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MARCH/APRIL 2020

Fighting Myths about Apprenticeships

Portable Battlebots Arena Saves Competitions

Spring Product Guide Inside

technically speaking

Vanessa Revelli vanessa@techdirections.com

March is Women's History Month. To honor this special month, I've spent a lot of time reading about the amazing female pioneers in the fields of science and technology. This website, obamawhitehouse.archives.gov/women-in-stem, has a wealth of information, and the source for this column.

Lillian Moller Gilbreth was an American psychologist and industrial engineer at the turn of the 20th century. She was an expert in efficiency and organizational psychology, the principles of which she applied not only as a management consultant for major corporations, but also to her household of twelve children. Her long list of firsts includes first female engineering professor at Purdue, and first woman elected to the National Academy of Engineering.

Edith Clarke was a pioneering electrical engineer at the turn of the 20th century. She worked as a "computer," someone who performed difficult mathematical calculations before modern-day computers and calculators were invented. Clarke struggled to find work as an engineer instead of the "usual" jobs allowed for women of her time but became the first professionally employed female electrical engineer in the United States in 1922. She paved the way for women in STEM and engineering and was inducted into the National Inventors Hall of Fame in 2015.

Rear Admiral Grace Murray Hopper was at the forefront of computer and programming language development from the 1930s through the 1980s. One of the crowning achievements of her 44-year career was the development of computer languages written in English, rather than mathematical notation—most notably, the common business computing language known as COBOL, which is still in use today. Hopper's legacy is still honored by the annual Grace Hopper Celebration of Women in Computing Conference.

Katherine Johnson, an African American space scientist and mathematician, was a leading figure in American space history and made enormous contributions to America's aeronautics and space programs by her incorporation of computing tools. She played a huge role in calculating key trajectories in the Space Race—calculating the trajectory for Alan Shepard, the first American in space, as well as for the 1969 Apollo 11 flight to the moon.

Despite growing up as a self-described outcast, Maria Klawe pursed her passion for technology and became a prominent computer scientist. Klawe is now the first female president of Harvey Mudd College and works hard to ignite passion about STEM fields amongst diverse groups. During her tenure at Harvey Mudd College, her work has helped support the Computer Science faculty's ability to innovate, and has raised the percentage of women majoring in computer science from less than 15% to more than 40% today.

To see our Women in History poster series please check out the ad on page 31.

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March/April 2020

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contents

March/April 2019
Vol. 79, No. 5

page 15

ROBOTICS

SPECIAL FEATURE

TECHNOLOGY EDUCATION

page 20

CTE

COLUMNS

About the cover: Technology Student Association members at work on a project. Photo courtesy of Steven Vanderloo and Connecticut Technology Student Association. Cover design by Sharon K. Miller.

the news report

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Major League Hacking Hosts World's Largest Hack Day for Students

Over 10,000 expected attendees from more than 300 communities across 50 countries participated in Local Hack Day: Build, the world's largest day-long hackathon for students. The worldwide event was hosted by Major League Hacking (MLH), the global student hacker community that empowers the next generation of programmers and entrepreneurs. The event was sponsored in part by Microsoft Corp. Attendees brought their ideas to life by collaboratively using hardware and software to create everything from websites to robots to mobile apps and beyond.

"Major League Hacking started six years ago with a simple goal: to share hacker culture with as many people as possible. Since then we've completely reinvented the on-campus hacker experience and introduced more than 350,000 aspiring technologists to our community through hackathons and technical workshops," said Mike Swift, co-founder and CEO of Major League Hacking. "Collaborating with Microsoft Corp. allows us to bring this transformative experience and learning culture to millions more."

At Local Hack Days, developers of all skill levels can learn valuable skills that they can bring with them to future jobs, personal projects, and schoolwork. In fact, out of 1,800 student hackathon participants surveyed, 93% revealed that they gained new skills at MLH events that they aren't getting in the classroom. In order to help foster this environment of learning, each Local Hack Day location has a selection of hands-on workshops through MLH's Localhost program.

MLH Localhost is a free workshop-in-a-box tool kit for local community leaders. Anyone interested in teaching technology to their peers can run events for their own local groups. Collaborating with companies like Microsoft Corp., MLH creates and distributes peer-led curriculum modules that are fully equipped with presentations, content, teaching materials, code samples, a code of conduct playbook, co-branded swag, and more. The content and activities offered through MLH Localhost meet the various skill levels of participants who range in experience from beginners to veterans. Attendees receive an opportunity to learn new technologies and skills from their peers,

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while connecting with brands that are supporting the next generation of developers.

"Microsoft is committed to empowering the next generation of creators with access to technology and training," said Jennifer Ritzinger, General Manager Audience Evangelism at Microsoft. "Collaborating with Major League Hacking (MLH) provides a unique learning experience to Local Hack Day attendees worldwide with fun, educational content and access to Microsoft experts and technology."

Local Hack Day events are adaptable for every culture and have been expanding across diverse communities since their inception in 2014. Additionally, organizers and student hackers in developing regions are provided with free technical resources that are generally difficult to access.

"Living in Yola, Nigeria, I did not have a hacker community because the resources simply did not exist," said Sa'ad Ahmad, a computer science graduate and Localhost organizer. "I heard about Major League Hacking from the local developer group and knew that this was the community that we needed. Now I host workshops twice a month to help empower other developers to make the world a better place through technology."

Local Hack Day: Build will be the largest to date, with additional support from GitHub. To become an organizer or to check out if there's a Build event already scheduled in your neighborhood, please visit https://localhackday.mlh.io/build/.

About Major League Hacking

Founded in 2013, Major League Hacking (MLH) is the global student hacker community and a Public Benefit Corporation that empowers the next generation of technology leaders and entrepreneurs with free, out-of-the-box workshops and events covering today's most relevant technology. Each year, MLH facilitates over 1,000 weekend-long invention competitions (hackathons), MLH Localhost technical workshops, and Local Hack Day developer conferences that foster community growth and teach computer science skills to more than 100,000 students around the world. For more information please visit: https://mlh.io/

Calendar

April 2-4. National Robotics Challenge World Championship. Marion, OH. thenrc.org.

April 2-5. National Conference on Science Education—20/20 Science: Expanding the Vision. Boston, MA. nsta.org/boston.

April 23-26. USA Science and Engineering Festival. Washington, DC. usasciencefestival.org/.

May 1. STEM Center for Teaching and Learning™ Safety Micro-Badging Professional Development Series. iteea.org/microbadge.aspx.

June 22-23. 2020 Delaware STEM Conference—Catch the Wave. Clayton, DE.

June 23-26. National Leadership and Skills Conference—SkillsUSA. Louisville, KY. skillsusa.org/competitions/skillsusa-championships/.

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Toyota's Woven City of the Future

If you live in a major city you probably expect that it will look quite different 50 years from now. In this hypothetical look into the future of your city, breakthroughs in each area of technology will leave their mark and yet one can expect that older forms of transportation, residential structures, office building, schools, and even forms of community life will remain the same. At best these older forms of transportation and physical buildings will just be maintained so they can function with only minor physical and technological updates.

At the 2020 Consumer Electronics Show I attended the Toyota press conference, a company known for its automotive technologies, and I expected a presentation that would focus on automobiles. The company's President and CEO, Akio Toyoda (Photo 1), told us how Toyota is ready to break ground on building an entirely new smart city of the future.

He described how Toyota was originally a weaving company and in homage to their early beginnings they have named their smart city of the future "Woven City" (Photos 2-5). The city that will soon rise in the shadow of Mt. Fuji was designed by the Danish architectural firm BIG (Bjarke Ingels Group). BIG has headquarters in Denmark, London, Spain, and New York City. Though you might not know their name, you probably have seen pictures, or even perhaps visited a past project that they designed—the new Two World Trade Center in New York City.

The BIG architectural team worked with Toyota designers and engineers to create the Woven City vision. It was visually designed to blend Japanese styles of construction and landscaping with maximum use of robotics, sustainable energy, artificial intelligence, and autonomous modes of transportation.

Images courtesy Toyota

Photo 1—Toyota's President Akio Toyoda surprised everyone when he announced that Toyota is building the city of the future where no one will drive cars.

Photo 2—An architecturally rendered aerial image of the Woven City that will be built at the foot of Mt Fuji in Japan.

Construction is scheduled to begin this year and will include architecturally innovative housing, schools, office buildings, medical facilities, courtyards, parks, recreational areas, and more. The transportation system for residents will only include completely autonomous vehicles (Photo 6).

Completely out of sight below all these structures and courtyards an underground city will also exist, designed to provide all the necessary supportive infrastructure to meet the needs of the residents living above. All the utilities will be installed and controlled underground out of sight of the residents who live above.

In the underground city, autonomous vehicles will move all the products that the people purchase online from point of delivery in the underground city directly into their homes, offices, and schools, completely out of sight of the above ground residents. The upgrading of systems, as technologies evolve, will be carried out through the underground city using the special access points into all the above ground buildings.

Replenishment of food and other supplies will, where possible, be ordered by sensor-based artificial intelligence systems perhaps 1,000% more powerful than your current voice-controlled Alexa, Amazon Echo, or Google Mini personal assistant. Imagine what the most powerful AI systems that are now available might be able to control compared to some of the smart technology that you now have in your home.

The goal is to build an entirely new city with all new systems that

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can be updated as new technology evolves, out of sight of the residents who live in the above-ground community. The Woven City's inhabitants will get to test and use all the newest artificial intelligence home automation and robotic systems in their homes, at work, and at school. The Woven City will be powered by hydrogen fuel cell technology and other renewable sources of energy.

For Toyota, this city will be a human-occupied laboratory where researchers, engineers, and social scientists can observe and receive feedback from the inhabitants that live and work in the city. The goal is to learn how people interact with artificial intelligent systems, new forms of mobility, and the use of robotic systems in daily life. Toyota wants the Woven City to provide answers to many questions about the practicality of using future tech wherever it is possible to implement it, since new technology not properly vetted could bring about unforeseen negative outcomes.

Humans need and crave socialization. Providing it to the community is seen as critical and the social scientists will want to quantify if the technology improves or diminishes human socialization. If you want to learn more about the Woven City and perhaps even become a resident, visit: https://www.woven-city.global/.

The e-Palette vehicle (Photo 7) will autonomously transport residents around this community. Twenty of these fully autonomous vehicles will be used for the first time July 24-August 9 to transport athletes during this year's Tokyo Olympic and Paralympics games.

This Toyota video of Akio Toyoda's presentation can further your understanding of the design as well as what the laboratory aspect of the Woven City hopes to achieve. https://www.youtube.com/watch?time_continue=121&v=B5M0lRZPcwA&feature=emb_logo.

Taking It a Step Further

1. Search online to check out some of the BIG architectural firms past, under construction, and future architectural projects.

2. Do you feel the people who live in the Woven City will be living in a fish bowl? Why?

3. Research all the different types of utilities and infrastructure that would need to be placed in the underground city to meet the needs of the residents.

Photos 3-5 (above)—The Woven City is both a city and a laboratory where residents use and evaluate cutting edge technology.

Photo 6 (above)—Autonomous vehicles will transport residents where they want to go.

Photo 7 (left)—The e-Palette vehicle that will autonomously transport residents in the Woven City.

Dennis Karwatka
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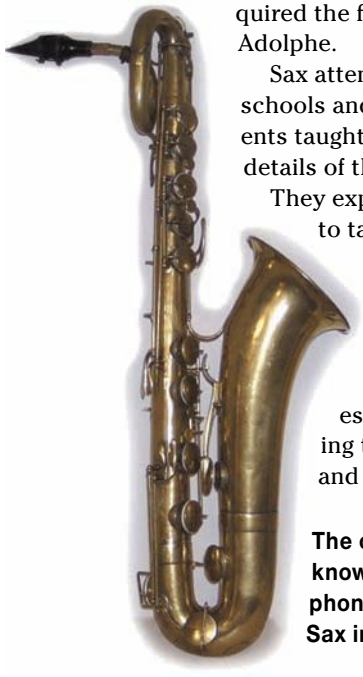
Adolphe Sax and His Saxophone

Musically trained professionals have the ability to detect subtle sound differences in orchestral instruments. Those in the 19th century noticed a musical gap between the brass and woodwind sections. Several instrument makers tried their hand at designing and constructing one to fill the void. The most successful was Adolphe Sax of Belgium. He invented the saxophone and patented it in 1846.

Adolphe Sax at age 30

Sax was born in 1814 in the town of Dinant, about 50 miles south of Brussels. His father and mother were musical instrument makers and he was the oldest of three surviving children. His birth name was Antoine-Joseph Sax and it is unknown how he acquired the first name of Adolphe.

Sax attended local schools and his parents taught him the details of their craft. They expected him to take over the family business. Sax became particularly interested in playing the clarinet and exhibited one he made at a Brussels industrial fair in 1830, when he was only 16.



The oldest known saxophone, made by Sax in 1846

Sax studied orchestral performance at the Royal Conservatory of Brussels in 1834. He specialized in the clarinet and worked on many improvements to its design. One major change was converting it from an instrument having 13 keys to one with 24 keys. That 1835 modification made the clarinet more challenging to play but allowed more variations in sound.

The clarinet uses a vibrating reed to make its sounds. Sax wondered if a reed could also be used with a larger instrument. That would make the tonal quality both pleasing and louder. He began working on an instrument to provide a stronger and more complete sound for orchestras, operas, and military bands.

The instrument that came to be known as the saxophone had to have a proper shape and length, with tone holes at precise locations. Those holes also had to be close enough for a musician's fingers to easily cover and uncover them. Sax experimented with air released into a closed tube to produce the sound quality he was after. It was serious technical work. He displayed his first saxophone at an 1841 Paris exhibition. Sax kept no diary and left no detailed notes to explain how he developed his new instrument.

Some military bands showed an interest and Sax remained in Paris to establish a business making saxophones and other instruments. Friends provided investment money and he opened the Adolphe Sax Musical Instrument Factory and salesroom in an inexpensive city location. He planned to make saxophones as well as clarinets, trumpets, and other musical instruments.

Sax's business was helped by the support of the important French composer and musical critic Hector Berlioz (1803-1869). Berlioz coined the word saxophone and encouraged the French military to use the instrument in their bands.

Sax patented his invention in 1846 and it won a gold medal at the Paris Industrial Exhibition of 1849. He ultimately had many talented workers who manufactured 20,000 musical instruments between 1843 and 1860. About 1,000 were saxophones. But that apparent success came at a heavy price.

Sax had a difficult personality and wanted to revolutionize how music was traditionally played. That combination created friction in the profes-

A display of Saxophones made by Sax at the National Music Museum in Vermillion, SD

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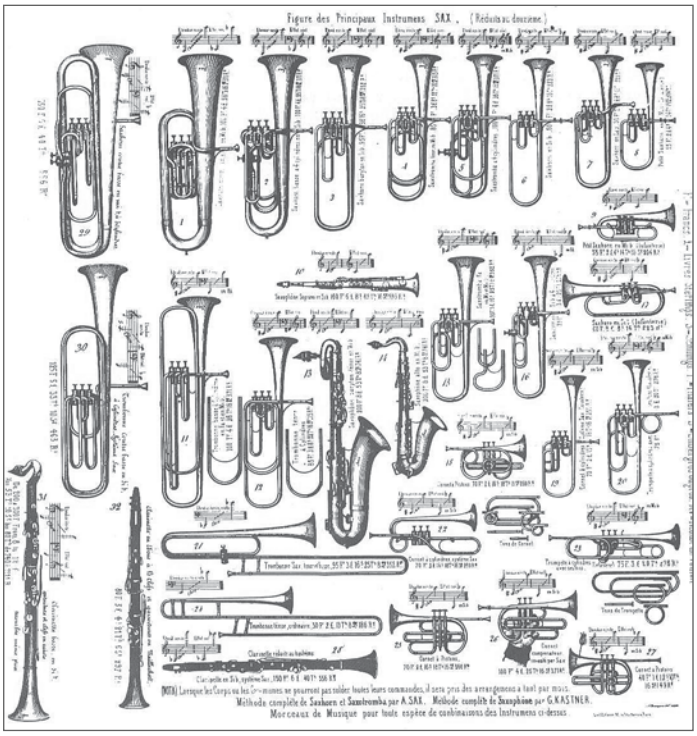
sion. Many people worked against the introduction of the saxophone and some competitors openly produced their own versions of his patented instruments. That kept Sax in court battles for almost 20 years. He declared bankruptcy three times and was never financially successful.

During his youth, Sax was accident prone and had several near death experiences. He fell out of a tall tree, nearly drowned in a river, and thinking it was milk, accidentally drank an acid solution. But Sax survived those and other serious episodes. He never married and lived a long life, passing away at 79.

A statue honoring Sax in Dinant, Belgium



A page from Sax's catalog (saxophones at center)

References

Horwood, Wally. (1980). *Adolphe Sax 1814-1894—His life and legacy.* Ergon Publishers.

Bloomsburg Solves BattleBots Competition Dilemma

By Barry Van Name

FOR several years, Kirk Marshall's Technology Education class at Bloomsburg Area High School in Bloomsburg, PA, had been entering their battling robots at national BattleBots IQ® events. These survival-of-the-fittest contests are held at various venues around the country. Not only had they been competing, they had been winning. Their entries in the 15 lb. class took many first, second, and third place awards in the competitions over the years, as well as awards for "Best Engineered Robot," "Best Documentation," and "Coolest Robot."

It came as quite a shock when they were told back in 2010 that according to a new ruling by the school board, they could no longer compete in national championship events without first entering regional contests, a new school policy ruling that would affect cheerleaders and other school teams as well.

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

The problem with this was that there were no regional BattleBot events in the central Pennsylvania area. A major incentive for his students to design and build their robots was the thrill of competing against other teams from around the country.

Above, Bloomsburg battling robots team *Malicious Intent* assembles their portable arena, dubbed the "Rage Cage."

Left, spectators watch Rhynex II take on a competitor.

At about the same time that Marshall was receiving the sad news from the school board, he was made aware of a $15,000 grant available from the Alcoa Foundation. The stipulation was that the money was to be used to provide students with a positive educational STEM experience. Coincidentally, Marshall had been wishing he had the funds to build their own BattleBots arena to host regional events for schools in central Pennsylvania that would include, of course, Bloomsburg Area High School. "I met with the Foundation and they were able to understand the many aspects of educational STEM experiences provided by such an

Student Andrew Chyko setting up the school's Tormach CNC mill

arena," said Marshall, "from the building of the structure to hosting events for students from all over to compete with their designed and engineered robots."

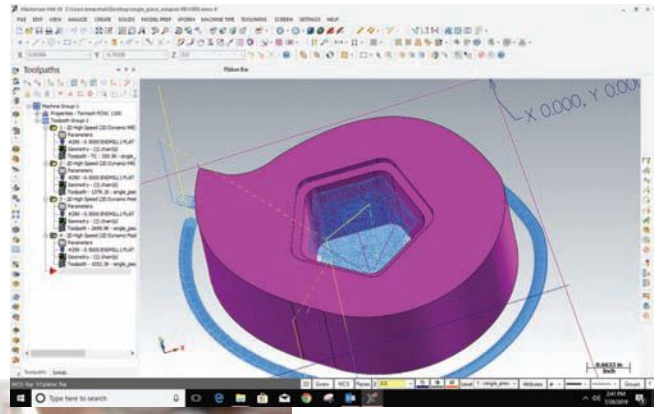
Grant in hand, Marshall used his decade or so of competing in other arenas from coast to coast to come up with a sturdy, yet portable, arena that would meet with the approval of all in the National Robotics League, overseers of the competitions who had subsequently taken over the 15 lb. class from BattleBots IQ®. "It would have to be portable," said Marshall, "because the only space available at the time was inside a former Moose Lodge that had been converted into a Bloomsburg Community Arts Center with generous floor space and room for spectators. The only drawback was that we couldn't leave the arena there after competitions, it had to be moved and stored each time back at the school."

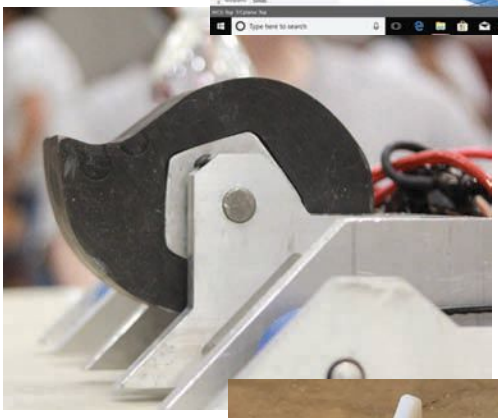
Marshall fine-tuned his drawings and he and his students went to work, fabricating all the components and turning a wish into reality. Comprised of a framework of welded 1" × 2" steel tubing (they have their own welding equipment) and a steel plate floor and 3/8" thick clear polycarbonate, steel-framed sheeting for the walls and ceiling, the arena is designed as an octagon. The floor is 3' above the ground for viewing ease and has eight pie-shaped sheet steel sections placed on the framework.

"Once the floor panels are in place," said Marshall, "the floor is very sturdy and can be walked on while putting up the rest of the arena sections." The eight rectangular polycarbonate walls are held in place with a system of tabs with locking pins and one of the wall sections includes a built-in door for easy access for team members and their battling robots. The eight pie-shaped, polycarbonate ceiling sections are dropped into place and tab-locked as a final step. All told, the unit is assembled from 24 pieces that all fit into a 6' × 12' trailer that is pulled by the school van seating the team members.

"It takes the students about three to four hours to assemble the arena and two to three hours to disassemble and load it into the trailer," said Marshall. "Although it's now based at a site made available for events at our own school, this year we have also transported it to regional competitions near State College at Penns Valley High School, Montgomery County Community College near Philadelphia, as well as a National Robotic League event at California University of Pennsylvania."

The arena has resulted in a rapid growth in BattleBot interest in central Pennsylvania. Where there had once been only one school fielding teams, there are now some 28 high schools and colleges in the area using Bloomsburg's arena to engage in metallic mayhem. Even schools without teams send students to Bloomsburg's competitions to learn about Battle-

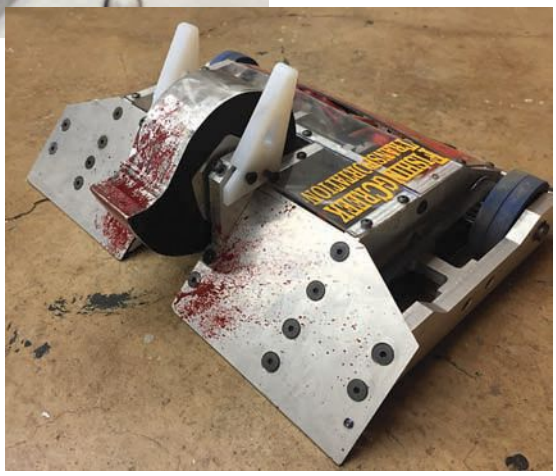




Above, Mastercam screen shot of Rhynex II's blade weapon.

Left, steel blade weapon mounted on Rhynex II.

Below, Rhynex II, ready for battle



Bots and see what's involved in building a battling robot program. "Because we have been able to host these competitions," said Marshall, "hundreds of students, in addition to our own here at Bloomsburg have been exposed to a robot design-and-build experience. This has led many of them to pursue careers in engineering and advanced manufacturing. Several have gone on to advanced manufacturing studies at nearby Penn College, the technical school of Penn State University."

The robotics program at Bloomsburg High has grown during the past 20 years from a desire on the part of Marshall to take his technology education students beyond the less challenging projects such as cutting boards, book racks, and coasters and into the more complex computer-aided design (CAD) and computer-aided manufacturing (CAM) environments found in the world of BattleBots. He has always let them pick items that are of interest to them that can be designed and created using a number of different platforms in plastics, glass, wood, and metals. He wants them to see how items familiar to them are produced in today's modern businesses using automated manufacturing processes.

"Designing and building BattleBots seemed to offer a lot of CAD/CAM possibilities," he said. "Besides, I watched some battles on a television show and it looked like a lot of fun. When you combine fun with what I wanted to teach them in advanced CAD/CAM curricula, that's a win-win for all of us."

A BattleBot begins with a lot of design work. "What do we want it to look like, what weapon do we want it to deploy, and what about defensive capabilities are just some of the questions kicked around in the design stages," said Marshall. "The students do a lot of the designing in SOLIDWORKS®. Once a design is agreed on, all of its components from framework to weapon to outside armor are downloaded to Mastercam® to create the toolpaths for our CNC mill."

Students machine each piece out of wood first, using Mastercam to proof the CAM program. Wood is forgiving and will not result in broken tools if a wrong feed, speed, or dimension has been entered. There are fifteen Mastercam workstations set up in the classroom, enough for all participants.

Once the program has been proven, the actual components for the battling robot are machined out of aluminum and steel. For each piece, a computer file record is maintained.

"Mastercam lets us program part tolerances that often need to approach a thousandth of an inch," said Marshall. "We have a new Tormach® 770 CNC mill that lets us take advantage of Mastercam's Dynamic Milling feature. The tool flies around the part so fast, it's really amazing.

"We actually cut a weapon blade for our latest battling robot, that we call *Rhynex II*, out of 1-1/2" thick S7 tool steel, in a single pass. All I could think was, 'this is awesome.' This weapon blade is 6" in diameter and spins at 12,000 rpm. Whatever competing BattleBot it hits, it destroys.

"Mastercam has given us the ability to field competitive BattleBots year after year. I introduced Mastercam into my curriculum back in the 1990s and have updated and used it consistently with my students in a wide range of CAD/CAM projects. I find it important to get them familiar with the software they will most likely find in the manufacturing com-

Continued on page 24.

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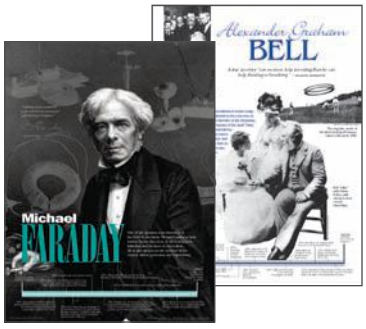

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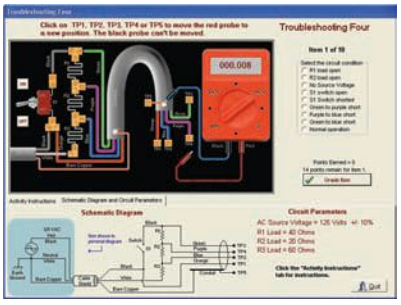

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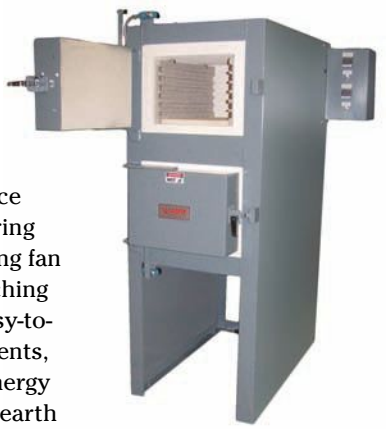

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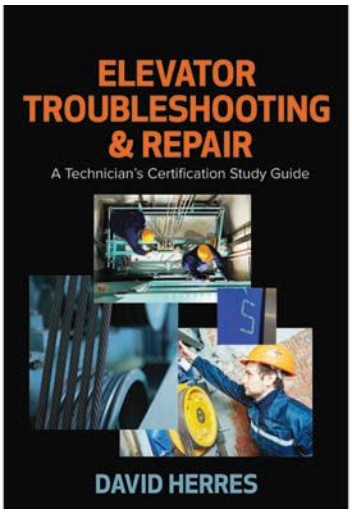

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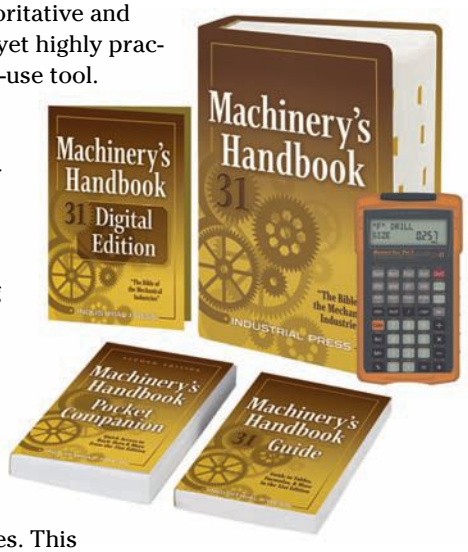

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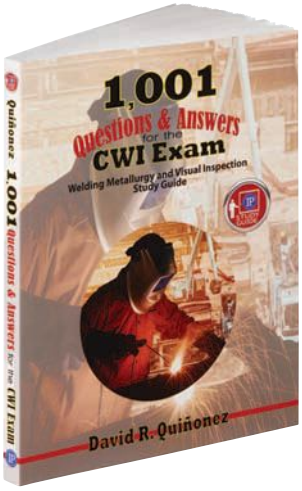

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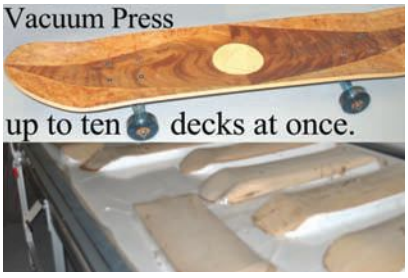

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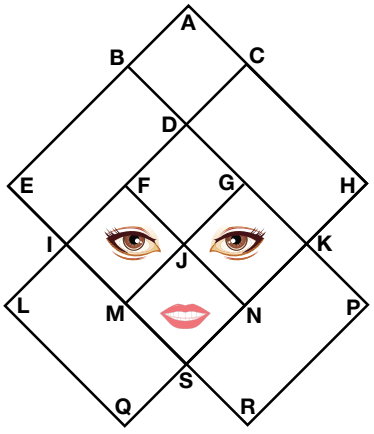
More than Fun Answers

The Lady and the Tiger

There are 11 squares and 20 triangles.



In the lady, there are 5 small squares: ABDC, DFJG, FJMI, GJNK, JMSN.

There are 5 middle-sized squares: BEMG, DISK, GMRP, CFNH, FLQN.

There is 1 large square: AESH.

In the tiger, the head contains 10 triangles, the body contains 3 triangles, and the tail contains 7 triangles.

They Grow Up So Fast

Jackson is 6 years old.
Let x = Jackson's age
Then x = 9 / (1/4 x)
So, x = 9 / (x/4)
Then x = 36 / x, $x^2 = 36$, x = 6

What Comes Next

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1. The break-even point is $9,100.
2. If he charges less than $9,100, he should use his Mastercard.
3. If he charges more than $9,100, he should use his American Express card.

Let x = the break-even point

Then the Mastercard Rewards = 0.01 x and the American Express Rewards = 0.01(0.20(6,500)) + 0.005(0.80(6,500)) + 0.05(0.20(x - 6,500)) + 0.0125 (0.80(x – 6,500))

Set them equal and solve:

0.01 x = 0.01(0.20(6,500)) + 0.005(0.80(6,500)) + 0.05(0.20(x – 6,500)) + 0.0125(0.80(x – 6,500))

.01 x = 91

So, x = $9,100

Students Learn Real World Skills in Industrial Technology Class

Business-school partnerships an important lesson for industrial tech students

By Jeanne Millsap

THERE was a time when many high school woodworking, metalworking, and other industrial arts courses were considered mostly hobby classes. Students might continue the work for their livelihoods after graduation, but business skills were rarely included in their classes.

Today, at least in Mark Smith's industrial technology classes at Reed–Custer High School in Braidwood, IL, students learn business acumen, industry standards, and how to network with professionals, right alongside carpentry, engineering, architectural design, and how to use tools and machinery. Businesses court them for jobs even before they graduate.

"We have companies calling for our students all the time," Smith said. "We just had a company come up from Florida who want to offer internships for our students at $15-$20 an hour. They'll pay for their housing, and they'll give them a great experience over the summer." Some of his students took advantage of a similar internship in Nashville last summer.

Brandon Carlo working on a cabinet face frame

Most of these business contacts are developed by Smith, with the knowledge that school-business partnerships are a win-win situation. He said he is happy to have grown these relationships over the years. They benefit his students as they seek training or jobs, and businesses benefit by having knowledgeable, trained applicants who can hit the ground running.

Industry leaders visit his classes and talk to students, and his students take field trips to their facilities. Other business partners give technical support to the classes and others donate equipment or dollars. The company Taylor Guitars recently donated $20,000 worth of guitar parts (students design and build acoustic or electric guitars in the Reed-Custer STEM classes), and the Association of Woodworking and Furnishing Suppliers (AWFS) donated $1,700 for students to travel to trade shows.

They are among a list of many businesses that help the Reed-Custer classes. "We have a company in Texas that is doing a fundraiser for us," Smith said, "to purchase a piece of digital fence equipment." The piece of machinery is commonly used in industry, but not so much in high schools.

Reed-Custer's industrial technology classes include CAD 1, 2, and 3; STEM 1 and 2; Production 1 and 2; and CAD/CAM 1 and 2. Smith explained that CAD (computer-assisted design) involves making blueprints using a computer. Most drafting is done on computers today, he said, rather than on drafting boards. One of his former students is studying engineering at an Illinois university and told Smith he was the only student in his class who knew CAD. The other students had to learn the program on their own time.

Jeanne Millsap iss a Shaw Media correspondent.

In the production classes, they build things like cabinets and furniture. This semester, they are building cabinets on commission for a local family. Students in the class built and installed kitchen cabinets for the same family a while back. "They liked them so much they asked us to build six more for them," Smith said. "We're going to turn their refrigerator into a built-in situation with cabinets all around it, and we're going to replace all the cabinets in the laundry room and one in the bathroom."

Gabriel Morris, a sophomore in this semester's Production Technology 2 class, said he took Production 1 last semester and enjoyed it, so he enrolled in the next one. "I love working with my hands and with wood," he said. "I had heard that the second class had more of a leadership role and that we could do more on our own." Morris grew up helping his father do carpentry and is considering an eventual career in manufacturing engineering. He hopes to be able to take all of Smith's classes before he graduates.

Sophomore John Selock enjoys the hands-on aspect of the industrial technology classes, as well. "You pick up more when you do it that way," he said. "There's something different and satisfying about learning something hands-on." His favorite part of the production classes is seeing the finished product that he and his classmates have been working on all semester. Selock hopes to go into the trades for Local 150 after graduation.

Sophomore Brandon Carlo, also taking Production 2, already landed a job at a local woodworking business, building bathroom and kitchen cabinets and doorways. He hopes to go into welding or programming CNC machines after graduation.

Students in the classes do well in national competitions, as well. Former Reed–Custer industrial technology student Chandler Norton earned 2nd place in the national AWFS Trade Show in Las Vegas last summer for a gaming chair he designed and built.

Chandler Norton designed his knock down gaming chair in AutoCAD, toolpathed it in Mastercam, and machined it on a Thermwood Model 43 CNC Router. He earned 2nd place in the national AWFS Trade Show.

MODERN APPRENTICESHIP

Perceptions Are Not Reality

By Nicholas Wyman

MOST Americans believe that the best path to a lucrative career is a four-year college degree. However, this view is changing in the era of stratospheric college tuition and crippling loan debt. People are looking for a surer and less financially burdensome path. Those who have some knowledge of work-based learning embrace it.

A Harris poll of 2,000 adults reports:

• 92% of U.S. adults with an opinion about apprenticeships view them favorably.

• 4 out of 5 Americans believe more people should consider earn-while-you-learn apprenticeship programs, and 7 in 10 wish they knew more about such opportunities.

• 9 in 10 of those who were apprentices themselves or know someone who had an apprenticeship say the experience had a positive effect on that person's career.[1]

The practicality and adaptability associated with Modern Apprenticeship enable it to deliver substantive results across a spectrum of occupations. As indicated in the Harris poll above, many of those who know about work-based learning agree.

Myths around apprenticeship harm efforts to ramp up one of the most powerful skill-building tools for growing America's workforce. It's time to set the record straight.

Nicholas Wyman is a workforce development and skills expert, author, speaker, and CEO of the Institute for Workplace Skills and Innovation (IWSI Consulting). This is an excerpt from "It's Time: Using Modern Apprenticeships to Reskill America." The full report can be found here: https://www.iwsiamerica.org/wp-content/uploads/2019/03/IWSI_ITS_TIME_REPORT.pdf

Myth One: Modern apprenticeship graduates earn low wages.
Fact: The average starting wage for apprentices is above $60,000.[2]

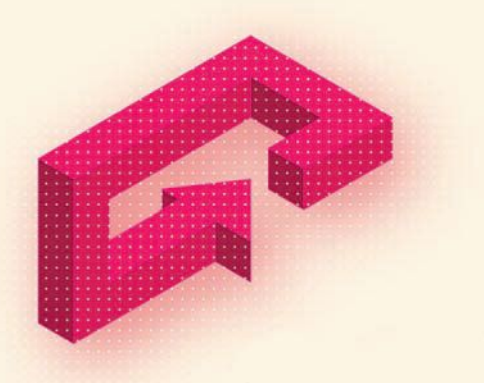
Apprentices earn higher starting salaries than college graduates on average. In 2018, college grads could expect to make an average of $50,390 annually.[3] This figure doesn't take into consideration the fact that degree holders will end up carrying an average of $39,400 in student debt.[4]

Not only do most apprentices move directly into employment upon program completion, but they largely do so debt-free and are earning while learning. An astonishing 91% of apprenticeship graduates find employment almost immediately after finishing their programs.[4]

Myth Two: Modern apprenticeship is mostly applicable to "the trades."
Fact: Modern apprenticeship offers a broad array of career pathways.

Historically, apprenticeships were almost exclusive to electrical, plumbing, carpentry, and other hands-on trades. This is no longer the case.

Modern Apprenticeship offers a broad array of career pathways. In fact, the list of companies now investing in Modern Apprenticeship includes LinkedIn, Lockheed Martin, JPMorgan Chase, Amazon, Nike, Dow Chemical Company, Interapt, Peterson Automotive Collection, CVS Health, and Black Oak Casino Resort.

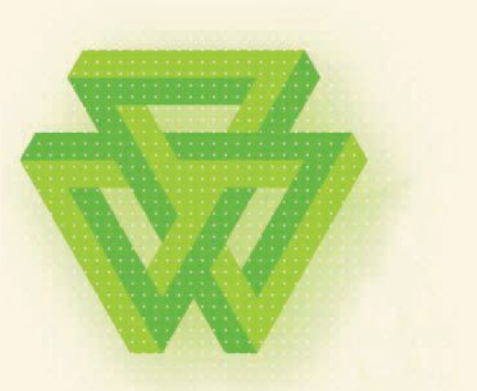


4 out of 5 Americans believe more people should consider earn-while-you-learn apprenticeship programs.

Myth Three: Modern apprenticeship programs are a burden on company resources.

Fact: Companies unanimously concurred that program benefits more than justified their costs.

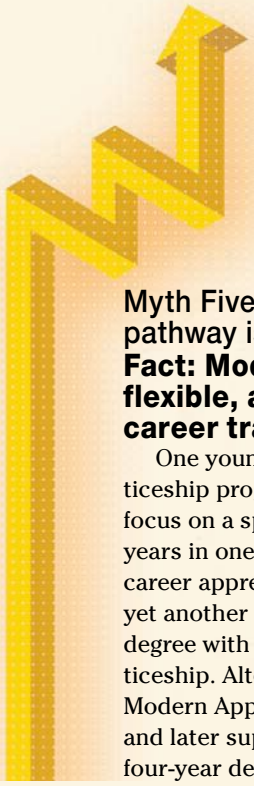
Just as any new business endeavor does, Modern Apprenticeship programs require an initial investment of time and money. However, in a study of the costs and benefits associated with Modern Apprenticeship, companies unanimously concurred that program benefits more than justified their costs.[5]



Myth Four: Modern apprenticeship is limited to technical skill building.

Fact: Modern apprenticeship teaches interpersonal skills along with technical and analytical skills.

According to employers, interpersonal ("soft") skills in particular are notably missing in many of today's young job candidates. In McGraw-Hill Education's recent Future Workforce Survey, over half of the more than 1,000 college graduates surveyed believed they were well prepared for the workplace in "essential career readiness skills"[6] like professionalism and work ethic (77%), critical thinking and problem solving (63%), and oral and written communication (61%). Employers' perception of graduates' career readiness was substantially lower: 43% for professionalism, 56% for critical thinking, and 42% for communication.[7] Technical skills aren't a big issue for employers or college graduates. Interpersonal skills are.



Myth Five: The modern apprenticeship pathway is rigid.

Fact: Modern apprenticeship is flexible, allowing for a variety of career trajectories.

One young adult may enter a Modern Apprenticeship program directly from high school and focus on a specific skill set; another may work for years in one occupation and then become a mid-career apprentice in a completely different field; yet another may combine a two-year associate degree with a certification and Modern Apprenticeship. Alternatively, a young person may enter a Modern Apprenticeship directly out of high school and later supplement that work experience with a four-year degree. The options are endless.

Endnotes

1. American Staffing Association. "Apprenticeships Can Kickstart Careers" (June 21, 2018). americanstaffing.net/posts/2018/06/21/ apprenticeships-can-kickstart-careers

2. Perez, T., and J. Zients. "ApprenticeshipUSA is Upskilling America" (October 21, 2016). obamawhitehouse.archives.gov/blog/2016/10/21/ apprenticeshipusa-upskilling-america

3. Lobosco, K. "Starting Salary for the Class of 2018: $50,390" (2018, May 14). money.cnn.com/2018/05/14/pf/college/class-of-2018-starting-salary/index.html

4. Student Loan Hero. "A Look at the Shocking Student Loan Debt Statistics for 2018" (May 1, 2018). studentloanhero.com/student-loan-debt-statistics

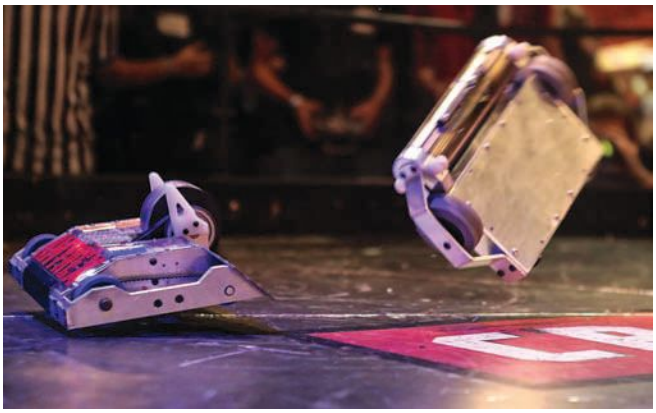
5. Case Western Reserve University. "The Benefits and Costs of Apprenticeship: A Business Perspective" (2016). files.eric.ed.gov/fulltext/ED572260.pdf

6. NACE Job Outlook 2018.

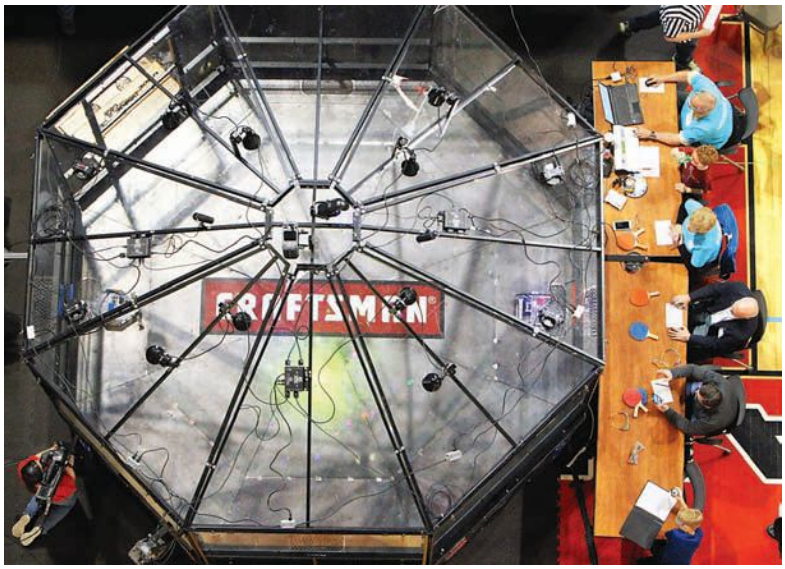
7. McGraw-Hill Education "2018 McGraw-Hill Education Future Workforce Survey" (2018). www.mheducation.com/future-workforce

Continued from page 14.
panies where they'll seek employment."

Many of the area's manufacturing companies are also sponsors of *Malicious Intent*, the name chosen for their team by Marshall's students. In return for a fee, they get their names and logos on signs and banners in the arena areas, on programs, T-shirts, and other team paraphernalia, just like NASCAR. "I send out brochures detailing our battling robots program and what we hope to achieve.



Bloomsburg's Rhynex II in action, flipping another combatant with its spinning blade weapon.



A view of the Rage Cage from above

"In addition to donations of tooling and materials for building our robots, we take in about $2,000 for sponsorship and arena rentals, etc., at each of our competitions. This helps pay for non-self-manufactured items for our robots, such as brushless drive motors and radio control systems, as well as costs involved in sending the team out of the area to national championship events. Because the manufacturers have come to realize the skills our students have upon graduation, those students not going on to Penn College or other technical schools are warmly received into the local and regional workforce."

Through an arrangement set up between the schools, students that complete Kirk Marshall's CAD/CAM courses and pass a final exam offered by the Penn College NOW program earn college credit. In the past two years, 16 students have passed the exam to receive seven college credits. "Penn College has a great automated manufacturing program," he said. "Not only are they Mastercam users but are a machining technology center with both two- and four-year degree programs. My courses dovetail with those at Penn and other colleges, providing many opportunities for our students to advance their education while still in high school."

To see a time-lapse video of Kirk Marshall's students constructing their portable arena on site, as well as some exciting events showing their *Rhynex II* BattleBot taking on, and defeating, some tough competitors, go to YouTube, search the user marsh107 and click on *2019 Malicious Intent Promotion Video*.

Most impressive is the team's record of awards won at BattleBots IQ (2005-2009) and National Robotics League (2011-2019) National Championship events (Fig. 1), in addition to their many regional titles.

Bloomsburg's Awards at National Championship Events

- 2005 – Orlando FL - Second Place
- 2006 – Miami, FL - National Champions, Second and Third Place
- 2007 – Miami, FL - National Champions, Fourth Place, Best Engineered Robot, Coolest Robot
- 2008 – Miami, FL - Best Engineered
- 2009 – San Francisco, CA - National Champions, Third Place
- 2011 – Indianapolis, IN – National Grand Champions, Fourth Place, Best Engineered Robot, Coolest Robot
- 2012 – Indianapolis, IN – Fourth Place
- 2013 – Indianapolis, IN – Fourth Place, Fifth Place
- 2017 – California, PA – Eighth Place
- 2019 – California, PA – Third Place

To Pay for College, More Students Are Promising a Piece of Their Future to Investors

As the Department of Education announces an experiment with income share agreements, the debate about these financial tools is growing louder

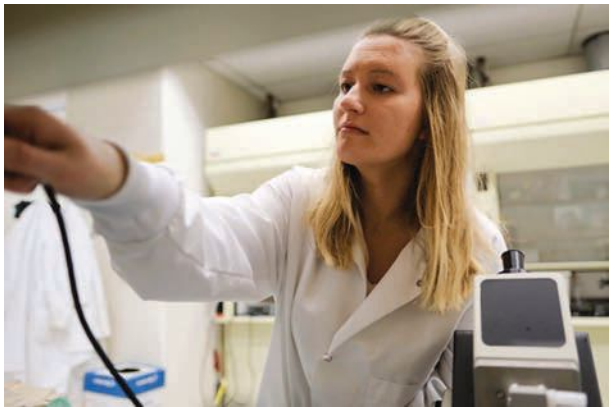
By Caroline Preston

ONE day in 2017, Lauren Neuwirth sank into a chair in her university's financial aid office feeling out of options. She was finishing her second year at Purdue University in northwest Indiana, a school she'd chosen for its top-ranked engineering program. Neuwirth, who grew up near Milwaukee, was working two jobs to cover her living expenses and quickly running through the money her mother had set aside for college. Federal student loans only covered some of Purdue's pricey out-of-state tuition. She worried that to remain in school she'd have to take out expensive private loans or join the Army.

But then Purdue offered her another way to pay. Investors—including wealthy alumni, a hedge fund, and the Purdue Research Foundation—would front her $50,000 to cover two years of college. In exchange, she'd owe them 14.8% of whatever income she earned in the eight years after she graduated. Neuwirth agreed.

Last fall, her fifth and final year as a double major in food science and biological engineering, she received a job offer from the agribusiness Cargill at a salary of $56,000. If all goes as planned, she'll eventually return a healthy profit for those investors.

"It has afforded me the opportunity to stay at Purdue," said Neuwirth, 22, who spent last summer as a Cargill intern tinkering with the corn-flour mixture that coats McDonald's Chicken McNuggets. "But it's tricky," she said, "because I'm going to have that pulled from my income, and then I'm also going to have to be paying off those federal loans. That makes me a little uneasy."



AJ Mast for The Hechinger Report

Lauren Neuwirth, a Purdue senior double majoring in food science and biological engineering, used income share agreements to help finance her degree.

This kind of arrangement, known as an income share agreement, or ISA, has been used in a smattering of places, but hasn't gained much traction in the United States—until recently. Now, more than five dozen U.S. universities and coding schools use ISAs, and, in December, the Department of Education said it would experiment with offering them. Senators have introduced bipartisan legislation to regulate the tools, and investors are taking notice.

As ISAs migrate from the margins of financial aid to the mainstream, the debate around them grows louder. Proponents tout the safety net they offer: With ISAs, unlike with loans, graduates pay nothing if they can find only low-wage work, and there are often limits on ISAs' duration and on the total amount graduates must repay. "It makes college less risky," said Beth Akers, a senior fellow at the Manhattan Institute, a conservative think tank.

The tool could produce other benefits: Investing directly in ISAs, as Purdue has done, gives schools a financial incentive to help their students through to graduation and into good jobs.

But critics of ISAs argue that they are just a new spin on debt. Some

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Caroline Preston is a senior 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.*

contract terms are less rosy than they first appear: Most graduates will likely end up paying far more than they receive (Purdue's cap is 2.31 times the size of the initial payment), and under some contracts, the repayment period is extended if students earn too little. Uncertainties abound, such as what happens if graduates have difficulty making payments.

Education experts worry that investors gambling on students' futures could produce all kinds of harms, from discrimination against students who are expected to earn less to hastening the transformation of colleges from places of learning to engines of skilled workforce production. At Purdue, for example, students studying for degrees that usually lead to low-paying fields are saddled with the most burdensome repayment terms.

AJ Mast for The Hechinger Report

Charlotte Herbert, a recent Purdue graduate, said she prefers her income share agreement to her loans. "Knowing that it's never going to be more than 10% of my income was rather reassuring," she said.

"My fear is that students, and particularly low-income, first-generation students, will end up paying more for their educations than they would have if they'd taken out traditional loans," said Mark Becker, president of Georgia State University. "The reality is that investors are investing to make money; this is not an altruistic undertaking."

These concerns notwithstanding, graduates who've started paying off their ISAs say they weigh less heavily than loans. Charlotte Herbert financed her senior year at Purdue with an income share agreement for roughly $27,000; each month, on top of her federal student loan payments, she pays her investors 10% of her $38,000 pre-tax salary, and will continue to do so for the next seven years.

"Knowing that it's never going to be more than 10% of my income was rather reassuring," said Herbert, 24, a technical writer of guidebooks and manuals for an engineering firm. "My big concern with my loans is, because of the interest, it's just going to keep going. I'm constantly looking at how I can squeeze out a little bit more to outpace the interest."

An hour's drive from Purdue, Kenzie Academy, a for-profit tech school located in a former opera house in downtown Indianapolis, is explicitly churning out graduates for well-paying jobs. One recent morning, nine students sat at white tables as an instructor wearing a blue Kenzie T-shirt fielded questions on how to tailor their resumes for jobs in software engineering and user-experience design.

"Our entire survival depends on our students being successful," said Chok Ooi (pronounced "Oy"), Kenzie's 39-year-old founder, sitting in a glass-walled room by the school's entrance that looks out on exposed brick walls, Wayfair furniture and an open floor plan. "So we really truly invest in our students."

Ooi, who grew up in Malaysia and moved to the United States for college, opened Kenzie in September 2017 with the goal of closing the gap between workers' skills and the needs of the growing tech industry in Indianapolis and beyond. He sought to attract students who'd been displaced by automation; wanted a quicker, cheaper way into the tech workforce than college; or were looking for a fresh start.

Like most coding schools, Kenzie doesn't qualify for federal financing, so students had few options beyond pricey private loans (assuming they had the credit scores to obtain them). Ooi researched the ISA model and liked what he saw. Students can pay tuition of $24,000 outright if they have the money, but today, most of Kenzie's 500 students pay for the school with ISAs.

Kenzie's ISA terms work like this: Students pay $100 up front and no tuition until they secure a job with a salary of at least $40,000. Once they do, they pay 13% of their monthly income for four years, up to a maximum of $42,000. If they lose their job or their income dips below $40,000, the payment time frame can stretch up to eight years.

To win admission, applicants are tested on their problem-solving abilities; about 25% of those who interview are accepted, the school says. Admitted students must pass additional hurdles to qualify for an ISA, such as demonstrating that their existing debts won't prevent them from managing their income-share obligations.

Some Kenzie students hold bachelor's degrees that didn't aid them in the job market. Nick Howell is one. Howell, 35, graduated from Purdue with an associate degree in professional flight and a bachelor's in business. But he could only find low-paying warehouse and office jobs, he said, and entered collection on the $50,000-plus he owed in student loans. He is now in a federal income-driven repayment plan that obligates him to pay 3% of his income to the government—down from 7% after Howell recently renegotiated it—but interest is still accruing.

In 2018, Howell enrolled at Kenzie with the hope of acquiring marketable skills. Within a year of starting, he received a job offer from a big web development firm. Today, he's earning $55,000 a year making websites for car companies. Between his financial commitments on his Kenzie and Purdue degrees, he's paying out 16% of his income, but he says it's manageable because his wife makes a decent salary as a lab tech.

"We're doing way better than we

were before," said Howell, who grew up in Crawfordsville, near Indianapolis. "Traditional loans are a scam," he added. "I will 110% push income share agreements on people over taking traditional loans just for the fact that, yes, the percentage is higher, but it's based off (a) a job you have, and you pay zero if you don't have a job, and (b) there's no interest."

Caroline Preston/The Hechinger Report

Chok Ooi founded Kenzie Academy in 2017 to help close the gap between workers' skills and the needs of the growing tech industry in Indianapolis and beyond.

The school got a big boost last fall, when San Francisco-based impact investment firm Community Investment Management said it would lend Kenzie up to $100 million to expand its number of students receiving ISAs into the thousands. Jacob Haar, managing partner of Community Investment Management, said the firm spent three years researching schools before choosing Kenzie because it focused on underserved students outside of tech hubs like the Bay Area, and it showed early success in helping students into good jobs. (Approximately 90% of Kenzie graduates find jobs that pay at least $40,000, the school says.) Under the deal, Kenzie will hold ISA contracts directly with the students, but Community Investment Management can halt its investment if graduation rates and job placement rates tumble, Haar said.

So far, the infusion of cash has been good for students: It enabled Kenzie to cut the share of income it requires of graduates to 13%, from 17.5%.

In the event of an economic downturn, though, graduates' earnings—and Kenzie's returns—could fall. But Ooi said he thinks that the pace of technological change is only going to intensify companies' need for workers, sending more students to the school. He also thinks more students will start choosing places like Kenzie in lieu of four-year schools. "It's a half-a-trillion-a-year tuition business with a very low satisfaction rate," he said of traditional higher education.

Purdue's president, Mitch Daniels, agrees that colleges have put too little emphasis on helping their graduates succeed, and he sees income share agreements as a way to push schools in that direction. "One very legitimate criticism of higher education is it's been charging higher amounts for a product of unproven quality," he said. "Higher education has been very resistant to proposals that they have some skin in the game, that they accept some proportion of the risk for student default."

In 2016, the university launched its income share agreement program, named "Back a Boiler" after the school's mascot, a mini-locomotive called the Boilermaker Special. Since then, more than 750 students have signed up. The program is managed by the Purdue Research Foundation, a separate nonprofit that invests directly in the ISA fund and raises money for it from outside investors.

Daniels, a former Republican governor of Indiana, articulates a relatively narrow role for ISAs: as a replacement for high-interest private student loans and federal Parent PLUS loans. He doesn't think they can compete with subsidized federal loans, and notes that the government already runs an income-driven repayment program itself, although those loans continue to accrue interest.

Still, some Purdue students use ISAs to replace federal loans. Herbert, for example, could have accessed more federal loans her senior year but decided the ISA was a better option because of downside protections like its built-in end date.

Other four-year schools are using ISAs to fill different gaps. Colorado Mountain College, for example, is using ISAs for undocumented students (who don't qualify for federal loans).

Caroline Preston/The Hechinger Report

Most students at Kenzie Academy, a tech school in Indianapolis, use income share agreements to finance their education.

Even some ISA skeptics say that if done well they could be a better alternative to private loans. "Is it a safer cigarette? Maybe," said Jessica Thompson, associate vice president with the nonprofit Institute for College Access & Success.

Instead of assessing borrowers based on their creditworthiness, ISA investors evaluate students' earning potential. And that's where things get tricky. At Purdue, one feature has

proved particularly controversial: Students with the lowest earning potential receive the worst repayment terms.

For example, Savannah Marina Williams, a senior from Auburn, Indiana, working toward a degree in the low-paying field of education, was fronted roughly $30,000 by Purdue, nearly $20,000 less than Neuwirth, the bioengineering student. But Williams is obligated to pay roughly the same share of her income as Neuwirth, nearly 15%, and she'll be paying it for 10 years instead of eight. Paul James Laurora, a chemical engineering graduate from New Jersey who was also provided more upfront money than Williams—$33,500—received more generous terms. He's paying 9.6% of his salary for 7.5 years.

The model is designed so that most students end up generating more or less the same return for investors. But some education experts argue that financial aid is meant to level the playing field and help generate economic mobility, not burden the most vulnerable. Plus, critics say, such terms could have a disproportionately negative impact on women and people of color, who are more likely to major in low-paying fields like social work, and less likely to major in high-paying fields like engineering. Income share agreements could thus run afoul of fair lending laws and even exacerbate race and gender wealth gaps.

At the same time, more investors are starting to view students as a promising asset class. Christopher Ricciardi is a managing partner with FlowPoint Capital Partners, a New York investment firm; he is known as "the grandfather of CDOs" for his role in popularizing collateralized debt obligations, the tools that seeded the 2008 financial crisis.

This past fall, FlowPoint unveiled edly, an online marketplace that matches schools selling "shares" of their students' ISAs with accredited investors. Ricciardi envisions that the market for ISAs could replace the entire $10 billion private loan market and then some, growing to at least $20 billion.

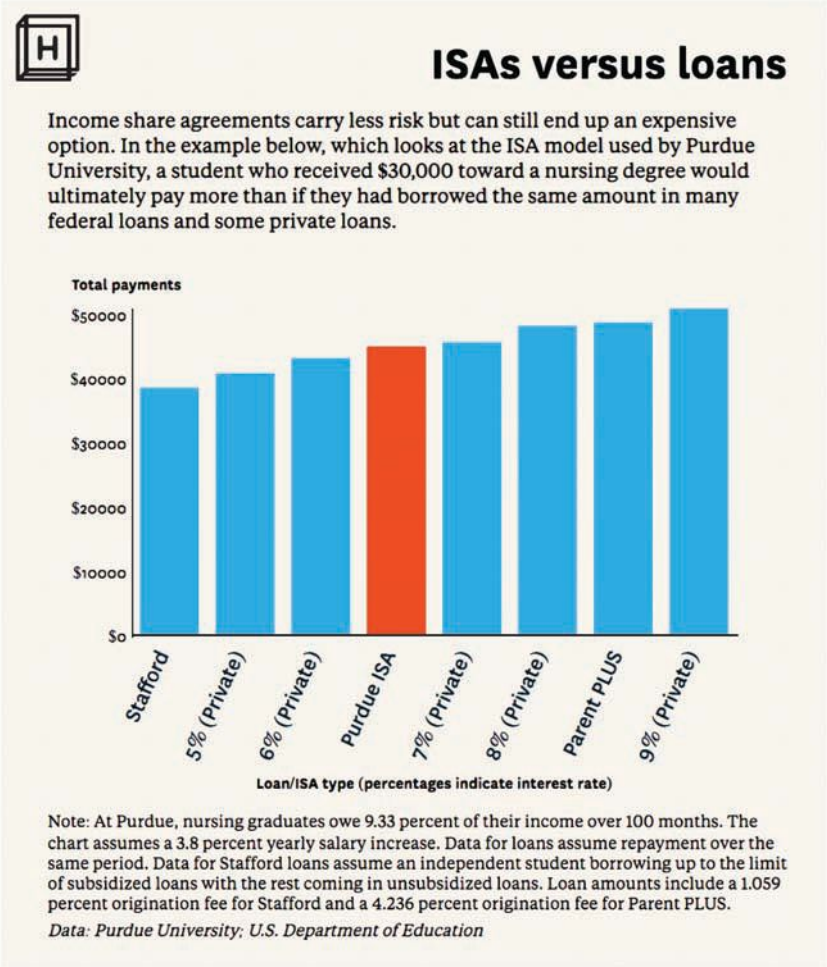
The platform solves a problem facing schools that use ISAs to fund their programs: It gives them some money up front, before students graduate and start repaying. In exchange, investors get partial rights to future payments from bundles of ISAs. Unlike Purdue, the platform doesn't stick students in different fields of study with different payment terms. Instead, investors can choose which types of students and which schools they want to buy a stake in.

Ricciardi said some investors comfortable with lower returns have already signaled their interest in bankrolling future social workers and teachers, whereas more profit-minded investors can choose to throw their money behind future engineers. So far, a dozen institutions (coding and vocational schools and one for-profit university) have signed on, and more than two dozen investors have put up about $20 million, Ricciardi and his colleagues said.

His firm is trying to ensure strong returns for investors—10-15% annually, according to the edly website—by working only with schools whose graduates have been successful in the job market and giving better financing terms to schools with stronger performance. That kind of talk makes some higher education experts wary: Could it lead to capital flowing only to job-focused schools, shifting the purpose of higher education from learning to preparation for certain well-paying jobs?

At the same time, because participating schools cede to investors a partial stake in their income share agreements with students, critics argue that investor decisions will increasingly drive the schools' operations. "ISAs are predatory," said Kim Crayton, a business strategist and founder of #causeascene, an organization focused on making the tech world more inclusive.

The Senate bill introduced last year would treat income share agree-



ments as a new category, apart from loans, and exempt from usury laws and other protections afforded to borrowers. Proponents say the legislation is necessary to regulate ISAs, and that ISAs are distinct from debt. But consumer advocates argue that the legislation provides a back door around lending rules, and that it could leave students vulnerable.

"It's exceedingly unclear how these products—especially products that are broad-based, across schools, across programs—expect to comport with basic fair lending laws that have been on the books for decades," said Seth Frotman, a former Consumer Financial Protection Bureau official who now runs the nonprofit Student Borrower Protection Center.

After a Department of Education official mentioned the agency's interest in income share agreements last May, the idea drew the ire of Senator Elizabeth Warren (D-Massachusetts), who joined colleagues in asking the department for more details of its plan. "It is deeply disturbing to see a Department official boosting novel forms of student debt instead of trying to stem the tide of indebtedness," they wrote, adding that ISAs "carry many common pitfalls of private student loans—with the added danger of deceptive rhetoric and marketing."

Even if the marketing of income share agreements isn't deceptive, it can be confusing. Laurora, the Purdue chemical engineering graduate, said he only realized after his payments kicked in that his contributions would be determined from his gross, not his net, pay. That leaves him less money each month than he budgeted.

And while some students say they're glad for the chance to be treated as investments, not debtors, income share agreements don't change the fact that the students will owe tens of thousands of dollars for their degrees. Plus, high tuition costs mean that students often have to take out loans on top of their ISAs, pinching them in repayment.

Caroline Preston/The Hechinger Report

Kenzie Academy invests heavily in helping its students find jobs. Here, students who are nearing graduation participate in a resume workshop.

Neuwirth, the Purdue senior, took out four different income share agreements, totaling $50,000. But that still wasn't enough to cover her costs, so she had to turn to private loans.

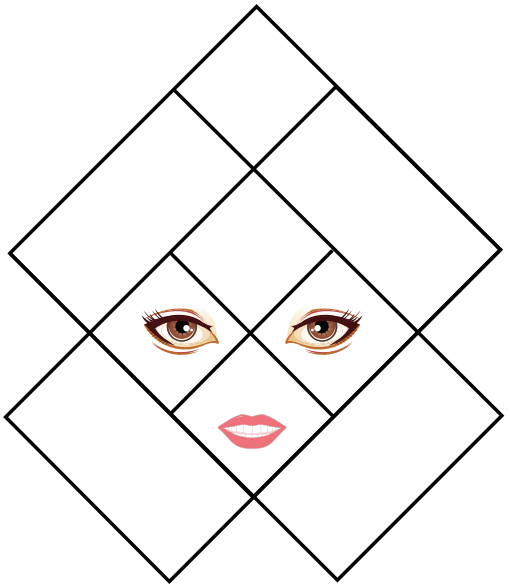
The youngest of three children raised by a single mother, Neuwirth could have gone to an in-state school in Wisconsin. But she felt an engineering degree from Purdue would help her achieve a secure future. Now, with her job at Cargill in hand, she doesn't regret the decision. But the 14.8% of her salary she's paying the school for her ISA "seems a little excessive to me." She added: "It's a little scary."

Still, Neuwirth said she doesn't begrudge Purdue the chance to profit from her success, since the income share agreement allowed her to stay on campus and finish her degree. She said, "It's good that I'm making Purdue some money."

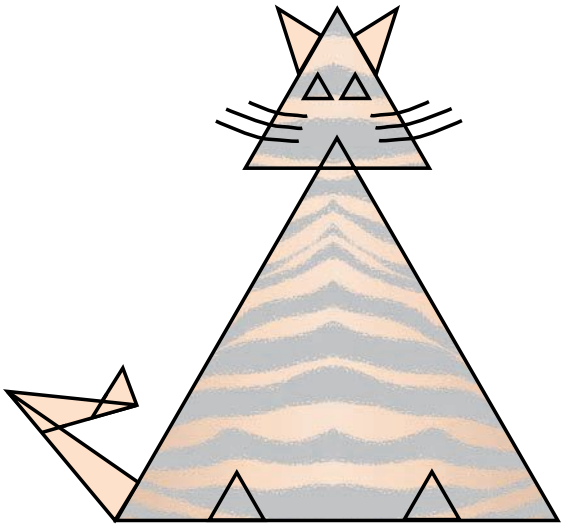
more than fun

The Lady and the Tiger

How many different squares are there?



How many different triangles are there?



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

They Grow Up So Fast

Jackson's age is 9 divided by one-quarter of his age. How old is Jackson?

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

A Rewarding Experience

Mr. P has two credit cards that reward him with cash based on how much he charges on the credit cards.

The Mastercard Rewards program is simple: Mr. P gets back 1% of all that he charges on that card during the year.

The American Express rewards program is a bit more complicated: On the first $6,500 of purchases in a year, Mr. P gets 1% on supermarket, drug store, and gas purchases, and he gets .5% on all other purchases. On all purchases over $6,500, Mr. P gets 5% on supermarket, drug store, and gas purchases, and he gets 1.25% on all other purchases.

Suppose that 20% of Mr. P's yearly charges are for supermarket, drug store, and gas purchases.

1. What is the "break-even" point on the two cards? That is, what amount must be charged on each card so that the rewards would be equal?

2. If Mr. P's annual charges are less than this amount, which card should he use?

3. If Mr. P's annual charges are more than this amount, which card should he use?

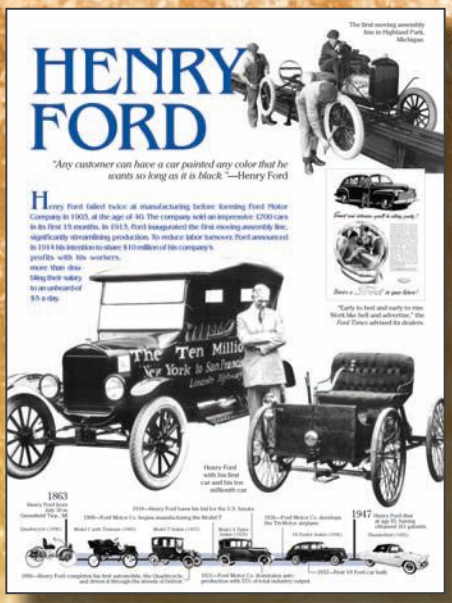
Puzzle devised by David Pleacher, www.pleacher.com/mp/mpframe.html

What Comes Next?

What will the next symbol look like?

See answers on page 19.

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



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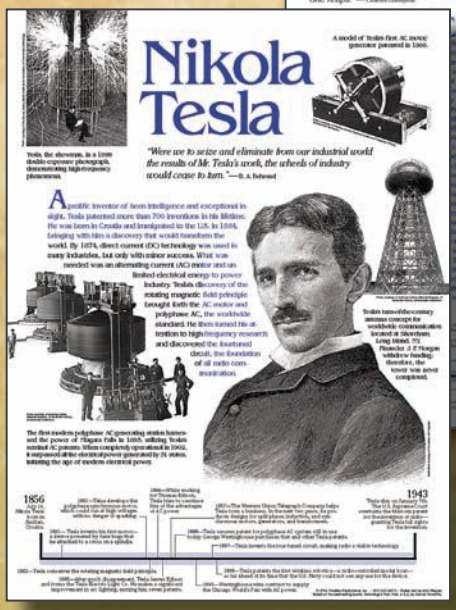

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