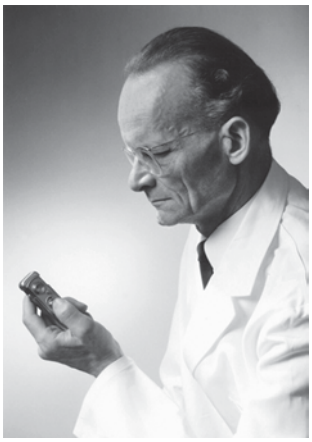
Walter Zapp and His Minox Spy Camera

Advanced amateur photographers of the early 20th century had to carry heavy, bulky cameras. Using them required prior planning and was inconvenient for casual activities. Walter Zapp of Latvia had a better idea. He designed the Minox camera in 1935, which could easily fit into a pocket or purse.



Walter Zapp

Zapp was born in Riga, Latvia, in 1905 and raised with a younger brother. Latvia was then a Russian protectorate. The Russian Revolution (1905-1907) and World War I (1914-1918) greatly disrupted Zapp's early life and he was educated only through the 8th grade.

Zapp had a special interest in mechanisms and read technical books in his spare time. After working at some minor jobs, he became an art photographer's apprentice. He was 20 years old when he developed a special paper cutter for photographic use. The paper cutter impressed a friend who introduced Zapp to an investor who agreed to support Zapp while he worked on other ideas.

A Minox camera made in Riga during World War II

Zapp was completely absorbed with the idea of a miniature camera. He wanted one that was small enough to fit in the palm of a hand but could still take high-quality, spontaneous photographs.

His first experimental camera was about the size of a candy bar. It featured a brass and stainless steel body, a parallax-corrected viewfinder, a film transport mechanism, and a multi-speed shutter. An Austrian university professor designed its three-element f/3.5 lens with a focal length of 15 mm.

Zapp chose an image size of 8 mm × 11 mm on film spooled inside a cartridge that held 50 exposures. The camera had 10 shutter speeds up to 1/1000 second. The name Minox evolved from the word "miniature" with an -ox suffix that was popular among camera names of the time.

Size of Minox negative

Zapp and his original investor signed a contract in 1936 with the state-owned Latvian radio and electrical company, VEF (its full name translates as "National Electrotechnical Factory"). The initial production rate of the complicated Minox in 1937 was only two a day. Production slowly increased and VEF would go on to make 17,000 cameras in Riga before and during World War II (1939-1945).

The easily hidden, palm-sized camera was ideally suited for spy photography, and espionage organizations kept the demand high. The camera came with an 18" measuring chain to assist in copying letter-sized documents.

A Minox camera being used by actor Martin Landau in the TV series *Mission Impossible*

German wartime requirements forced Zapp to move to a Berlin research facility in 1941. He worked on the development of the electron microscope until the war ended. Zapp then reconnected with his associates from Latvia and they established the Minox Corporation in Wetzlar, about 325 miles southwest of Berlin.

Limited production of an improved Minox model began in 1945 in a small workshop. The partners soon found financial support from a large cigar manufacturer, who provided them with space in an unused warehouse. Zapp had some disagreements with the cigar manufacturer and separated from the company in 1950. He then moved to Switzerland and became an engineering consul-

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Left, a modern Minox EC film camera

Right, a modern Minox DSC (Digital Spy Camera)

Left, modern Minox EC film camera with flash adapter and film cartridge

Right, Minox pocket telescope

tant. Zapp received about 80 patents in his lifetime.

In an unusual twist of fate, Minox faced bankruptcy almost 40 years later in 1989. Zapp was 84 years old but the company persuaded him to renew his association with Minox. Zapp agreed and the company quickly recovered. He did further work on his patented Minox pocket telescope, bringingt it to market in the 1990s. Zapp died in Switzerland in 2003 at the age of 97.

Little information about Zapp's personal life is available, other than that he had a son and a daughter. The Minox camera's basic design remains unchanged; over a million have been sold. A special edition Minox LX commemorative camera was produced in 2005, the 100th anniversary of Zapp's birth.

Reference

Young, D. Scott. (2000). *Minox: Marvel in miniature.* 1st Book Publishers.

Alan Pierce
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SLIPS—The Slipperiest Engineered Coating in the World

In our natural world, you will find many living organisms that have amazing characteristics that scientists and engineers want to copy. At the Harvard University Wyss Institute for Biologically Inspired Engineering, scientists and engineers were able to create an ultra-slippery self-healing coating by duplicating the properties of the Nepenthes Pitcher plant (Photo 1). Their research has now reached the point of creating viable products through a spinoff company first named SLIPS Technologies Inc., and very recently rebranded as Adaptive Surface Technologies (AST).

Wong Laboratory for Nature Inspired Engineering, Penn State

Photo 1—The carnivorous pitcher plant gets its name from its distinctive shape. It catches bugs that crawl on its moist top rim that is so slippery they fall in.

The pitcher plant is carnivorous, but visually it appears to have no way to catch and trap the crawling bugs that it needs to eat. It traps its prey by having a surface that is ultra-slippery. When moist, bugs that crawl on its top surface can't keep their footing and therefore slide into the pitcher of the plant to become dinner.

The coating that the Wyss scientists, engineers, and their students created is named "SLIPS," which stands for Slippery Liquid Infused Porous Surfaces. Besides being very slippery, it is also transparent, self healing, durable, and basically repels everything that falls on it (Photo 2). It is more slippery than Teflon and like Teflon it can handle very high temperatures without losing its slippery properties.

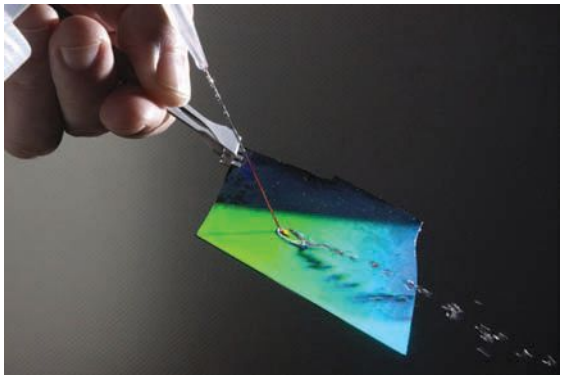
Dr. Tak-Sing Wong invented SLIPS while he was working at the Wyss Institute under the leadership of Dr. Joanna Aizenberg. He is now an Assistant Professor of Mechanical Engineering at Penn State University and continues, working with his students, to research new technologies that are inspired by biological organisms.

Photo 2—Two balls in oil, one uncoated (left) and one SLIPS coated (right)

Wong Laboratory for Nature Inspired Engineering, Penn State

To fabricate SLIPS into what the Wyss scientists called a "superglass," the team assembled micro-sized polystyrene hollow beads into a tightly packed layer on top of a piece of glass. The tightly corralled beads were entombed in a second layer of liquefied glass, then the beads were burned away, leaving a micro-sized honeycomb structure that was created because the beads were hollow.

This second layer of glass was intentionally thin so it would leave micro-sized openings into the honeycomb layer that once contained the beads. Into the honeycomb layer they infused their SLIPS formulation. (Photo 4). Since SLIPS doesn't evaporate or dissolve in water or oil, the backup reservoir, in the honeycomb, is for self healing of the surface layer.



Wong Laboratory for Nature Inspired Engineering, Penn State

Photo 3—If you look carefully you can actually see the liquid hit the surface and bounce back into the air.

To add SLIPS to any material one needs to create a hybrid micro sized honeycomb outer coating that can be infused with SLIPS (Fig. 1). Laboratory experimentation indicates it should be possible for AST to create coatings that can be applied to many different types of materials including glass, metals, and ceramics. The Wyss news releases indicate that SLIPS could even be used as a coating on medical instruments, but the

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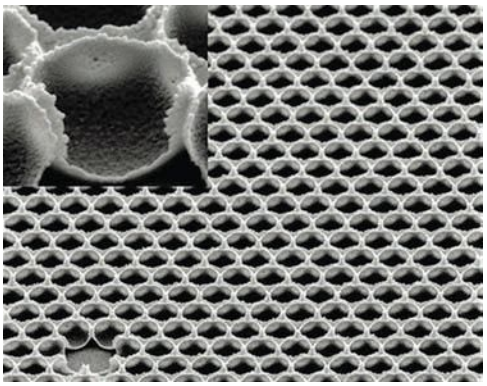
Alan Pierce, Ed.D., CSIT, is a technology education consultant. Visit www.technologytoday.us for past columns and teacher resources.



Wyss Institute at Harvard University

Photo 4—To create the self-cleaning superglass, the Wyss Institute scientists needed to create a sheet of glass with a middle layer that contained a honeycomb of micro-sized wells into which they infused SLIPS. To see these opening you would need to view the glass under an electron microscope.

spinoff company was not given the rights to develop SLIPS infused medical products at this time.

Now that SLIPS has moved from the laboratory to manufacturing, what makes it so special is it can be clear or opaque, colored or colorless, and coat almost any type of surface. It doesn't have to be infused into a glass substrate unless you want to create superglass self cleaning windows, scratch proof optical lenses, or self-cleaning solar panels.

Used as a metal coating on ships, it would prevent barnacles from forming. Used on steel, it could prevent corrosion. On medical equipment it could prevent the growth of bacteria and viruses. The list of uses is endless; it is only a matter of time before you might be able to purchase products with a SLIPS outer coating. This YouTube video visually shows SLIPS slipperiness: youtube.com/watch?v=-b8SAZMqg0s

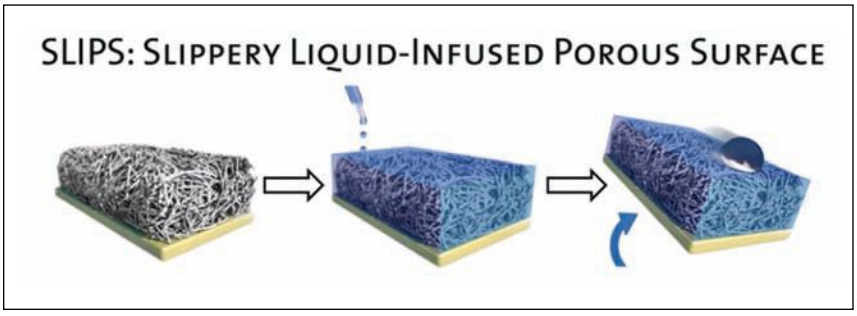
Taking It a Step Further

1. Stickiness is the opposite of slipperiness. There are many glues being sold with the tag line "our adhesive creates a stronger bond than any other glue." Select different commercial glues and develop a testing procedure to determine which one gives the strongest bond. Each of the glues must be applied following the manufacturer's application and curing directions.

Instructor note: This testing phase should be supervised to prevent students from getting injured if the testing procedure does not provide adequate protection from falling or flying material when glue joints fail.

2. Creating medicine from parts of plants and animals existed in ancient civilizations. Working in teams of 3-5 students, see which group can find the most examples of:

- Ancient uses of plants and other living organisms for their curative abilities.
- Modern uses of plants and other living organisms to create medical breakthroughs.



Wyss Institute at Harvard University

Fig. 1—The figures show openings that would be invisible unless you were looking at the object under an electron microscope. To infuse SLIPS, the outer layer of a metal or ceramic material would need to have micro-sized openings that serve as SLIPS wells to self-heal the outer coating if it is damaged.

More than Fun Answers

But It Just Doesn't Add Up!

There are at least two possible answers:

25 + 4 – 3 = 26 and 4 – 3 + 52 = 26

5 (2 × 3) – 4 = 26 could also be acceptable since it doesn't use the same multiplication symbol twice.

Merrily We Roll Along . . .

The average speed is 13.333 mph.

Let the distance up the hill be 20 miles. Then it took 2 hours to go up and 1 hour to come back down.

So, the average speed is found by dividing total distance (40 miles) by total time (3 hours).

Road Trip!

165.749 or 166 mpg.

To find mpg, you must divide total miles by the total gallons.

Let x = the mpg for the second part of the trip. Set up the following table to help you:

	mpg	Gallons	Miles
1st Part	39	21 / 13	63
2nd Part	x	28 / x	28
Whole Trip	51	91 / 51	91

The number of gallons used on the first part of the trip plus the number of gallons used on the second part must equal the total number of gallons used for the trip, so this gives us our equation:

$21 / 13 + 28 / x = 91 / 51$

$1.65153 + 28 / x = 1.784$

Then $28 / x = 0.1689291105$, so $x = 165.74999$ or 166 mpg.

Tech Inventors

1—D Bowie knife
2—G Braille alphabet "M"
3—C Bunsen burner
4—J Ferris wheel
5—B Foucault pendulum
6—H Fresnel lighthouse lens
7—E Klieg carbon arc spotlight
8—A Morse code "M"
9—I Petri dish for bacterial cultures
10—F Wheatstone bridge

Welding Is a Dynamic Industry with a BIG Future

By Pat Toensmeier

A CLEVER Bronze-Age worker was thinking outside the box one day 5,500 years ago when he came up with an inspired idea. A great way of making things with the bronze alloys that were being developed then, he reasoned, would be to heat them until they started melting and pound them together with a hammer. By combining heat and pressure in this way, craftsmen could make just about anything that required a strong metal like bronze.

This was the birth of welding, a process that has had a major impact on metalworking and product engineering ever since.

Anything made of metal, no matter how big or small, can be welded. Examples are everywhere, from vehicles like cars, trucks, and motorcycles to rail cars, ships, aircraft, rockets, and space stations. Construction is a huge market, and skyscrapers, bridges, and highways would be impossible to build without welding, as would oil and natural-gas pipelines, offshore oil platforms,

Reprint courtesy of American Welding Society.

Staff Sgt. Nicole Lomax uses a gas metal arc (GMA) welding machine to weld a t-joint at Lackland Air Force Base, Texas.

giant wind turbines, and solar panels. Welders help install and maintain boilers, antipollution systems, and other large structures, as well as piping for industrial, commercial, and residential facilities. Welding is even used by artists to create sculptures and decorative items.

There is almost no limit to what welding can do, especially since developments in the technology continually improve its accuracy, quality, and versatility. Welding is, in fact, an increasingly high-tech skill. Welders are being trained to operate robots and other automated systems that use powerful lasers, electron beams, and sometimes explosives to bond metals. The ability to work with computers and program software is consequently vital to the successful operation of these systems.

Don Howard, a welding specialist at Concurrent Technologies Corp., an engineering firm in Johnstown, PA, estimates that 20%-25% of U.S. welding is automated and predicts this trend will grow by about 20% in the next few years.

"A lot of very intelligent people are coming into the welding community," says Howard. There is money to be made, he notes, but the industry also offers career paths. "Welding is not just about working on a manufacturing line anymore. Once in the industry, people know they can find a niche."

"These are good times to be in welding," says Patricio Mendez, director of the Canadian Center for Welding and Joining at the University of Edmonton in Alberta, Canada. Mendez notes that students who like designing and building with metal and are interested in fields such as materials engineering, robotics, lasers, computer programming, and systems integration will find plenty of career opportunities in welding.

Many students are introduced to the process by virtual welding. This simulation program is being developed by the Edison Welding Institute (EWI) of Columbus, OH, to teach the basics of welding in classrooms. "The objective is to give students a virtual experience that is very much like the real thing," says John Coffey, engineering manager at EWI. The system uses sensors that duplicate the look and feel of welding.

There are more than 80 welding processes. Most involve a skilled worker using a high-heat torch (2,800°F+), filler material that is usually in wire or stick form (though some welds don't use fillers), and pressure to permanently bond metal pieces. Welding can also be used to cut and dismantle objects of all sizes as well as for repairs.

A mission specialist working on the International Space Station performs extravehicular activities, putting welding to work to connect power, data and cooling cables.

The most common process is gas metal arc welding, or GMAW. In GMAW, an electrode, which is also the filler, is continuously fed through the nozzle of an arc torch. When the welder activates the torch, several operations take place: The electrode begins feeding through the nozzle, a direct current is generated that creates an arc when it comes in contact with the electrode, and shielding gases are released around the nozzle to protect the weld from atmospheric gases that could degrade its quality. The arc, whose movement the welder controls, consumes the electrode, fills in the weld joint, and creates the weld.

Other widely used techniques like gas tungsten arc welding (GTAW) and shielded metal arc welding (SMAW) are variations of the process. GTAW, for example, is a relatively low-heat method that uses a non-consumable tungsten electrode. Its low-heat characteristic reduces distortion in thin metals, such as those used in aerospace. SMAW, also called "stick welding," uses a flux-coated consumable electrode ("flux" is a chemical cleaning agent that removes oxidation from the metals to be joined) and is primarily used for repair and steel welding. As the electrode burns, the flux disintegrates, which releases a shielding gas that protects the weld from degradation.

In more advanced welding technologies, lasers are combined with GMAW in a hybrid process to make what one expert calls "scalpel-like cuts" that are up to 1/2" deep, narrow, and extremely precise. The GMAW part of the process then deposits the filler and melts it with a secondary heat source.

The influence of welding is so broad that many of the product designs and building techniques people take for granted would not be possible without it. With demand for skilled welders rising and the technology of welding becoming more advanced, especially where automation is concerned, students have a unique opportunity to learn a career that can be shaped around their interests.

"There are many aspects to welding," Mendez says. "When people come in contact with it, they love it."

Enhancing Welding Education through Community Involvement

By James Wilkey

LEARNING to weld takes practice. No matter how you're learning, or who you're learning from, every student needs to log some time behind an electrode to truly understand the craft.

However, practice doesn't have to stay in the workshop. Public projects are a great way for budding welders to develop their skills and help their communities at the same time. Community projects are also a good way for students to develop relationships and take advantage of opportunities such as scholarships, financial aid, training, and employment.

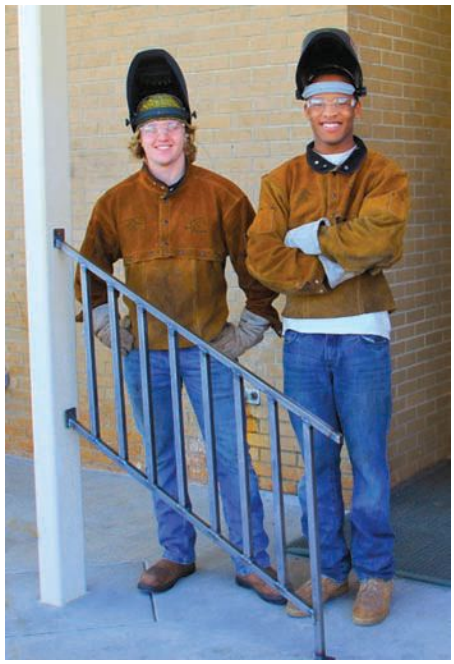
For example, in Green Bay, WI, welding students at Northeast Wisconsin Technical College (NWTC) are building bike racks to be placed around the city. The cost of materials for the bike racks is being handled by the city because the racks are for public use. Meanwhile, the students are donating their labor in exchange for a real-life welding experience.

Community projects are an "excellent learning tool for students," said Jon Russel, a welding instructor at NWTC. "They're learning how to measure, how to layout, how to fabricate accurately, because, as you can see, this is not a work of art, it's an actually measured fabrication."

Actually, public art is another great way to obtain welding experience and give back to the community. Many states offer grants and funding for public art projects of all sorts, including welded sculptures. All that is needed is a carefully considered budget and a compelling proposal explaining how the project will help the community and the project's participants. There are a great variety of how-to sources for procuring public art funding according to state (https://forecastpublicart.org/artist-support-2/).

In Spartanburg, SC, artist Erwin Redl is leading a public art project with student welders from the Daniel Morgan Technology Center. Students are making floating islands of light that will decorate the city's Duncan Town Lake. The project is part of a "See Spartanburg in a New Light" campaign.

According to Jennifer Evins, presi-



Students from Daniel Morgan Technology Center pose behind a handrail they welded for a senior citizen.

James Wilkey is a contracted blog writer for the American Welding Society. Article courtesy of American Welding Society, reprinted from their website, https://awo.aws.org/2016/05/enhancing-welding-education-through-community-involvement/

dent and CEO of the Chapman Cultural Center, "Each piece that Erwin is creating is unique, so to have the students working alongside his creative vision, using their technical skills to help him work out the kinks, that's what they do in industry. They come up with a prototype, test it, and then make more."

Students can also speak to family and community members about items that may need repair. Potential projects include everything from fences to fenders and broken household goods gathering dust in garages. Students can even hold an event designed to collect these types of projects. If project drives become a regular community activity, more and more people will likely seek help from their local students before giving up on their broken goods.

The same principle applies to community organizations. For example, students at Western Nevada College (WNC) helped the Big Brothers Big Sisters of Northern Nevada repair broken and vandalized donation bins earlier this month. The students were guided by their welding instructor, Joseph Brillhart.

"This is an incredible service to us," said J. Merriman, a community outreach specialist for Big Brothers Big Sisters. "This is something we deal with all of the time. Finding people who can even fix them is difficult, and it's an incredible amount for us to spend. WNC is not only saving us the cost to fix the bins, I know Joe is looking at ways to deter people from breaking into them in the future."

A student welder from Western Nevada College repairs a vandalized donation bin.

If you are interested in getting your student welders involved in a public project, identifying a community need is a good way to get the ball rolling. For instance, is the city in need of certain items or repairs? Consider projects that students have the skills to complete, as well as those that will require additional practice to accomplish.

Once an appropriate project has been identified, the instructor can reach out to those in need. A strong relationship between the welding classroom and the community can quickly develop into a reliable source of support for students, while providing them with the skills and experience they need to succeed in the industry. TD

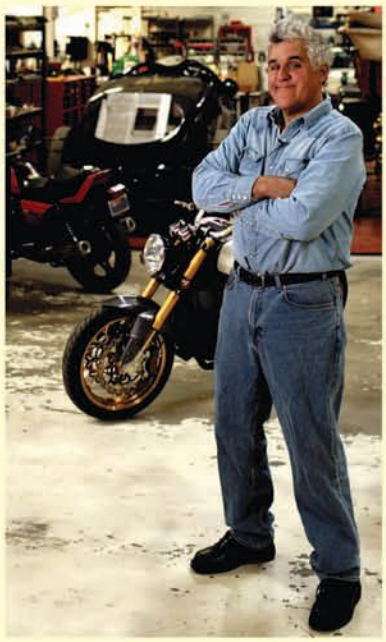
Fun Facts

About welding

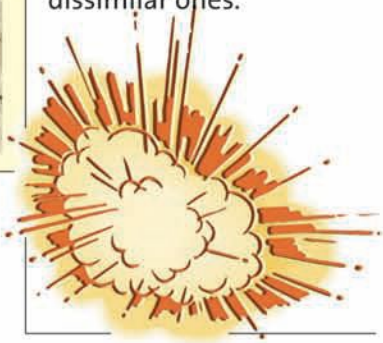
1 NASCAR—Long before the rubber hits the road, roughly 950 man-hours are spent on welding and fabrication for each race car. Hundreds of parts are hand-cut, welded and machined, from the chassis and suspension to the drivetrain.

2 In 1961, General Motors installed the first industrial robot in history, the Unimate. Featuring a motorized arm that weighed more than two tons, the Unimate performed spot welds by following step-by-step commands stored on a magnetic drum.

3 Which famous comedian has a large antique car and motorcycle collection and employs welders regularly? **Jay Leno!** His large collection includes models from the early 1900s to modern vehicles.

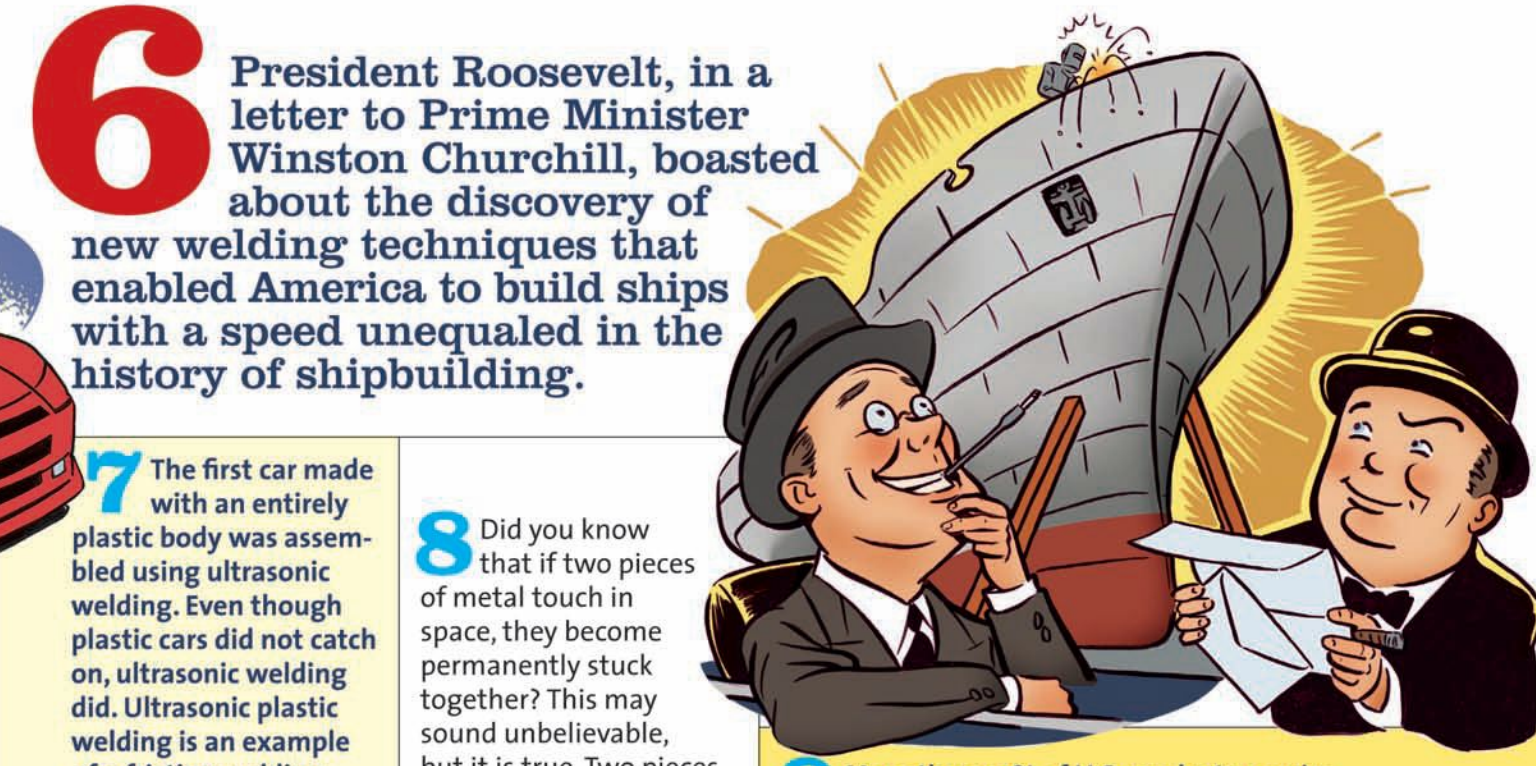


4 Explosion welding is a powerful welding process that can accomplish what many other welding methods can't—it can join nearly every kind of metal together, even the most highly dissimilar ones.



5 Welding in space was first attempted in 1969 by Russian cosmonauts. Today, advances in welding technology have made it essential for projects like the construction of the International Space Station.

6 President Roosevelt, in a letter to Prime Minister Winston Churchill, boasted about the discovery of new welding techniques that enabled America to build ships with a speed unequaled in the history of shipbuilding.



7 The first car made with an entirely plastic body was assembled using ultrasonic welding. Even though plastic cars did not catch on, ultrasonic welding did. Ultrasonic plastic welding is an example of a friction welding process, which creates energy through high-intensity acoustic sounds that cause plastic pieces to vibrate together and form a bond.

8 Did you know that if two pieces of metal touch in space, they become permanently stuck together? This may sound unbelievable, but it is true. Two pieces of metal without any coating on them will form into one piece in the vacuum of space. This doesn't happen on Earth because the atmosphere puts a layer of oxidized material between the surfaces.

9 More than 50% of U.S. products require welding. Do you know which of the following products rely on welding?

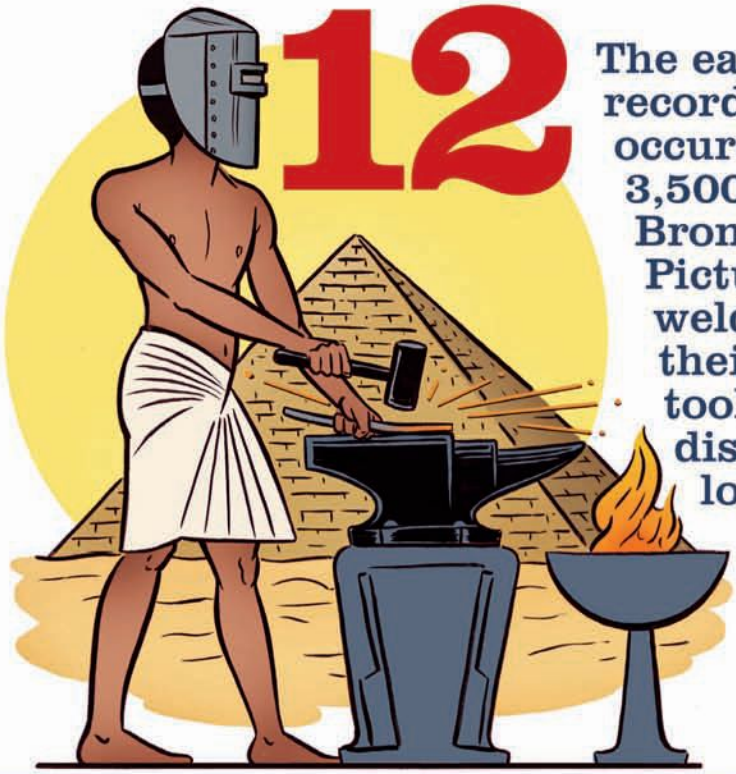
- Race cars
- Ships
- Medical devices
- Farm equipment
- Scooters
- Bridges
- Computers
- Oil rigs
- Cell phones
- MP3 players

Answer: All of them.

10 What is a "fume plume"? It is the visible column of fume that rises directly from the spot of welding or cutting.

11 The current record for the world's deepest underwater dry weld, which is carried out in a chamber sealed around the structure to be welded, was set by Global Industries in 1990, at 1,075 ft. deep. But that is only half as deep as the world's record wet weld, set by the U.S. Navy in 2005, at 2,000 ft. deep. Wet welding is performed underwater, directly exposed to the watery environment.

12 The earliest recorded welds occured in 3,500 B.C., the Bronze-Age. Pictures of welders and their ancient tools have been discovered in long-sealed Egyptian tombs!



ILLUSTRATIONS: JONATHAN CARLSON

Want the Stacked Dimes Look When Welding Aluminum?

Follow These 7 GTAW Tips

By Andrew Pfaller

MANUFACTURING products with aluminum can help extend part life, reduce weight, and deliver greater integrity in cold temperatures, making the material well-suited for applications such as truck and trailer manufacturing, cryogenic piping, and boat components. As aluminum grows in use and popularity in many applications, operators are welding the material more often.

However, welding aluminum presents some challenges, from the need to control heat input to dealing with the oxide layer. Gas tungsten arc welding (GTAW) has traditionally been considered the go-to process for welding aluminum because of the weld integrity and high aesthetic appearance the process can provide.

Achieving high-quality welds—and getting the coveted stacked dimes appearance—when welding aluminum with the GTAW process takes practice and skill. It's also helpful to follow some key best practices.

Andrew Pfaller is product manager, CWI, Miller Electric Mfg. LLC. This article first appeared in the July/August 2018 issue of The Welder.

Overcoming Aluminum Challenges with GTAW

While GTAW is a slower process and therefore not typically used in high-production manufacturing, it is often a good choice in aluminum welding applications where productivity isn't as important but quality and appearance are critical.

When welding aluminum with the gas metal arc welding (GMAW) process, filler metal is fed into the puddle as soon as the welder squeezes the gun trigger. These "cold starts" can result in lack of fusion and insufficient penetration.

By comparison, in the GTAW process the operator has control over when the filler metal is added, so the welder is better able to establish the puddle and ensure proper penetration before adding filler metal. Keep in mind that having more control over this variable also adds another layer of complexity and operator skill when comparing the GTAW process to others such as GMAW.

Proper heat input is a critical factor in successfully welding aluminum with GTAW. Because aluminum is so conductive, the heat of the weld puddle can be pulled away quickly. This requires putting in a lot of heat to establish the weld puddle. However, this heat must be controlled to prevent a runaway puddle or burn-through.

The heat of the welding process is a function of amperage and voltage, which means the higher the arc voltage, the more power going into the part. Although welding with a longer arc increases arc voltage, which in turn means more heat, it also heats a much larger area of the material. This can result in a runaway puddle that grows quickly. Therefore, it's recommended to use a shorter arc length to help localize the heat to a small area.

In addition to properly controlling heat, consider these seven tips to optimize results when welding aluminum with GTAW.

Tip No. 1: Use the Right Polarity

Many operators—especially those new to welding aluminum—may not realize the material generates an

oxide layer. Oxidation on aluminum tends to be a dull silver color and is harder to see than red oxidation, or rust, on steel. In addition, the melting point of aluminum oxide is much higher—about three times the melting temperature of the base material.

Cleaning the oxide layer with a dedicated stainless steel wire brush or carbide cutter prior to welding is important. However, even with proper cleaning, the oxide layer begins reforming immediately, which can obstruct the view of the weld puddle.

This makes it critical to use alternating current (AC) polarity with the GTAW process on aluminum. With alternating current, the direction of current flow continuously changes throughout the weld. AC polarity provides a cleaning action that helps remove the oxide layer when welding aluminum, allowing the operator to see the molten weld pool.

Tip No. 2: Adjust the Balance Control

Another step that contributes to making a good aluminum weld is setting the proper balance control. When welding in AC polarity, the weld has an electrode negative cycle and an electrode positive portion of the cycle. Electrode negative (EN) is often considered the welding side of the AC waveform, while electrode positive (EP) is where the cleaning or oxide removal occurs. On modern welding equipment, the balance control feature allows operators to adjust the ratio between the two in response to what they're seeing in the weld puddle.

While older equipment had a truly balanced 50-50 ratio of EN and EP, many modern GTAW power sources have a factory preset balance control of 75% electrode negative to 25%electrode positive. If small black flecks appear in the puddle during welding—referred to as "peppering"—this is a sign that the balance control is not adjusted properly. Turning the balance control down so there is less EN and more EP helps remove more oxide during welding and should reduce the peppering.

Turning the electrode negative down to provide more cleaning action may be necessary when welding material that's been in service or exposed to the elements and as a result has a thick oxide layer that wasn't completely removed during material preparation. But be aware that using a lower balance setting (more electrode positive) puts the majority of the heat on the tungsten and can cause the tungsten tip to ball back, which affects the welder's ability to control arc direction and placement of the weld.

The ability to adjust balance control does not replace the need for proper material prep and cleaning when welding aluminum.

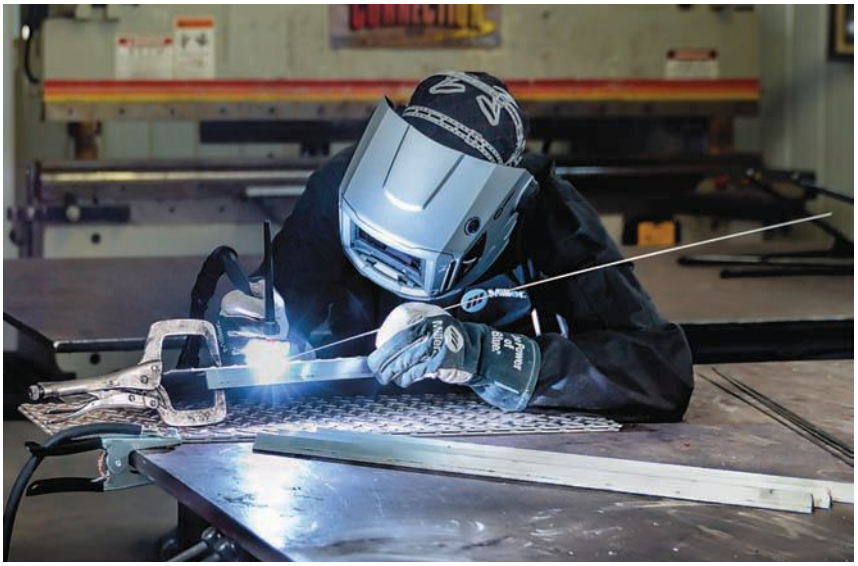
Tip No. 3: Set the AC Output Frequency

Another factor that makes weld placement easier is the AC output frequency. This can also be set and adjusted on modern welding power sources. AC output frequency shouldn't be confused with high-frequency arc starting, which only comes into play for arc starting.

The output frequency references how many times per second the power source switches polarity. Older GTAW power sources are 60 Hz, which is determined by the input power, but modern equipment, such as Dynasty® TIG welders from Miller Electric Mfg. LLC, have a factory preset of 120 Hz output frequency. The higher the AC output frequency, the more stable the arc becomes. This results in a tighter, narrower arc column that provides more directional control—allowing the operator to more easily weld in tight spaces and weld precisely without the arc wandering.

Turning the AC output frequency down to 80 or 90 Hz provides a wider arc cone, which can be helpful when welding an outside corner joint.

On thinner materials that require placing the weld accurately to prevent heating up a large area or burning through, a higher output frequency of 150 to 250 Hz is typically recommended. When welding thicker materials, a wider weld is often preferred due to the higher amperage, so it's recommended to turn the AC frequency down. A setting of 80 to 120 Hz is typically well-suited for materials 3/8" and thicker.



While GTAW is a slower process and therefore not typically used in high-production manufacturing, it is often a good choice in aluminum welding applications where productivity isn't as important but quality and appearance are critical.

Tip No. 4: Use Appropriate Amperage

Amperage can be controlled during GTAW with a foot pedal or fingertip control, but it's best to set the appropriate maximum amperage on

the equipment. The general rule of thumb when GTA welding aluminum is to use 1 A for every thousandth (.001) of material thickness. In other words, welding base material that is 1/8" (.125) thick would require about 125 A.

When the base material is more than 1/4" thick, the rule of thumb begins to deviate and not as much amperage is needed. For example, 3/8" material can be welded with a 280 A power source.

Proper heat input is a critical factor in successfully welding aluminum with GTAW. Aluminum is conductive, so the heat of the weld puddle can be pulled away quickly. This requires putting in a lot of heat to establish the weld puddle, but controlling that heat is key to preventing a runaway puddle or burn-through.

Joint geometry must also be considered because it can affect the necessary amperage. When welding a T joint, the heat can flow in three directions, compared to welding a butt joint where the heat can only flow in two directions. This means a T joint requires more heat input.

Tip No. 5: Set AC Amperage Independently

Some higher-end modern welding power sources allow operators to independently set the AC amperage, which helps achieve greater penetration and productivity.

With this feature, welders can increase the amperage during the electrode negative portion of the cycle to drive greater penetration in the weld, since more amperage is generally correlated to more penetration.

This feature is generally used in higher amperage applications where the application may only need 200 A for the electrode positive cycle to achieve the necessary oxide cleaning, but the welder may want 300 A for the electrode negative cycle to achieve more penetration. This can also prevent the need for increasing tungsten size, since most of the heat is put on the tungsten in the electrode positive portion of the cycle. A power source with the right technology allows operators to tailor each amperage independently to achieve the desired results.

The balance control and the independent AC amperage may sound the same, but they control two different aspects. Adjusting the balance control affects the level of oxide cleaning while adjusting the AC amperage can provide more penetration while maintaining tungsten geometry.

Tip No. 6: Add Filler Metal for the Stacked Dimes Look

Adding more filler metal is one technique welders can use to achieve the stacked dimes look when welding aluminum with GTAW.

Because filler metal is a solid being consumed into a molten liquid, it requires energy to change the material state—like putting ice cubes into a glass of hot water. The ice cubes melt but also cool the liquid.

The same idea applies when adding filler metal during GTAW. Adding more filler rod causes a cooling effect on the backside of the weld puddle that helps produce the stacked dimes appearance of the finished weld. Adding more filler metal with each dab helps produce a more pronounced appearance, whereas adding less filler metal with each dab produces a weld with a fairly smooth appearance.

Although it's not necessary, some operators also use the foot pedal to vary amperage to help achieve the stacked dimes look. Different welders have varying techniques but can achieve similar results.

Tip No. 7: Make Safety a Priority

While GTAW is traditionally a clean welding process with no spatter, it's still important to use the proper personal protective equipment, including safety glasses, a welding jacket, gloves, and welding helmet. Since aluminum is highly reflective and requires a great amount of energy to weld, the arc intensity of GTAW can cause sunburn to exposed skin.

Because it's so critical to clearly see the arc when welding aluminum, consider new helmet technology that improves visibility and clarity of the weld pool. Technology available on some auto-darkening helmets allows more colors to come through the lens, so welders see more contrast among objects in the viewing area. This can help the welder achieve better results while reducing eye strain and fatigue.

In Closing

Whether the goal is greater penetration or achieving the stacked dimes look for improved aesthetics, following these tips can help welders of all skill levels achieve success when welding aluminum with the GTAW process.

Circling the *Globe* to Talk About Skills

"It is mind-boggling," says this former SkillsUSA student and international competitor, who's now an automotive engineer and advocate for skilled trades around the world.

By Karen N. Kitzel

Photo: Lloyd Wolf

Kieron Kohlmann has a passion for automotive technology and a mission to connect with like-minded skilled trades peers from around the world.

A CHILDHOOD passion for cars led Kieron Kohlmann to become a technical training developer for Fiat-Chrysler Automobiles. "Today's complex vehicles require a highly educated person to diagnose and repair them," he says. It's something the 27-year-old has confirmed in his new role as an ambassador for the WorldSkills organization.

"WorldSkills is a global hub. I've met so many amazing people in my industry from around the world. Being able to connect is an invaluable asset."

Selected in January 2018 for the WorldSkills Champions Trust (WSCT), Kohlmann now serves on an advisory board to help raise levels of engagement among WorldSkills countries.

His journey began in 2010, when as a Washington Park (WI) High School student, he won a gold medal in Automotive Service Technology at the SkillsUSA Championships. That led to his selection for the WorldSkills Competition in Leipzig, Germany, in July 2013. His "wow" moment came when the team took the stage with the American flag in front of all the other countries.

Another trip, in 2012, took him to Brazil for the WorldSkills Americas competition. "I remember being with the competitors from South America and realizing they do the same job as me," he recalls in awe. "We spoke different languages, had different cultures, and different vehicles, but we all had the same passion for cars."

Kohlmann serves as one of 10 young ambassadors. In addition to the United States, he represents Canada, Mexico, Dominican Republic, Barbados, Jamaica, and Trinidad and Tobago. He has taken five international trips and communicates daily with his peers around the world.

This exclusive network advocates the power of skills to transform the lives of young people. While it takes a lot of effort on top of his day job, Kohlmann says the rewards are worth it. "We

On the Web

- **Follow the 2019 WorldSkills USA team's road to Kazan, donate, or get involved at: www.worldskillsusa.org**
- **Watch a video about SkillsUSA's quest to field the best team ever for international competition: https://www.youtube.com/watch?v=OlOqmFz-UAY**
- **Learn about WorldSkills Kazan: https://tinyurl.com/y76cs42x**
- **Read about the WorldSkills Champions Trust: https://tinyurl.com/ydfofjra**

Karen N. Kitzel is manager, Public Relations/Communications, SkillsUSA Champions *magazine.*

have a monthly Skype meeting and text often, so the group has become really close as a result."

Kohlmann, who has a bachelor's degree in automotive engineering technology from Ferris State University in Michigan, is ASE certified as a master automobile technician, master heavy truck technician, and an advanced level specialist. As with his certifications, he feels his competition experience has helped him professionally.

"It is the people you meet, seeing how other countries do things, and have different education paths. It is mind-boggling," he explains. "I have more cultural awareness, and I am able to communicate professionally in a way that bridges cultures—skills I use daily."

A Life-Changing Trajectory

Kohlmann says SkillsUSA changed the trajectory of his life in high school, though he didn't know it at the time. "When I went to nationals, my teacher told me to prepare and do well, so I took his advice."

Classroom teacher Dave Dixon and a retired instructor, Gottfried Georgi, were mentors. During the competition, a Ferris State brochure caught his interest. In his junior year of college, Kohlmann was selected for the U.S. team going to the internationals. "To me, being selected for WorldSkills was like going to the Olympics," he says. "I trained with industry professionals and met new people. It was an honor to be selected and to be a part of an organization that truly cares about skilled trades."

Kohlmann (front and center) joins other WorldSkills Champions Trust members in Amsterdam last October. Each represents a different region. These young skilled professionals include (front row, from left): Chirag Goel of India; Amelia Addis, New Zealand; Kohlmann, United States; Jacqueline Tanzer, Austria; Tjihimise Karearua, Namibia; (back row) Gary Condon, Ireland; Caroline Soderqvist, Sweden; Anna Prokopenya, Russia; and Pearl So, Hong Kong. A 10th member, Giovanny Sanchez of Colombia, is not pictured.

Mike Elder helped Kohlmann train. "Kieron is a true champion," says the assistant professor at of Pittsburg State University. "He forged friendships not only with competitors, but also with experts and business representatives." Adds Pittsburg State's Scott Norman, the technical delegate for WorldSkills USA, "It has been wonderful to watch Kieron transform from a SkillsUSA student to a professional peer and colleague in the industry."

Like these mentors before him, Kohlmann hopes one day to teach and pass on his knowledge and skills. "I think one of the greatest ways we help others is through showcasing our experience," he says. "By being young voices for trade skills, we can inspire others to follow the same journey."

EVERY two years, young people from 80 countries and regions compete in the industrial trades and service sectors of the global economy. "SkillsUSA participates because the skills gap is rapidly becoming a global crisis," says executive director Tim Lawrence. "Through WorldSkills, nations can work together to compare training methods, analyze issues, and seek solutions."

3M is lead sponsor for the WorldSkills USA team. "As a global science-based company, we recognize that STEM skills are the foundation for many trades," says Maureen Tholen, sustainability director for 3M's Industrial Business, and Safety and Graphics, Business Groups. The new chair of the SkillsUSA Foundation, Tholen adds, "By sponsoring the team, we're helping to ensure students have the training and technical skills needed to close the gap and build the skilled workforce of the future."

In One State, Students Are Ditching Classrooms for Jobs

How 'Work-Based Learning' Is Getting Vermont Kids Ready for Careers before They Graduate

By Jackie Mader

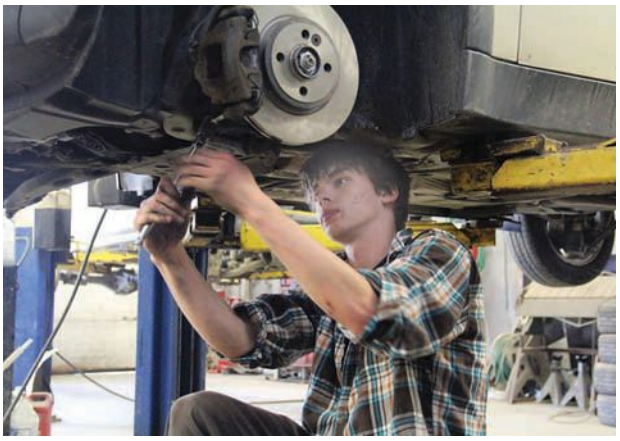
AT 8:00 on a chilly spring morning in this rural Vermont town, while most kids his age are filing into classrooms and preparing for a day of school, 17-year-old Silas Woods rolls up the sleeves of his plaid button-down shirt and hoists a tire up to a mini Cooper, suspended a few feet above ground in the corner of the noisy Duxbury Auto Shop.

Woods is calm and confident as he moves around the garage, which serves as an unconventional math and science classroom. Thanks to a work-based learning program offered through nearby Harwood Union High School, Woods has been able to earn math and science credit by working 15 hours a week at the garage, instead of sitting in a classroom. His boss has been so impressed by Woods' work ethic and job performance, he offered Woods a full-time paid job at the garage this summer.

Woods, who has never liked school, says that being able to earn academic credit by working with cars is ideal. "I'm not a classroom worker, I'm not a paper learner," he said as he rifled through a large red toolbox. "The main way I learn is by screwing up and doing it again, which is honestly a lot more interesting and definitely makes it stick in your head a lot more."

Work-based learning programs are slowly gaining traction in Vermont and other states as schools consider ways to better prepare students for college and careers. Educators and experts say such programs may engage disengaged students, increase graduation and attendance rates, and help students develop career goals at an earlier point in their lives.

"I think for a lot of students, they can start to see the relevance in their education," said Rachael Potts, who is part of a two-person team overseeing the work-based learning program at Harwood Union High School. Students at Harwood have earned academic credit—or are working toward credit—for teaching ski lessons at a nearby ski resort, working for a financial investment firm, and writing music reviews for a blog. "Students who have been in the classroom for years can start applying some of their content knowledge in real world settings, and that's real exciting for students."



Photos: Jackie Mader/The Hechinger Report

Silas Woods works on a car at Duxbury Auto Shop. Woods earned math and science credit by working during the school day.

The increased interest in work-based learning opportunities comes at a time when companies nationwide are calling for more skilled workers, and not just for jobs that require a college degree. In June, an executive order was signed that called for private companies to create apprenticeship programs for students to address both workforce needs and a "skills gap." Many em-

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Jackie Mader is multimedia editor, The Hechinger Report*. She has covered preK-12 education and teacher preparation nationwide, with a focus on the rural south. 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.*

ployers say they are unable to find qualified workers for jobs.

Brent Parton, deputy director of the Center on Education and Skills at the Washington-based think tank New America, said that's why companies are stepping up to participate in educational programs that could build their workforce. "More and more, employers are realizing the education system can't, nor should it be, producing exactly what they need without their engagement and importantly, their investment," Parton said.

Nationwide, about 65% of public high schools reported offering opportunities for students to participate in work-based learning during the 2007-08 school year, the last year data on the topic was collected by the National Center for Education Statistics. However, programs like Harwood's that offer academic credit in core subject areas are rare, Parton said. Many programs offer only job-shadowing opportunities or internships with little depth or responsibility.

> **"The main way I learn is by screwing up and doing it again, which is honestly a lot more interesting and definitely makes it stick in your head a lot more."**
>
> *Silas Woods, a student who earns school credit while working at a garage*

Several states have taken steps in recent years, however, to ramp up work opportunities for students, often in an attempt to address workforce needs. New York's Pathways in Technology Early College High Schools, or P-TECH schools, offer students a high school diploma and an associate's degree upon completion of coursework. During the program, students have access to internships and work experience. Utah launched a program in 2015 that uses work-based learning to teach high school students about the state's aerospace industry. Montana's Department of Labor & Industry offers a curriculum and assistance to teachers running work-based learning programs.

For the past four years, Vermont has prioritized broadening work-based education in secondary schools to include more than what has traditionally been offered in career-technical education. In 2013, the legislature passed Act 77, the "Flexible Pathways Initiative," which encourages schools to expand opportunities to programs like work-based learning, increase access to virtual learning experiences, and amplify the number of dual enrollment courses.

At Harwood Union High School, students can earn academic credit for work experiences.

Jessica DeCarolis, the division director overseeing the implementation of Act 77 at the Vermont Agency of Education, said the state's focus on work-based learning is an acknowledgement of "the future of learning," and comes from "a desire to have opportunities and experiences available to students that are authentic."

"Teachers have always been presented with a question, 'Why do I need to know this?' Work-based learning provides an opportunity to give students a really robust answer to that question," DeCarolis said.

Veronica Newton, work-based learning program coordinator at the Vermont Agency of Education, said the state hopes that students are "actually ready and prepared for life after high school," after pursuing a flexible pathway, regardless of whether they choose to continue education or join the workforce. "It gives them opportunities to really expand the learning beyond the classroom," Newton added.

Although Vermont's graduation rate—88% of high school students graduate in four years—is well above the national average, only 52% of graduates went to college in 2013. Forty-five percent of Vermont's college-going students attend schools out of state.

Many Vermont educators and people in the business community see work-based learning as a strategy to better prepare students who are not college-bound for the state's available jobs. Businesses report a shortage of qualified workers for "middle-skill jobs," those that require some education beyond high school, but not a four-year degree. Such jobs made up about 49% of the state's jobs in 2015. Experts and Vermont teachers say work-based learning could also address the persistent problem—especially in rural states—of a "brain drain" of youth leaving for more urban areas.

"Offering these kinds of opportunities allow students to really see what's available here in our community," said Potts of Harwood Union High School. "My hope is eventually if [students] leave the state for college, they might think about all of the cool things that are offered right here

> **"Every kid wants to find that job that they can just wake up and be stoked for in the morning which is my main goal right now. I look forward to waking up and going to work."**
>
> *Silas Woods, who learned about math and science through work at a garage*

in Vermont so they come back and raise their families here," said Potts.

The state is so serious about growing work-based learning programs in its high schools, it now offers a teaching endorsement for staff members who run these programs, and grants to help schools launch or expand them. Between September 2016 and June 2017, the number of licensed work-based learning coordinators in Vermont increased from 38 to 53. Next year, the state will ramp up professional development opportunities for work-based learning coordinators, state officials said.

Before students can earn academic credit, they must complete a final project, which is then assessed by a highly-qualified teacher in that content area. Potts said students have written papers, designed structural models, or created business plans for their projects.

At Harwood, Potts said, the school's work-based learning program spans more than work experience. Potts and her colleagues try to introduce all students to potential careers to get them thinking about post-graduation life earlier, as soon as they start high school. The school's program begins with a semester-long class for ninth graders called "Personal and Future Explorations," which introduces students to careers and other learning opportunities they can opt into at Harwood, and in which every student completes a job shadow or speaks to people in fields they are interested in.

Harwood Union High School's director of work-based learning, Rachael Potts, and a student learn about a potential work-based learning opportunity at nearby Knoll Farm.

Students who participate in the program's work-based learning experiences say they do so for a myriad of reasons, including the chance to earn academic credit, being able to explore a potential career path, and earning real work experience before college.

Recent graduate Caleb Eurich learned about finance hands-on through Harwood's program by working at KDP Investment Advisors, a financial investment firm in Montpelier. He did research involved in trading bonds, participated in daily meetings, and managed data in spreadsheets. Eurich also earned credit in economics, part of the social studies curriculum at Harwood, which meant he graduated with a full four years of social studies credit on his diploma. He believes colleges view him more favorably because of those credits, and adds the experience also helped him decide to pursue a degree in economics and finance at Bowdoin College this fall.

"I just thought it was really awesome to have the chance to explore your interests in ways outside the classroom setting and gain skills that may actually be useful in the workplace," Eurich said. "Because it's really hard to gauge that just by taking classes similar to a career."

Harwood's program is open to all students, including students with disabilities, students in the district's alternative learning center, and students taking advanced, college-level courses. "Our goals with all students, regardless of whether they're on an IEP [for special education students] or whether headed to Harvard, are the same," said Ellen Berrings, the employment and transition specialist at Harwood, who co-directs the work-based learning program with Potts.

Students say the experience of working while in high school can be life-changing. Work-based learning introduced recent Harwood graduate Anna White to new science and math topics, including special optics and coding, which inspired her to apply to postsecondary electrical engineering programs. Potts invited White to a discussion with a local electrical engineer at the beginning of her senior year because White wasn't sure what kind of career she could have in a science or math field. White ended up working two days a week at Creative MicroSystems, a company that provides design and engineering services for other companies.

Caleb Eurich earned economics credit by working in finance during his senior year of high school. He said it encouraged him to pursue finance and economics in college.

"I was skeptical at first," White said. But she quickly became passionate about the work. "It was an eye-opening thing." This fall, White plans to study engineering at Wentworth Institute of Technology in Boston.

Despite the benefits of work-based learning, it has yet to become a common option for high school students. "Right now in this country, we still view work-based learning as a 'nice to have,' as an add-on, versus something that's being deeply integrated within our learning system," Parton of New America said. ►

That may be due in part to the challenges involved in creating a work-based learning program. Rural areas may not have transportation available to take students to job sites, or even many useful job opportunities for students. Potts says that if schools do not have a designated point person for work-based learning, it can be hard to build relationships with employers and match students to relevant work opportunities.

> **"I just thought it was really awesome to have the chance to explore your interests in ways outside the classroom setting and gain skills that may actually be useful in the workplace. Because it's really hard to gauge that just by taking classes similar to a career."**
>
> *Caleb Eurich, a high school student who worked for a financial consulting firm as part of his high school studies*

Potts acknowledges that the program takes immense work. She frequently calls employment sites and visits work sites with students to introduce them to potential internships and gently lead community members to embrace the idea of hosting a student for a semester—or longer in some cases. "More often than not, we get yeses," Potts said. "We have a fantastic community … they've been really receptive."

Potts said it's also important to make sure the work experience is meaningful and relates to academic content. Each student who participates in Harwood's program and is receiving academic credit, not just an elective credit, has an academic adviser who helps home in on academic standards or proficiencies, depending on graduation requirements, to determine how the work experience relates to content areas.

For Jackson Greenleaf, 16, who is earning English credit while working with a music critic, that means studying the state standards with English teacher Jonah Ibson to make sure his work activities, which involve writing critiques of music, align with writing skills from the standards.

"I think that opportunities like these are when real, deep learning happens," Ibson said. "Would you have the opportunity to do something like this in a traditional classroom? … I think you could dip your toe into exploring your interest and we teachers try to provide as much choice in the classroom as possible, but never could you take a huge block of time and just go really, really in depth in a real way … [and] learn from an expert, not the teacher, but the community member."

Silas Woods worked with two advisers to align elements of his work at the garage with academic standards. Eric Larose, a student support specialist at Harwood, said he has used math standards from Harwood's personal finance class to make sure Woods is learning important math concepts. While working at the garage, Woods developed a business plan, which included creating a budget and learning about payroll and taxes.

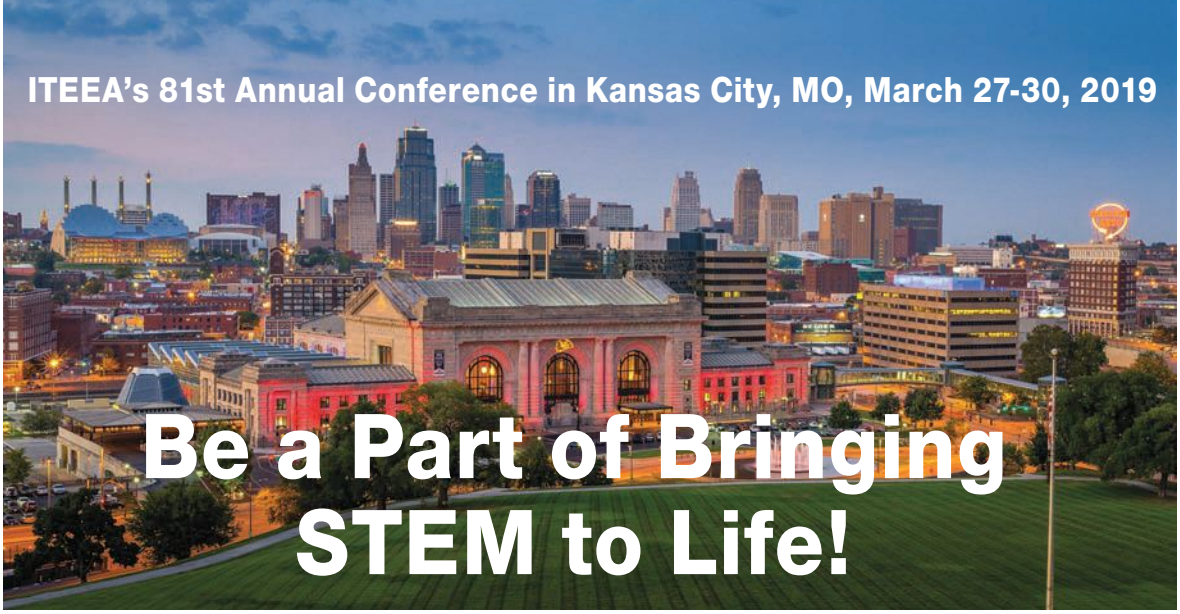
Anna White works on a project at Creative MicroSystems. She says the experience made her fall in love with coding.

Science teacher Alex Rawson said he worked with Woods on "communicating and using the language of science as related to auto industry," to ensure Woods' job could translate into credit. That means being able to understand concepts like friction and mass and use that understanding to explain to a client why brake pads would last longer in a smaller car, for example.

Larose said Woods' investment in his education has improved greatly since starting his work placement. "This is a guy who wants to meet over school break and do more work, and do more math," Larose said.

Rawson says he knows Woods may miss some concepts because he is learning outside of the classroom, but those concepts may not have added much to Woods' education. "For a student like Silas, I think we would say that the courses that he may have taken in a traditional setting, he wouldn't have retained as much as educators might like to believe. He wouldn't have taken [the information] with him in the long run," Rawson said. "He's a happier, more well-rounded person by being able to craft his own educational pathway … he's learning more and he is benefiting from that specialized system."

For Woods, his experience working at Duxbury Auto also reinforced his career path. He plans to attend Universal Technical Institute in Massachusetts this fall for additional training to become an auto mechanic. He says students should take advantage of work-based learning so they can carve out their future careers while still in high school. "Honestly, if you get the ball rolling way earlier, it'd be way easier for you as you go through life," Woods said. "Every kid wants to find that job that they can just wake up and be stoked for in the morning which is my main goal right now," he added. "I look forward to waking up and going to work."



Be a Part of Bringing STEM to Life!

PLANNING for ITEEA's 2019 conference in Kansas City is well underway! Atlanta 2018 provided a diverse range of professional development and networking opportunities, but we have even bigger things in store for Kansas City!

The 2019 conference theme focuses on how technology and engineering bring STEM to life for all children PreK-12 and beyond. Students who study technology and engineering through an integrative STEM education approach learn about the technological world that inventors, engineers, and other innovators have created. This conference promotes sharing best practices demonstrating how technology and engineering bring STEM to life!

With over 100 learning sessions, preconference workshops, educational field trips, the latest products and services, specialized programming strands (including Elementary STEM, STEAM, and International), TEECA Competitive Events, EbDLabs, and more, the 2019 Kansas City conference offers an unparalleled Integrative STEM Education professional development opportunity. Highlights include:

Keynote Presentation by Jeff Weld, Senior Policy Advisor and Assistant Director for STEM Education at the White House Office of Science and Technology Policy.

Weld will discuss "The U.S. Federal STEM Education Strategic Plan: North Star." The American STEM education community has spoken with one voice in shaping the Federal STEM Education Five-Year Strategic Plan for 2018 to 2023 (and beyond). Consensus goals and pathways help everyone row the STEM boat in the same direction, assuring that the coming decade of our nation's STEM movement will be maximally impactful and culturally transformative.

STEM⁴: The Power of Collaboration for Change

During the conference, ITEEA will present a session unveiling a joint paper promoting collaboration in STEM education. STEM⁴: The Power of Collaboration for Change is a newly released pivotal document authored by Advance CTE, Association of State Supervisors of Mathematics, Council of State Science Supervisors, and International Technology and Engineering Educators Association. The paper is the product of an organized and coordinated effort among the leadership of the respective organizations to address the challenges faced when implementing STEM education and providing access to the knowledge, skills, and career pathways necessary for all students, particularly those in underserved populations

Keynote Presentation by Travis McCready, President and CEO, Massachusetts Life Sciences Center

McCready's keynote will cover "The Importance of Experiential Learning in STEM Education." By definition, the scientific process requires experimentation, trial and error, and the practice of experiencing results, successes, and failures.

The ITEEA STEM Showcase is truly an event where educators and ideas come together!

Now more than ever, as STEM in all its facets is embedding itself across sectors, it is crucial for experiential learning to become an integral part

of education pedagogy to ensure that classroom and applied learning remain connected. In this session, McCready, CEO of the Massachusetts Life Sciences Center and operator of the largest state-run internship program in the U.S., will discuss the strategic importance of STEM experiential learning in achieving a state's education, workforce, and economic development goals.

Administrator I-STEM Education Professional Development Strand

Bring your administrator at no additional cost (sponsored registration). A special strand of presentations designed for administrators will be offered to build understanding and support for your program!

The ITEEA STEM Showcase—*Highlighting Best Practices Through Integrative STEM Education!*

The ever-popular ITEEA's STEM Showcase is back with nearly 100 educators sharing ideas, techniques, and best practices related to learning activities, marketing materials, career guidance, facility design, program design, assessment methods, equity, and classroom and laboratory management techniques. Showcasers illustrate a single element of technology or engineering teaching and learning that they feel they have exemplified. Attendees are invited to join ITEEA for our Celebration Reception immediately following the STEM Showcase.

Inaugural Presentation of the William E. Dugger Award

Be on hand for the first-ever presentation of the William E. Dugger Exemplary Collaboration Award, at ITEEA's Awards and Recognition Brunch on Saturday, March 30th. The award honors the life's work of Bill Dugger, whose outstanding collaboration-focused career affords him a place of respect earned by very few in the Technology and Engineering Education profession. The award will be presented to an individual who has made a significant contribution to Technology and Engineering Education through collaboration.

ITEEA Dream Ride...Go Baby Go Style

Go Baby Go is a national, non-profit research program based at the University of Delaware that provides modified ride-on cars to babies and toddlers who experience limited mobility. Incorporating the best of Go Baby Go and STEM curriculum, the ITEEA Dream Ride course brings this real-world mobility challenge to the classroom, where students and teachers work together to modify a battery-operated, toy ride-on car for a young child with limited motor function. This innovative design project highlights the diversity of children with developmental delays and integrates the school within the community. In this endeavor, ITEEA is partnering with children's charity VarietyKC and a local school to connect with the Kansas City community!

Student builders from Central Connecticut State University congratulate a child who has successfully "mobilized" in his adapted ride-on car for the first time!

New from EbD™

On Wednesday March 27, ITEEA's EbD STEM Center for Teaching and Learning™ is unveiling the 2018-2019 course revisions at preconference workshops: TEEMS PreK-6 and Foundations of Technology, 9th grade. Join us March 28-29, 2019 for a four-hour action-packed course-centered EbDLab™ chock full of hands-on learning experiences; an elementary, middle school, and high school EbDLab™ will be offered each day.

Kansas City Here We Come!

Along every boulevard and around every corner, there's something to do that's unique to Kansas City. With a thriving creative arts scene, eclectic mix of entertainment, and die-hard sports—it's safe to say there's something for everyone. Find your way in KC by doing it all...or, at least trying to.

There's more to Kansas City than meets the eye. Unique attractions throughout KC beckon locals and visitors alike to find the city's hidden gems. Explore the nationally recognized World War I Museum. Let curiosity guide you at Union Station. Walk in the steps of America's 33rd president in Independence. Uncover the city's charm by discovering its attractions.

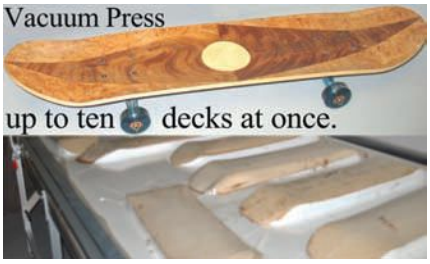
According to ITEEA president Yvonne Spicer, DTE, "My experience over the years at the ITEEA conferences have helped me to develop relationships and have access to resources that have provided fresh perspectives and outlooks on my work in the STEM field and beyond. This year's conference will be filled with many opportunities to get involved and stay engaged. I strongly encourage you to attend and meet professionals and educators from across the country who, like you, are on a mission to educate, coach, and promote the finest minds in our field."

For full conference details, visit www.iteea.org/ITEEA_Conference_2019.aspx

product spotlight

The newest and best for CTE and STEM classes

Skateboards/Vacuum Press: Free Two-Hour Instructional DVD



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But It Just Doesn't Add Up!

Take the numbers 2, 3, 4, and 5.

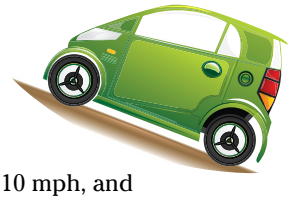
Using each number only once, and selecting any math operations (but each operation can only be used once), create an equation whose answer is 26.

The following solution is not acceptable because the multiplication operator is used twice:

$2 \times 3 + 4 \times 5 = 26$

You may use addition, subtraction, multiplication, division, parentheses, square root, and exponentiation.

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



Merrily We Roll Along . . .

A car went up a hill at a speed of 10 mph, and came back downhill at a speed of 20 mph.

What was the average speed for the round trip?

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

Road Trip!

On a trip from Fort Collins to Grand Lake, our 2010 Prius averaged 39 mpg for the first 63 miles (to the top of Trail Ridge Road in Rocky Mountain National Park). However, we averaged 51 mpg over the whole trip of 91 miles. How many miles per gallon did it get over the last 28 miles?

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

Wacky Scienti c Units

Time between slipping on a peel & hitting the ground = 1 bananosecond

1,000,000 aches = 1 megahurt

Basic unit of laryngitis = 1 hoarsepower

453.6 graham crackers = 1 pound cake

2 million bicycles = 2 megacycles

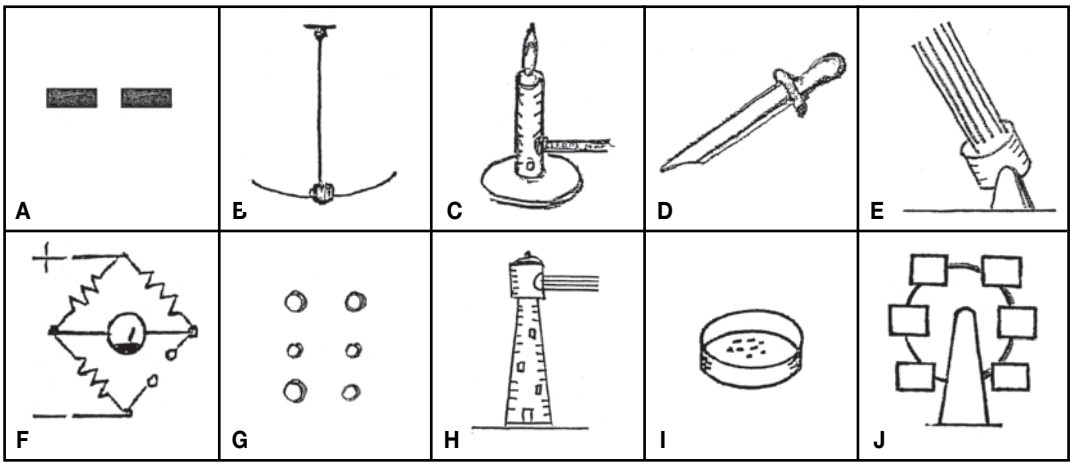
1000 milliliters of wet socks = 1 literhosen

1 millionth of a fish = 1 microfiche

10 rations = 1 decoration

Tech Inventors

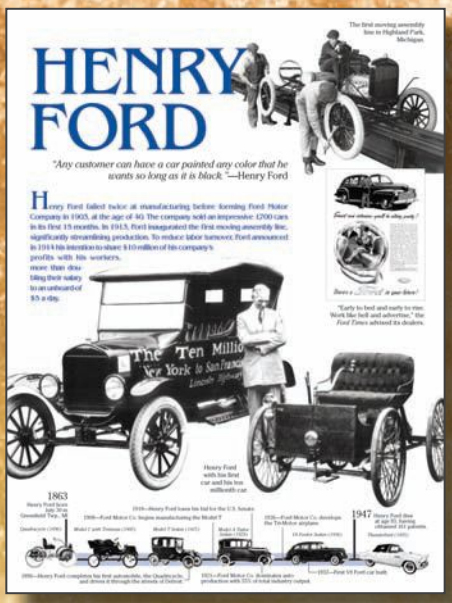
Many well-known inventions carry the name of their inventors. See if you can match the names (1-10) with their inventions (A-J).



1. Bowie
2. Braille
3. Bunsen
4. Ferris
5. Foucault
6. Fresnel
7. Klieg
8. Morse
9. Petri
10. Wheatstone

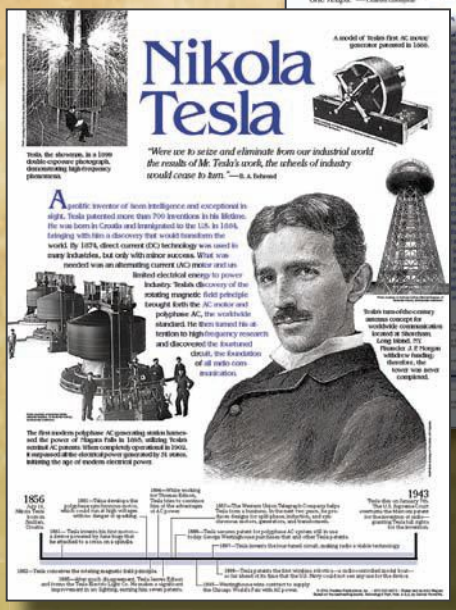
See answers on page 11.

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.



Technology's Past POSTERS

Each 18" × 24" poster features a brief biographical description and a timeline of key life events.



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