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technology and engineering TEACHER

April 2023

Integrating Technology for Remote Learners

An invitation from ITEEA's 2022-23 President, Debra Shapiro, DTE

Greetings! As ITEEA President, I am so excited and honored to invite you to join us to experience ***Learn it, Try it, Teach it! STEL Experiences to Advance Our Profession,*** the theme for our 85th Annual ITEEA Conference in Minneapolis, Minnesota. We are so excited to have everyone back together for a full face-to-face conference this year!

We have realigned our conference program this year to make sure there is something for everyone. In addition to regular events like the Thursday Special Panel Session and Opening Reception, the Maley Spirit of Excellence Breakfast, the STEM Showcase and Go Baby Go Dream Ride, we have added a Wednesday social event at Brit's Pub, a new Celebration of Award Winners Reception, and a complimentary Friday Lunch in the Exhibit Hall!

Additionally, professional development learning sessions include strands tailored to the following audiences:

- Elementary Educators (EE): most relevant to elementary educators; curated by ITEEA's Elementary STEM Council (ESC)
- General Audience (GA): relevant to all attendees
- International/PATT (IP): most relevant to those interested in international technology and engineering and/or STEM education practices
- Secondary Educators (SE): most relevant to middle and high school educators
- STEM Leaders (SL): most relevant to supervisors, administrators, and other STEM leaders; curated by ITEEA's Council for STEM Leadership (CSL)
- Teacher Educators (TE): most relevant to teacher educators and others interested in technology and engineering and/or STEM education research; curated by ITEEA's Council for Technology and Engineering Teacher Education (CTETE)

Don't miss a variety of other events happening this year in Minneapolis including awards for deserving educators, TEECA competitive events, vendor Action Labs, and even a Saturday morning STEM Yoga session!

ITEEA is thrilled to launch its Secondary STEM Council (SSC) to meet the needs of our secondary educators. Come meet the new SSC leadership team as well as representatives from each of ITEEA's Councils (Council for STEM Leadership, the Council for Technology and Engineering Teacher Educators, the Elementary STEM Council, and the Technology and Engineering Education Collegiate Association) at a special "Meet and Greet" event on Friday afternoon.

As you can see, there are a lot of great things happening at the 2023 ITEEA Conference! I cannot wait to see you there!

Debra E Shapiro

Debra E. Shapiro, DTE

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Cover: Intubation chamber working prototype staged on crash cart prior to hospital use. Photo credit: Anna Wan in Eagle Maker Hub.

on the iteea website

ITEEA Offering Authorized Teacher Effectiveness Coach Virtual Training May 19-21

ITEEA's Authorized Training Institute (ATI) develops T&E leaders to become certified Authorized Teacher Effectiveness Coaches (ATECs) in Engineering byDesign course(s). Current or aspiring Technology and Engineering (T&E) leaders are invited to take the opportunity to professionally grow in the STEM field, to be a leader in professional development for teachers, and to access further paid training opportunities as an ATEC with ITEEA. Those completing the training will receive 24 hours of professional development that can be used for certification and may be eligible to present on behalf of STEM CTL at the ITEEA Conference or at other future paid opportunities as well as obtain three graduate credits.

Full information and a link to register can be found at www.iteea.org/ati.aspx.

ITEEA Users Can Now Add Additional Demographic Information to Their Profiles

Additional Demograhic Information on user profiles allows ITEEA to share more tailored resources and news, reducing the number of emails you receive overall! Just follow these easy steps:

1. Navigate to https://portal.iteea.org/My-Account/My-Profile.
2. Under ITEEA Demographics, select your appropriate "Position" from the pull-down menu.
3. Click "save," and you're done!

stem education calendar

April 12-15, 2023
ITEEA's 85th Annual Conference
Minneapolis, MN
Learn it, Try it, Teach it!* STEL *Experiences to Advance Our Profession
www.iteea.org/ITEEA2023.aspx

April 25-May 4, 2023
VEX Robotics World Championship
Dallas Texas
www.roboticseducation.org/vex-robotics-world-championship/

June 28-July 2, 2023
National TSA Conference
A Legacy of Innovation
Louisville, KY
https://tsaweb.org/events-conferences/2023-national-tsa-conference

July 10-13, 2023
STEM Leadership Alliance Summit
Orlando, Florida
www.stemleadershipalliance.org/events

July 17-21, 2023
64th Annual VTEEA Conference
Hampton, VA
www.vteea.org/annual-conference

October 2-4, 2023
Technology Education New Zealand (TENZ) Conference
Expanding Possibilities
Ao Tawhiti Unlimited Discovery School, Christchurch/Otautahi
www.vteea.org/annual-conference

October 25, 2023
STEMATHON 2023
Ignite ▪ Innovate ▪ Inspire ▪ Imagine
Conference & Training Center at IU13 in Lancaster, Pennsylvania
REQUEST FOR PROPOSALS NOW OPEN
https://sites.google.com/iu13.org/stemathon/home

technology and engineering TEACHER

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stem education news

ITEEA Announces REACH Challenge Winners

Students from across the United States discovered recently that their REACH Challenge projects, which changed the lives of people with different abilities in their communities, have earned awards through ITEEA. REACH Challenge is an impactful Adaptive & Assistive Technology (AT) design-thinking project for middle school, high school, and college level STEM programs. Teachers are provided with lesson plans and activities on Empathy, User-Centered Design, Prototyping and more, to lead their students in using their STEM skills to REACH a member of their community who has a challenge to overcome. This innovative project shows students that they can use their STEM skills for social good, making a real-world difference in the lives of those around them. Read the full news release at www.iteea.org/221015.aspx.

ITEEA STEM Schools of Excellence to be Recognized

ITEEA recently announced the recipients of its STEM School of Excellence Recognition. ITEEA recognizes outstanding schools for their commitment to providing a robust Integrative STEM education program. As ITEEA School of Excellence winners, awardees will be honored at the Opening General Session at ITEEA's 2023 Conference in Minneapolis and receive a certificate and a banner to display in their school. ITEEA President, Debra Shapiro, DTE, shared, "I would like to congratulate each of our STEM School of Excellence Recipients for the 2021-2022 School Year. It is exciting to see so many schools being honored for their outstanding work in Integrative STEM! The addition of our College and University category gives us the opportunity to highlight the great work happening in post-secondary education in STEM! Congratulations and I look forward to all being recognized in April!" Read more at www.iteea.org/220219.aspx.

Newest 21st Century Leadership Academy Cohort Set

The 21CLA empowers dedicated educators to develop new knowledge and skills and become more effective leaders in the technology and engineering profession. Past Academy participants have included graduate students; early career university faculty members; elementary, middle, and high school teachers; and supervisors and administrators. Since its formation, the 21CLA has provided over 90 educators the opportunity to network with colleagues and peers, connect with and learn from established leaders, and participate in online and face-to-face leadership development activities. Congratulations to the following individuals who were selected from a competitive pool of applicants to comprise the 2023-2024 cohort: Natalie Crosby, Brent Curran, Barbara Dunham, Deidre Paris, Carol Unterreiner, and Tracy Young. Learn more about the newest cohort members at www.iteea.org/220996.aspx.

pandemic-transformed activities inclusive of remote learners

By Anna Wan and A. Dean Franks

The pandemic made clear that we no longer have the excuse to exclude students who cannot physically attend class.

This article shares the transformation of three activities; a boat float, acrylic sheet nets for heat bending, and modeling of repeated patterns for K-12 students within the makerspace pre- and post-small-scale pandemic manufacturing. For each task, the authors share the activity, explain the relationship to STEM education and how the activity ensures accessibility for all learners, and discuss the development due to pandemic needs.

Setting

Eagle Maker Hub (EMH) is a university makerspace at the The University of Southern Mississippi serving the university community and the public. It grew out of start-up funds to research teaching and learning of mathematics with digital fabrication. Before the pandemic, EMH focused on specifically teaching and learning of mathematics and science enhanced by engineering and technology. K-12 students, pre-service teachers, and in-service teachers were introduced to digital fabrication, coding, and engineering through informal and formal activities addressing mathematics and science content standards.

The selection of digital fabrication tools at EMH vary from hobbyist to entry level professional grade equipment to give the local public a wide range of options to access when making decisions based on their level of skill. The tools include vinyl cutters like Cricut, 3D printers, and laser cutters.

Additionally, the space's renovations were complete by December 2019 with updated equipment, electrical, and networking capabilities. People working at EMH during the time of COVID prototyping were the mathematics education faculty that started the makerspace; a shop technician with a background in mechanical engineering; undergraduate student workers in computer science, accounting, and psychology; polymer scientists at the Mississippi Polymer Institute; and the community at large.

Figure 1. Thermoform Machine with Sample Boat Mold

Activities

For each of the three activities discussed below, authors provide a description of the activity, information on how it meets STEM educational goals and inclusion goals, and how pandemic activities in EMH influenced the development of the activity.

Task 1A: Boat Float

One of many commonly used engineering design challenges is the tin boat float challenge where a boat is made out of aluminum foil and should float in water to withstand increasing weight—usually marbles. Since the pandemic, an extension was added to the traditional boat float activity by having students build a mold with LEGOs® for a thermoformed boat to then be tested in the water. First, they are shown what a thermoform machine does: heats the sheet of plastic above the mold, and when heated to the correct temperature, the heat-deformed sheet is draped over the mold and a vacuum is triggered to start when the mold is covered by the sheet. Figure 1 shows a thermoform machine with a sample boat mold. Students were allowed additional opportunities to test various models as time permitted and most had a boat that would carry a fair amount of weight by the third iteration. The boat design is limited by the size of the tray for the piece of plastic to be heat-deformed. The EMH machine had a forming bed size of 200mm x 200mm.

Task 1B: Relationship to STEM Education and Accessibility for All Learners

The additional challenge offered by thermoformed boat design tested students' abilities in spatial visualization and introduced the concept of negative mold making. Figure 2 shows a student testing their first boat design. The first test mold allowed students to test out what it meant to make a model and how it would work with thermoforming. With each iteration, students figured out how to position the LEGOs® to accommodate more marbles. Each iteration generally added additional layers within the confines of the plate size for the thermoformer. Figure 3 shows the three iterations of design by a single student.

The aluminum foil boat not only challenged students' engineering abilities, but also their ability to fabricate by hand, which can vary, though the foil boat activity can still be accessible to students with limited hand mobility. However, they will need to be paired with another student or have an adult help, who will allow the student to make their own design choices and make their own mistakes. This type of interaction models autonomy for students with physical disabilities and provides the helper with an opportunity to engage the student with empathy and respect. Students with disabilities receive the added benefit of working on communication skills as they describe their planned boat design to the helper in a way that ensures the outcome properly matches their plan.

With additional time and a little activity modification, the thermoformed boat exercise allows for students who would face difficulty using their hands to create their mold and the ability to develop models using 3D printing, providing agency for their design. If they are not able to access LEGOs®, there are options to 3D model assembled LEGOs® dimensions and share their design with the makerspace—allowing this activity to be conducted remotely. Tinkercad is a commonly used Computer-Aided Design (CAD) software for school-age students and is free and web-based, requiring no downloads or installations. For additional resources to get started with Tinkercad, see Wan and Ivy (2021) (www.igi-global.com/chapter/adding-a-new-dimension-to-teaching-mathematics-educators/215512) and Wan and Ivy (2019) www.tandfonline.com/doi/abs/10.1080/21532974.2021.1965506. The thermoformed boats are waterproof unless they exceed the dimensions that the melted sheet can handle or if molds have holes (the vacuum creates the hole in the plastic due to force).

Task 1C: Sample Standards Alignment

For Grades 6 through 8, STEL benchmark 1M directs: "Apply creative problem-solving strategies to the improvement of existing devices or processes or the development of new approaches" (ITEEA, 2021, 6-8 STEL-1M). Students will have the opportunity to build a number of models from multiple materials for both foil and plastic boats. After several trials and comparison of thermoformed boats to foil boats to discuss their best characteristics, students will demonstrate NGSS: MS-ETS1-3: "Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success" (NGSS Lead States, 2013, p. 74)

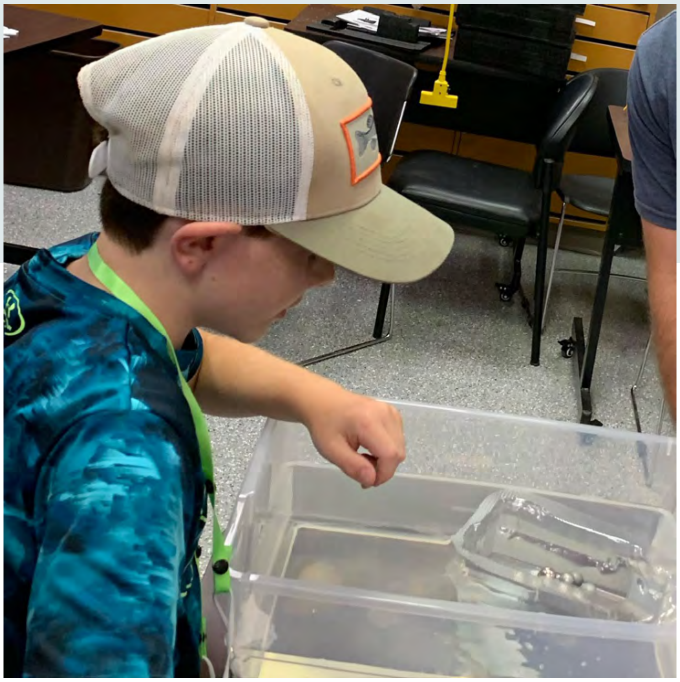

Figure 2. Student Testing the Boat

Figure 3. Three Iterations of Design

Task 1D: Development Due to Pandemic Needs

During March of 2020, two problems arose related to masks: medical professionals were wearing them longer than intended due to the number of COVID-19 patients and a shortage of N95 masks for medical professionals due to a rush on supplies by the general public. The team at EMH, with Mississippi Polymer Institute and the community, came together to solve this problem for the local medical professionals. The team saw thermoforming as a solution to the problem of rapidly producing personal protective equipment (PPE). The hobbyist-level thermoforming machine was less than $800 and each sheet was around $2, making it budget-friendly for small-scale manufacturing while avoiding the typical pitfalls of 3D-printed masks, including lengthy printing time, printing errors, and a lack of sanitization options. Thermoforming took no more than two minutes per mask, rather than the 4-6 hours required for 3D printing. Single sheets eliminated errors per layer of printing and a single wipe of sanitization cloth or dip into chemical solution could sanitize the entire mask (Berg, 2020). Pre-COVID, these machines were used in the makerspace for making chocolate and soap molds.

Task 2A: Acrylic Sheet Nets For Heatbending

This task asks students to develop a net, an unfolded 2D covering of a 3D object. Teachers can develop their own requirements for the students to build, but one task that has been found to be well suited to the students' needs and current understanding of concepts is a birdhouse. Similar to the traditional task, students will build a birdhouse, but with an acrylic sheet that is cut for the net of the three-dimensional birdhouse. Additionally, this task requires students to create the mold for the bending of the acrylic and instructions for construction of the final product. Most of the sides of the birdhouse would be painted or have wood paneling installed to protect the birds nesting inside the birdhouse, but one side of the acrylic can be left unpainted to be mounted to a clear window, allowing students to view the development of the bird family. The mold for bending and the net can all be modeled in Tinkercad. Generally, a 3D-printed mold will withstand 1-2 iterations of heat bending before it will deform. Students can also generate two-dimensional elevations for each side of the birdhouse mold to be cut from wood, taking into consideration wood joining for all the pieces being assembled together. Tinkercad can export as an .svg, the format for 2D cutting with a tool like a laser cutter. Figure 4 shows the net of a rectangular prism with a hole for the bird, The design can then be exported into a file that can be used with a laser cutter.

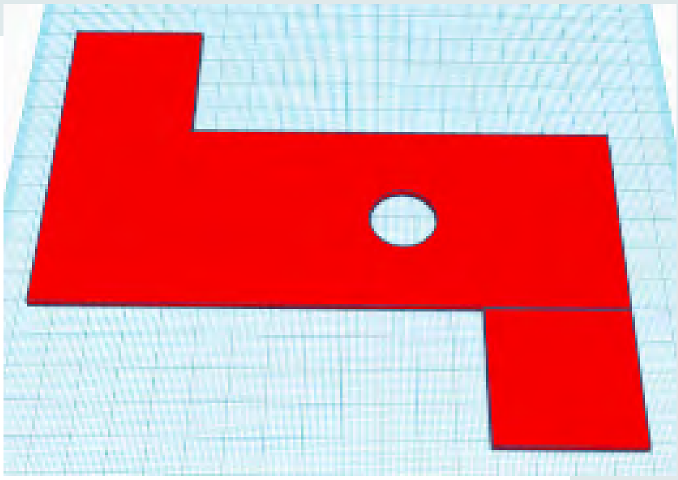

Figure 4. Sample Net of a Birdhouse

Task 2B: Relationship to STEM Education and Accessibility for All Learners

This activity relies on students' ability to use technology with 2D and 3D modeling, Earth and life science such as knowledge of birds and birdhouse needs, engineering to know material tolerances and margin of error, and mathematics for spatial ability and precise measurements. In addition, students will need literacy skills to be able to articulate the instructions for building through text as this activity can also be conducted remotely. None of the students will heat bend the acrylic, and college-age student workers have been excited to follow exact instructions as written by the birdhouse maker. Tasks leading up to this culminating birdhouse build activity would be a rectangular prism build with three different number dimensions where students first test their design for the mold, tolerance at the bends, and net making ability. Students learn more from a mold with three different dimension measurements than a cube. Digital fabrication makes this activity equitable for all students with access to a computer.

Task 2C: Sample Standards Alignment

It is expected that students will be permitted more than one iteration to achieve their desired birdhouse design and final product. The engineering design alignment to the *STEL* standards would include MS-ETS1-4 "Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved" (NGSS Lead States, 2013, p. 74). However, if the students were to take a more life science approach to look at the design of the birdhouse and the type of bird that would use it, the activity would align to MS-LS2-4 "Construct an argument supported by empirical evidence that shows changes to physical or biological components of an ecosystem affect populations" (NGSS Lead States, 2013, p. 63).

Task 2D: Development Due to Pandemic Needs

With a low supply of full COVID PPE, this project was developed in collaboration with a intensive care physician who performed multiple intubations daily. The intensivist needed a mostly controlled area, or "chamber," in which they could see each patient's airway to intubate, but include multiple access holes for additional staff as needed. The chamber also needed an easy way to fit it onto a "crash cart." Early available designs required gluing sides of the box, which, with repeated use, fell apart within days. The chamber was then constructed from one piece of acrylic with heat-bent edg-

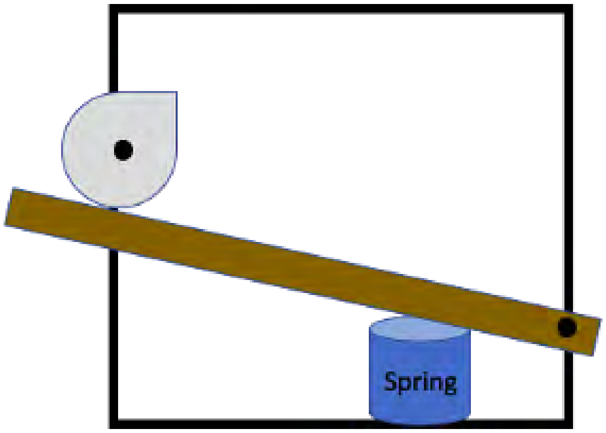

Figure 6. Sketch of 1:1 Pattern

es and included screws and adhesives at areas with less structural stress. Figure 5 shows one of the final designs, which was used in the hospital. Through hours of observation of the unit in use, it was determined that the majority of the stress occurred when shifting the unit on the hospital bed to better adjust for the constantly moving patient. Each user brought their own disposable sleeves that could be pulled over the hole flanges and lids were provided for the holes that were not in use.

Task 3A: Modeling of Repeated Patterns

The set up for this task requires a frame with a fixed point for a rotating cam. The camera is in constant contact with a lever attached to a fixed point a distance away from the cam, but forced upward by a spring. The goal is for students to create cams of different shapes to represent a lever movement in a 1:1 pattern, 1:2 pattern, 1:3 pattern, and so on. Figure 6 shows a simple sketch of the set up for a sample 1:1 pattern.

Task 3B: Relationship to STEM Education and Accessibility for All Learners

This activity is open-ended and developed to integrate STEM content as well as individual science, technology, engineering, and mathematics (STEM) content by modeling repeated patterns using a motor at the center of shape. Additional mathematical and/or science knowledge could be beneficial, but this activity is one with multiple points of entry. With the added benefit of tools for digital fabrication, students with physical disabilities can easily accomplish this task as well. Students can either 3D print the cam shape or cut from an exported .svg, both of which can be modeled in Tinkercad.

Task 3C: Sample Standards Alignment

For Grades 6 to 8, *STEL* benchmark 3F directs, "Apply a product, system, or process developed for one setting to another setting" (ITEEA, 2021, 6-8 STEL-3F). Students will have the opportunity to see and experience the cam functioning at the 1:3 ratio. They will research other applications for repeated patterns and apply the new ratios and cams to those scenarios. Observing and creating patterns is then aligned with *NGSS* MS-ESS2-3 cross cutting concept of Patterns, "Patterns in rates of change and other numerical relationships can provide information about natural systems." (NGSS Lead States, 2013, p. 70). The process of researching and writing other cam designs then is also aligned to CCSS ELA: ELA-Literacy.W.7.1, "Write arguments to support claims with clear reasons and relevant evidence."

Task 3D: Development Due to Pandemic Needs

Medical professionals requested that a simple machine be made using an Ambu bag (a bag valve mask used to deliver ventilation to a patient) readily available in ambulances for emergency situations—to keep a patient breathing as an alternative to ventilators as resources became scarce. The problem with Ambu bags is the need for a person to manually compress it for a second every 4 seconds, 1 second for inhalation, and 3 seconds for exhalation to mimic natural breathing at a paralyzed state. Many university makerspaces and professional designers answered this engineering challenge with microcontrollers to keep the 1:3 rhythm and manual buttons added to the microcontrollers to adjust for the strength of compression as needed. The anesthesiologist leading this team asked not to use microcontrollers if possible, as they would be a new device for his team to learn. The 1:3 ratio was modeled with a cardioid driven by a windshield wiper motor with 2 x 4s depressing the Ambu bag and a manual lever to move the location of the fulcrum to adjust for the pressure. Figure 7 shows the prototype with a cardioid as the shape of the cam.

Figure 7. Prototype with Cardioid

Lessons Learned

The pandemic caused a rapid pivot to online instruction for all educational entities. This experience taught educators to be flexible in how to better accommodate students working remotely. There was no longer any excuse to exclude students who cannot physically attend class. Additionally, many makerspaces had to rapidly pivot to online activities to continue functioning and, in many cases, to keep their funding. Fortunately, EMH stayed open for COVID PPE production as well as online instruction for instructors associated with the makerspace. Many of the tasks discussed in this article were immediately used in university-level content area coursework for mathematics and science, teacher preparation coursework, and informal activities with K-12 students and teachers remotely. In addition, the makerspace reopened in the summer of 2021 for summer camps while being able to also accommodate students who wanted to participate remotely in camp activities. These were the lessons that a PPE-manufacturing makerspace learned and how it adapted through the pandemic. For further resources on the PPE manufactured through the makerspace, visit www.usm.edu/computing-sciences-computer-engineering/eagle-maker-hub.php

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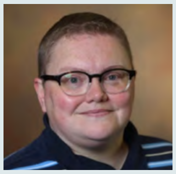
Anna Wan, Ph.D., *is an assistant professor of Mathematics Licensure and founding director of Eagle Maker Hub at the University of Southern Mississippi in Hattiesburg, Mississippi. She researches integration of digital fabrication and coding in teaching and learning mathematics. She can be reached at* anna.wan@usm.edu.



A. Dean Franks, Ph.D., *is an assistant professor of Elementary Education in the School of Education at The University of Southern Mississippi. Their research areas are STEAM education, disciplinary literacy, and social-emotional learning. They can be reached at* Dean.Franks@usm.edu.

This is a refereed article.

proposing accessible line standards

for tactile drafting accessibility for blind and low-vision students

By Wade H. Goodridge, Natalie L. Shaheen, Scott R. Bartholomew, and Anne Cunningham

Note: In this article, the authors use identity-first language (e.g., disabled person, blind person) rather than person-first language (person with a disability, person who is blind) to refer to blind and low-vision people as the community prefers the identity-first convention.

It is important to realize that blind and low-vision individuals hold jobs in the engineering and architecture fields and methods that help them communicate can have reaching impacts.

Introduction

Drafting, the process of creating a technical drawing, has been a staple of education and work—at all levels—for many years. Producing construction documents for houses, structures, tools, fixtures, and parts has largely included a drafting process as a means of communicating and locating desired features in the produced item. Specifically, drafting has been one of the major means of creating a "plan" to produce the majority of products in existence today. The process of drafting has changed significantly over time: from stone tablets to high-tech three-dimensional models and virtual walkthroughs. Advances in technology have largely given way to a transition away from hand-drawn drafting practices to computer-based practices (Madsen & Madsen, 2016; Lieu & Sorby, 2009). Engineering Design Graphic courses, in both hand-drawn, and computer-aided form have been taught for decades (ITEEA, 2007) but have had to evolve to keep up with technological innovations (Barr and Juricic, 1994; Jenison, 1997). Developments in CAD drafting programs, solid-modeling software, and CAD/CAM programs have drastically changed the drafting process and its subsequent instruction.

In conjunction with the shift away from hand-drafting to CAD, some efforts have studied differences in these approaches (Brandon & McClain-Kark, 2008; Ozkan & Yildirim, 2016); specifically, many of these efforts have resulted in arguments for an increased emphasis on the spatial skills of intuition, reasoning, and visualization, which are more effectively developed through hand-drafting approaches (McLaren, 2007). On that note, Seidler and Korte (2009) argued that the process of hand drafting requires more understanding of what is being drawn before beginning than CAD and Wilson & Parrott (2011) reported that, when surveyed, students preferred hand-drafting approaches over CAD if they had prior experience with hand sketching and drawing. While students have expressed interest in hand drafting and the associated benefits, CAD approaches include significant advantages in productivity and uniformity in drawings across the industry. As CAD approaches have largely replaced all hand-drafting approaches, they have also had a distinct influence on the overall design process and experience (Condor, 1999). For example, different solid-modeling software options have largely facilitated prototype design and testing in a virtual setting, resulting in a significantly expedited production process.

However, despite contrary opinions on the virtues of hand- and CAD-drafting techniques, one commonality remains: little has been done to facilitate access to drafting (either by hand or via CAD) for blind and low-vision individuals. This is unfortunate as technical advancements in this area could also feasibly facilitate access for this population. Further, an exploration of the usefulness and accessibility of hand- and computer-aided approaches to drafting for blind and low-vision students does not exist in the literature.

This article presents tactile drafting techniques developed in collaboration with blind educators and students that have the potential to increase BLV students' access to drafting and engineering graphic curriculum in K-12 and higher education. This work builds on previous work funded by the National Science Foundation (Goodridge et al., 2019; Ashby et al., 2018; Lopez et al., 2020; Goodridge et al., 2021a; Goodridge et al., 2021b) and it is the authors' hope that some of the practices included herein will allow BLV youth to further develop technological and engineering literacy in related technology and engineering graphics courses.

How Many Individuals Could This Approach Serve?

Within 55 countries, there are approximately 37 million individuals who are blind and 124 million who have low vision (Fostner & Resnikoff, 2005). The United States Individuals with Disabilities Education Improvement Act of 1990 (amended in 2004) requires full access to education for students with disabilities, including blind and low-vision students, but there is still a significant lack of accessible learning opportunities for these individuals in many STEM areas (Beck-Winchatz & Riccobono, 2008; Rule, Stefanich, Boody, & Peiffer, 2011). The authors see this as a significant lost opportunity and, using 2015-2016 figures investigated by the National Center for Education Statistics (NCES, 2019), which noted 18% of the total bachelor's degrees awarded in the United States in STEM areas, there are nearly 6,660,000 BLV individuals who may have STEM interests if provided the opportunity.

Expanding the Curriculum by Taking a Step Back

The drafting techniques (hand-drawn and computer-aided) taught in drafting classes are largely confined to visual conventions. Conventions that assume that both the drafter and the audience are sighted—an assumption that does not hold for all potential students. Hand drafting offers techniques that are more readily adaptable to methods that are accessible to BLV populations.

Blind and low-vision people create and read drawings (and other spatial representations such as charts and figures) tactually with their fingers, just as they read Braille. These tactile representations, called tactile graphics, utilize raised lines, textures, and Braille to render all of the information that sighted people perceive visually (see Goodridge et al., 2019). To draw tactually, recent work has enabled blind and low-vision people to draw by hand using a tactile drawing board as seen in Figure 1. These boards have a rubberized surface that causes the paper (or other drawing material) to pucker and form a raised line as the person draws using a pen or stylus.

Like sighted people, blind and low-vision people use computers to do a variety of daily tasks (e.g., search the internet, communicate, write code). Unfortunately, a great deal of technology is built on the faulty assumption that everyone is sighted and, consequently, render those interfaces inaccessible to blind and low-vision people. Inaccessible technologies abound in U.S. K-12 education, from websites and standardized tests to eBooks, thereby excluding

Figure 1. Tactile Drawing Board

Figure 2. Manual Tactile Drawing Tools

blind and other disabled students from critical learning (Shaheen & Lohnes Watulak, 2019). While CAD and solid modeling software remain inaccessible to BLV students, the development of manual tactile drawing tools provides an opportunity for hand-drafting techniques to be utilized as an accessible option for blind and low-vision students (an example of these tools, such as Braille calipers and a tactile ruler is shown in Figure 2). Similar efforts have been seen in industry when architects have tried to communicate designs with BLV executives during renovations (see Figure 3).

Considering the prevalence of drafting courses in middle and secondary education, and the fact that most BLV students attend public schools, it is probable that a K-12 technology and engineering teacher may have a handful of blind students over the course of their career. Fortunately, the recent development of tactile drawing methods could begin to bridge such a gap and create a medium through which BLV students can learn about engineering graphics (Goodridge et al., 2019) This work continues and as presented herein, new suggestions around tactile drawing lineweights and linetypes may be an effective way for communicating technical material through touch. In essence, the authors, suggest that technology and engineering teachers consider *including* in their pedagogy—an intentional step to more traditional and tactile hand-drafting methods to accommodate any BLV students and let those who will be professionals in this area become familiar with

Figure 3. Raised line floor plans (white) and tactile 3-D model of rooms

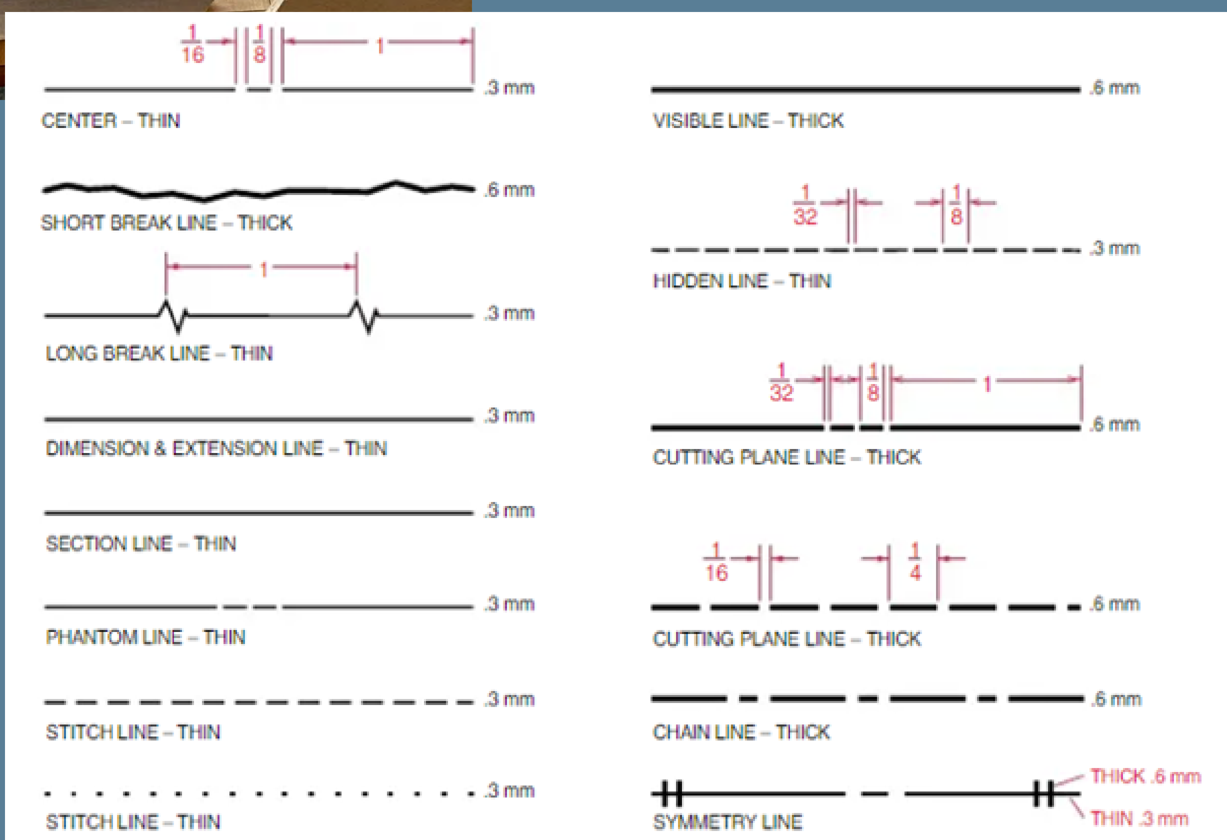


Figure 4. The Alphabet of Lines from Bertoline-Wiebe (2006).

the standards that the BLV community may use. The authors seek to provide suggestions and techniques that can help an educator accommodate a more diverse range of students in their drafting course. Historical drawing methods are more readily adaptable than more current CAD methods for tactile interpretation. The technology to implement such drawing techniques need not rely on needed computer accessibility but can leverage traditional means for a more immediate solution. This is not to say the authors are arguing against CAD or other technologically centered drafting practices as they are currently taught; rather, the authors are trying to provide tools and techniques that can lend themselves to being more accessible and adaptable and that may help diverse students develop technical literacy. These hand-drawing methods are envisioned to be implemented in instruction with a BLV student to allow them to develop skillsets and attributes that competency in engineering drawing can provide. Their use can open doors to a BLV student that typical CAD software may not allow to open. These techniques may also be of interest and benefit to sighted students *in addition to CAD and other techniques already in place*. The authors recognize that intentionally using *both* hand-drafting and CAD approaches in classrooms will not necessarily be detrimental should that route be chosen (e.g., while advances in technology have largely given way to a transition from hand-drawn drafting practices to computer-based practices (ITI, 2020), research into the CAD or hand-drafting approaches' effectiveness in teaching engineering graphics knowledge (e.g., hand-drafting and CAD) to sighted students is inconclusive); as an example, Brandon & McClain-Kark (2008) used 40 interior design students to investigate the differences in the two approaches (hand vs. CAD) in terms of overall design merit. Their results showed no significant advantage of either approach over the other. The authors also recognize the inherent advantages of CAD over hand-drafting in terms of the ability to rapidly reproduce lines faster, easier, and of higher quality; nevertheless, they acknowledge that there may be value in including both approaches—especially when a diverse student population in the class is present and communication with a diverse community may present itself to our future technologists and engineers. Unfortunately, BLV students are often prevented from engaging with CAD approaches due to inaccessible interfaces, which presents a loss of a significant opportunity to develop technical literacy.

Groundwork for a movement towards including *both* CAD- and tactile hand-drawing approaches, or implementing tactile hand-drawing approaches alone, begins with an investigation into, and an establishment of, linetypes and lineweights that are tactually interpretable through touch by BLV students. The authors present here some initial findings around the tactile interpretability of given linetypes and lineweights typically associated with engineering graphics coursework. The American National Standards Institute (ANSI) has typically dictated appropriate standards of lineweight and linetype to provide uniformity in drawing practices across the industry. Students introduced to drafting and engineering graphics must master these lineweights and linetypes to communicate efficiently amongst their peers and colleagues. A summary of these standards, found in Bertoline-Webb (2006) is seen in Figure 4.

Adapting these Lineweights and Linetypes

Tactile interpretation of linework on a tactile drawing presents an interesting dilemma as the affordances and limitations of visual perception differ from those of tactual perception. The linetypes and lineweights that are easily discernable visually are not always discernable tactually. With some initial investigation conducted at National Federation of the Blind programs and training centers, the authors present a discernable structure for BLV students to interpret via touch. Future research is needed to continue to validate and refine linetypes and lineweights that are tactually advantageous to BLV students.

The article is not suggesting a change in original ANSI line standards, but it is rather offering a separate set of standards to be used when rendering drawings in a tactile format for BLV students. This suggestion is made so that BLV students can better communicate engineering design and develop a sense of technical literacy. It is recognized that teachers will have to expand their knowledge base to include these standards, but their inclusion can enhance

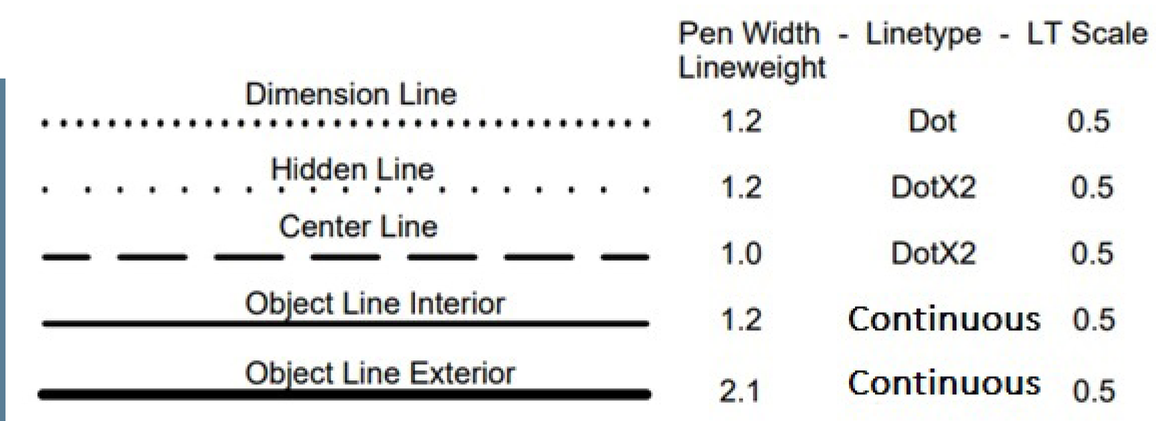


Figure 5. Initial Lineweight and Linetype recommendations for the BLV Drafting Student

accessibility for the BLV students that they may find in their courses. Figure 5 presents these newer tactile lineweight and linetype recommendations; in summary, two continuous linetype object lines are presented with a recommendation that 1.2 mm pen width be used for object lines for features interior to the object lines used to describe an object's perimeter. This allows tactile interpretation for transition between features seen within the view as opposed to those that establish the edges of the object as seen from that particular vantage point (front, top, R-side). The exterior object lines are suggested to have a lineweight of 2.1 mm. It has been observed that this allows the BLV student to discern that they are on the outside edge of a view rather than an edge internal to the view. This convention accounts for the methods by which tactile perception and nonvisual learning occurs—namely part-to-whole. The heavier external object line makes it easy for one to identify the boundary of an object tactually. Center lines are recommended to have a pen width of 1.0 mm and a DotX2 linetype in AutoCad. AutoCAD drawings may be produced and then developed into tactile graphics for BLV student interpretation. The steady size dashes available with this linetype are easier for the BLV student to track moving through an object to then locate a curve or circular feature. Hidden and center lines are recommended to maintain a 1.2 mm pen width and a Dot linetype for hidden lines and a DotX2 linetype for center lines. The reader will also note a significant increase in lineweight, which makes finding and tracing lines by touch much easier. The LT-scale found in the AutoCAD software is recommended to be set at 0.5 but is certainly adjustable by small amounts if needed.

The authors provide a simple multiview drawing using these BLV line standards (see Figure 6), which allows the reader to see the application of these five linetype and linescale recommendations as they present themselves in a typical engineering drawing. Technology and engineering teachers are encouraged to develop additional drawings for their instructional purposes using these initial BLV line standards. Additional work is currently in development investigating best practices concerning the line standards for other typical drafting lines not yet investigated with this work.

For the convenience of non-Braille readers, dimensions are provided in print. To make this drawing accessible, the lines must be raised and the dimensions provided in Braille. Raised lines can be made manually using tactile drawing tools or digitally using a Braille embosser or microcapsule paper and fuser. Both the manual and digital tools should be available to teachers through school districts' blind and low-vision services, usually part of the special education department.

Within Autodesk's AutoCAD software, setting the linetype, lineweight, and LT Scale standards through the layers interface allows linework to be visualized in model space and plotted via paper space. Some LT scale adjustment may be possible if needed, but it is recommended that it be informed by a BLV student or instructor regarding its tactile interpretation.

With a manual application on a tactile drafting board (Goodridge et al., 2019), spacing between dashes and dots should be close to 1/8 of an inch for center and hidden lines and 1/16 of an inch for

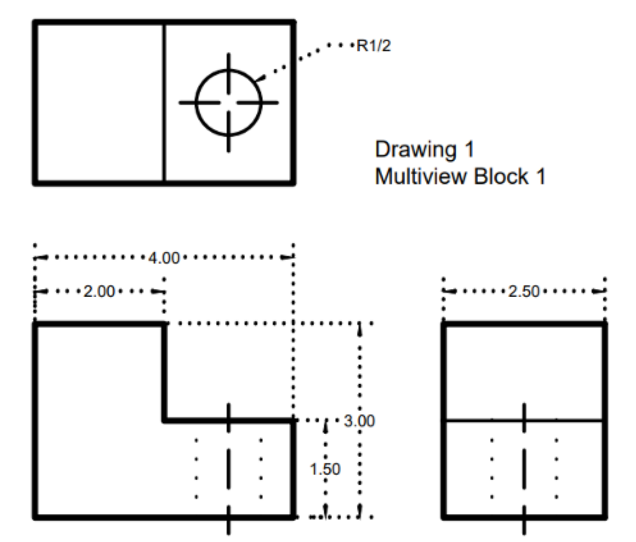


Figure 6. Simple author-created multiview drawing using recommended BLV line standards

dimension line dots (see Figure 5).

Conclusion

The authors hope an opportunity exists for technology and engineering education instructors—at all levels of education—to consider their approaches to teaching drafting. Specifically, the authors advocate for the implementation of these new tactile drawing standards and techniques when a technology and engineering teacher finds themself needing to offer a more accessible curriculum to a BLV student. There is a hope that providing these methods can open a door to technical literacy for the BLV student that may not currently be present. Additionally, the authors also suggest teaching these techniques along with traditional ones in a class so that the class itself and the future work environment can be diversified and provide a means of communication between BLV and sighted peers. Finally, the authors present a lesson plan centered on this opportunity and encourage teachers to review it with a lens of consideration around how their own plans, practices, and approaches may be expanded and improved.

Acknowledgements

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Tactile Multi-view Drawing Development

Description: This activity will allow BLV students to experience multi-view drawings of simple introductory 3D solids similar to those taught in sighted drafting coursework. The BLV students will use an accessible drawing board, triangles, ballpoint pen, and braille caliper to create the drawings. They will either interpret a provided simple 3D solid or a snap cube-constructed model to then develop a front, right side, and top view of the object. Their drawing will be interpretable by another BLV peer through the sense of touch. Reversing the process to require a student to tactually interpret a multi-view drawing and then construct a snap cube model is also recommended. Students should also be taught how to scale drawings in this process.

Table 1. Multi-view Drawing Rubric

Item	Description	Pts Possible	Total
Front View	Present and tactually interpretable	12	
Top View	Present and tactually interpretable	12	
R.S. View	Present and tactually interpretable	11	
Views Align	Views should align correctly and be placed in appropriate locations on the paper	5	
Linework	Distinct and uniform tactile impressions from the ball point pen, fine and medium point. Dashes present on hidden, phantom, and center lines. Fine ballpoint pen used for these lines as well as object lines. Medium ball point pen used for object lines.	15	
Object lines	All required object lines present to describe features, made with fine tip ball point pen, Both continuous line types present (Figure 5).	5	
Hidden Lines	All required hidden line present to describe features, made with fine tip ball point pen, dotted linetype Hidden Linetype (Figure 5)	5	
Center Lines	All center lines present to locate features, made with fine tip ball point pen, short-dashed center line type (Figure 5)	5	
Border Lines	Border lines present to frame picture, made with medium tip ball point pen, heavier continuous Linetype (Figure 5)	5	
Title Block	Appropriate title block present with Braille information (detail is subject to instructor's discretion)	10	
Dimensions	All dimension linework desired by instructor is present, drawing with fine tip ball point pen, includes extension lines and dimension value in braille, dotted linetype Dimension Linetype (Figure 5)	10	
Notes	Any required notes present in braille format.	5	
TOTAL		100	

Table 2. BLV Multi-view Drawing Activity

Lesson Purpose:

In the lesson, BLV students are engaged in learning to develop tactile multi-view drawings requiring an understanding in 3rd angle projection, drawing layout, dimensioning, line weight and line type, and the mastery of tactile drawing instruments. Newer tactile lineweight and linetype standards are suggested. We believe this lesson provides an opportunity for BLV students to engage in a drawing process that can inform them of the ways that engineers, designers, and technologist communicate.

Lesson Duration: 1 week (Five 45-minute class periods)

Engineering Core Concepts and Sub-Concepts:

- **Engineering Design – Engineering Graphics**
  - Engineering Drawing
- **Measurement and Precision**
  - Measurement Instrumentation
  - Accurate Layout and Precision Measurement
- **Manufacturing** (Possible on Instructors Discretion)
  - Design for Manufacture

Global or Local Issue: Accessibility in STEM education is a priority for all educators and their students. Additionally, as students need to become proficient in typical communication mediums used in TEE, this lesson attempts to address the issue of an instructor with a blind or low-vision (BLV) student who is desirous of having opportunities to learn the fundamentals of engineering graphics.
Connected STEM Standards: Standards for Technological and Engineering Literacy ▪ *Standard 7:* Design in Technology and Engineering Education ▪ *Practice 3:* Making and Doing ▪ *Context 6:* The built environment Mathematics ▪ Practice Standards o PS.4: Model with mathematics. o PS.5: Use appropriate tools strategically o PS.6: Attend to precision
Learning Objectives: ▪ I can create a multi-view drawing following 3rd angle projection techniques that will describe a simple 3D solid. ▪ I can demonstrate my knowledge of line type and line weight to begin to develop methods that will allow me to tactually communicate design to peers.
Enduring Understanding(s): ▪ Rules and principles of graphical communication are used to convey attributes of solid objects
Driving Question(s): ▪ Why is it important to communicate designs? ▪ What is the purpose of a multi-view drawing? What is the advantage of conveying information using a multi-view drawing over a pictorial drawing? ▪ Why are the views laid out on paper the way they are in a multi-view drawing?
Career Connections: There is a wide variety of careers and professions associated with multi-view drawings and engineering graphics. Knowledge to be able to communicate designs capable of spanning a BLV and sighted medium can be important in opening venues to jobs in architecture, civil, mechanical, aerospace, biological, environmental engineering, drafting, and manufacturing. It is important to realize that blind and low-vision individuals hold jobs in the engineering and architecture fields and methods that help them communicate can have reaching impacts.
Required Student Prior Knowledge and Skills: Integration of students' prior knowledge is critical in any successful lesson. In order to successfully build upon their knowledge, the following concepts are expected to be understood prior to beginning this lesson: ▪ Mathematics o Produce and analyze diagrams o Draw and identify lines and angles o Ability to convert between units of measurement o Ability to scale ▪ Engineering/Technology o Ability to choose correct tools for given task o Proper use of rulers and other measurement tools

Tools / Materials / Equipment

The following is a list of materials and equipment necessary for successful delivery of this lesson plan:

- Drafting table with rubber surface and parallel edge
- 30/60/90 notched triangle – notched by instructor
- 45/90 notched triangle – notched by instructor
- Fine and Medium tipped ball point pens – purchased at nearby Walmart
- 3D Drawing Objects – create by instructor
- Tactile Ortho Cube – created by instructor
- Snap Cubes – purchased on Amazon
- Braille Caliper – purchased from the National Braille Press

Daily Plan

(Times can be variable based on the prior knowledge and adaptive skills of the student)

Day 1: Familiarization with the Tools

1. Familiarize BLV students with using a Braille caliper to measure an object and let them measure some objects. (10 min)
2. Familiarize the BLV student with the tactile drawing board, parallel rule (edge), and triangles. (12 min)
3. Familiarize the BLV student with drawing a line so it indents upon the paper. (3 min)
4. Introduce the new suggested hidden, object, and centerline line types and have student practice them (10 min)
5. Familiarize the BLV student with some simple objects they will draw. Let them feel the objects and interpret them. (5 min)
6. Familiarize the BLV student with feeling the line they have drawn. (1 min)
7. Let the BLV student experiment drawing more lines and ask them where they need help (4min)

Day 2:

1. Ask the BLV student to draw two parallel lines. (2 min)
2. Ask the BLV student to draw a centerline, object line, and hidden line across the page 5 times for each. (10 min)
3. Ask the BLV student to draw a square (any size). (5 min)
4. Ask the student to draw a rectangle measuring 5 inches on its base and 3 inches on its height. (8 min)
5. Ask the BLV student to draw a 1-inch by 1-inch square inside the rectangle and at its center. (10 min)
6. Ask the BLV student to draw a 6-inch by 4-inch right triangle. (8 min)
7. Ask the BLV student to reflect on their work today and assess it. (2 min)

Day 3:

1. Introduce BLV students to the Tactile Ortho Cube made of plexiglass that surrounds some 3D solid mounted on the dowel in the middle (Goodridge et al., 2019). Use the Tactile Ortho Cube to let students feel how views of a certain feature of the object project to its surfaces. Pay particular attention to projecting features to the Top, R-Side, and Front of the cube. (15 min)
2. Unfold the cube on its hinge points to show the BLV student how the multi-view projections drawings are developed from a 3rd angle projection technique. (5 min)
3. Replace the Tactile Ortho Cube, place a new simple 3D solid inside, and have the student identify if that solid matches a previously prepared tactile graphic that the instructor created. (5 min)
4. Place a new 3D solid with a hole in it within the Tactile Ortho Cube and ask students to locate linework on appropriate views describing the hidden features of the holes. (5 min)
5. Hand out a multi-view drawing of an object along with the 3D model and ask BLV students to reproduce it. Coach them on using the instruments to do so. You will develop techniques with them that are highly individualized so think about how to help them locate the start of a line or its end and how to bring the instrument to that point to begin to develop a new line from it. (13 min)
6. Ask the BLV students to reflect on their work today and assess it. (2 min)

Day 4:

1. With the BLV students, develop one simple snap cube model (at least 4 pieces) and have them draw a multi-view drawing of the object. (10 min)
2. Discuss with the BLV student how to choose a most characteristic side to set as the front view. (2 min)
3. Ask the BLV student to make two more snap cube models requiring at least 6 pieces in their construction. (10 min)

4. Ask the BLV student to draw both of these models as a multi-view drawing. (21 min)
5. Ask the BLV student to reflect on their work today and assess it. (2 min)

Day 5:

1. Discuss the concept of scale with the BLV student. (3 min)
2. Hand the BLV student a simple model of an object and have them draw it at full scale. (10 min)
3. Have the BLV student repeat the multi-view drawing of the object at ½ scale. (10 min)
4. Hand the BLV student a 3d Object and have them use the braille caliper to measure features and tell you what they should draw their size as in a ½ scale drawing. (10 min)
5. Have the BLV student draw a multi-view drawing of a snap cube object that they can then build themselves. (10 min)
6. Ask the BLV student to reflect on their work today and assess it. (2 min)

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Wade Goodridge, Ph.D. *is an associate professor in Engineering Education at Utah State University. He conducts research in Spatial Cognition, Accessible Curriculum, and Professional Development and he is the lead research on a NSF AISL award that develops and enhances engineering curriculum for Blind and Low-Vision students. He can be reached at* wade.goodridge@usu.edu.

Natalie L. Shaheen, Ed.D., *is an assistant professor of Low Vision and Blindness at Illinois State University. Dr. Shaheen's research focuses on equity and access for disabled students in technology-mediated K-12 learning environments. She can be reached at* nlshaheen@gmail.com.

Scott R. Bartholomew, Ph.D. *is a former middle school teacher who works with teacher education students at Brigham Young University. He and his wife Julie are the proud parents of five children and love living in the mountains of Utah.*

Ann Cunningham *has accessible works of art in public and private collections across the U.S. She has taught tactile art classes at the Colorado Center for the Blind for 23 years and is now focusing on making embossed picture books for toddlers to begin their journey to literacy on a more level playing field with their sighted peers.*

This is a refereed article.

the legacy project:

Donald Maley, DTE

By Johnny J. Moye, DTE, Thomas R. Bell, DTE, and Richard P. Bray, DTE

Many industrial arts, technology education, and now technology and engineering education leaders have made their mark on our profession. Their legacy is something that members of the profession enjoy and have a responsibility to continue and build upon.

This is the 22nd in a series of articles entitled "The Legacy Project." The Legacy Project focuses on the lives and actions of leaders who have forged our profession into what it is today. Members of the profession owe a debt of gratitude to these leaders. One simple way to demonstrate that gratitude is to recognize these leaders and some of their accomplishments. The focus in this issue will be on Dr. Donald Maley as remembered by three of his colleagues.

Dr. Donald Maley

Professor and Head, Industrial Education Department, University of Maryland

Place of Birth:

Buena Vista, Pennsylvania

Degrees:

Bachelor's degree with a major in Industrial Arts from California State Teachers College (1944)

Master's degree (1947)

Doctorate degree (1950) in Industrial Education from the University of Maryland

Occupational History:

Occupational History: Dr. Maley held various positions during his lifetime including Foundryman/Musician (1936-1940), Teacher (1943), PT 106 - Ensign/Executive Officer/Captain (1943-1945), Instructor (1946-1951), Associate Professor (1951-1953), Professor (1953-1957), Professor & Chairman (1957-1974), Acting Dean (1974-1975), Professor & Chairman (1975-1987), and Professor Emeritus (1987-1993). Dr. Maley was internationally known for his innovation in Technology Education and Vocational-Technical Education (Zoominfo, 2009).

Donald Maley (1918-1993) was certainly a product of the times in which he lived. Those were times when the great industrial revolution was going full speed ahead, when our nation was in one of the great wars of all time, and when the nation was positioned to be a world leader for generations to come. He was the son of a coal miner in western Pennsylvania just outside of Pittsburgh with five siblings who became outstanding in their own occupations. The Maleys were a strong family, products of challenges and opportunities that shaped their lives. In turn, they were able to touch the lives of many others through their work. The family included hard working community- and nation-builders, and with a strong sense of commitment to help others through their work. Each family member was known for trying to do their very best in whatever they attempted to accomplish.

The Maley siblings lost their father to black lung disease due to his occupation as a coal miner. The loss left their mother with six small children to raise in Buena Vista, Pennsylvania. They lived in a small, four-room floodplain house on the banks of the Monongahela River. When the rains came and flooded the riverbanks, the Maley house flooded. The family carried their furniture to the second floor and then traveled up a hill to a neighbor's house to stay until the river receded. The family would then return home and scoop the mud out of the house, dry it out, and eventually move their furniture downstairs until the next flood threatened them. The family lived in that house until the children became adults and moved on with their lives. The neighbor who so graciously let them stay in his house willed the house to Mrs. Maley upon his death so that she no longer had to worry about the floods. These times and challenges did a lot to shape the kind of person that Donald Maley eventually became.

School was important to the Maley family, and teaching was a highly respected occupation. Donald attended McKeesport Technical High School, which today might be known as a vocational or career and technical education school. Upon graduation, he worked for five years at the Fort Pitt Steel Castings Company in McKeesport, accumulating enough money to attend college. His major occupation was steel mill work where he became a pattern maker. This hard work in a dangerous occupation helped to make him into an even stronger person.

Maley never played golf, but he caddied at the local golf course on weekends to make extra money. He worked for tips, and if he had a good day, judging by the amount of tip money, he would allow himself one nickel to buy an ice cream cone on the walk home. That became the reward he would continue to give himself and others after what he judged to be a good day.

Maley's beginning college experience was one to remember. He traveled to California, PA to enroll at California State Teachers College (CTSC). The college was small, with only a few buildings that included administrative offices and classrooms in the same location. He went to the registration office and was told by the registrar that he could not attend college because he had not gone to the right high school in preparation. Maley became very angry and loud in his response to this news because he had worked five hard years to make enough money to get an education. He was so loud that the college president came into the office to find out what was happening.

The president discovered what Maley had done to finance his planned college education. The president asked Maley what he planned to study or have as a major. Maley replied that he thought he would study business. The president asked if he had ever considered being an industrial arts major. Maley responded that, if he was allowed to attend the college, he would become an industrial arts major. This marked the beginning of Maley's journey to becoming a major player in the industrial arts, technology/engineering education fields for the rest of his career.

The president ensured that Maley had a room and one meal a day at the boarding house next to the college. Maley responded by taking a course overload each semester that resulted in his graduating with honors in three years. He was not present for his college graduation. World War II was in full force, and Maley was already assigned to a PT boat in the South Pacific. Due to his diligence and intelligence, he became Captain of that boat before the war's end. The college president invited Maley's mother to walk across the graduation stage to accept the diploma for her son. As the war and his naval career neared its end, Maley was assigned as a medical hospital administrator. He was deeply influenced by his naval experiences, which served him well during his career.

Maley left the navy to attend the University of Maryland for both his masters and doctoral degrees. He was fortunate to arrive at Maryland when Dr. R. Lee Hornbake (also a CSTC graduate) was beginning a long and very respected career. He was Maley's mentor for the rest of his life. Hornbake eventually went on to become Vice President of Academic Affairs, and today the Hornbake Undergraduate Library bears his name because of his dedication and excellence at the university. Hornbake received his doctorate at The Ohio State University studying under Dr. William E. Warner, a noted professional of the time. Warner started Epsilon Pi Tau and the American Industrial Arts Association (AIAA). The two organizations were known for their leadership capabilities. AIAA is known today as the International Technology and Engineering Educators Association (ITEEA).

Warner was also known for his philosophy to include industrial arts as a part of general education, not just subordinate to vocational education. Warner had studied under John Dewey at Columbia University when Dewey was promoting and became famous for his "learning by doing" philosophy. Emphasizing the learning by doing philosophy made Warner a hero in some camps and disliked in others.

Hornbake influenced Maley's philosophy that promoted the qualities of industrial arts as being a part of both a solid general education and a strong place to gain the beginning skills for a vocational, career, or technical education. Hornbake had the ability to attract outstanding graduate students to the university. Hornbake's graduate students and Maley's classmates included Dr. Stanley Drazek, who later became the Vice President of University College at Maryland when it had courses taught in U.S. military bases around the world. Another student was Dr. Walter B. Waetjen, Vice President of Research at Maryland and later President of Cleveland State University for over 18 years. Waetjen was known for implementing Maley's "Group Project" ideas into junior high inner city Philadelphia schools through industrial arts classes that he taught. Hornbake and Maley's fellow graduate students had a lot to do with shaping the philosophy that he espoused for the rest of his career.

As Hornbake rose through the university administration, Maley became Department Chair in Hornbake's former position. Maley would hold that title for the rest of his career, leaving only to assist the university as Acting Dean of the College of Education. He always returned to the field and the position that he loved most. His career at Maryland provided educational leadership that lasted over 47 years.

A resumé of his many educational activities notes more than 160 articles, speeches in print, six movie productions, and thousands of speaking engagements that included dedications of new facilities or colleges, graduation ceremonies, and philosophical directions—each promoting industry and technology education in some way. People attending a Maley presentation got their money's worth whether it was a speech, class session, or any other type of presentation. Most often, his presentation was available in written form. He believed that listeners would implement more of his ideas if they had the actual material in writing.

Maley became a leader within the industrial arts (and later technology education) profession because he had a vision and direction for the field. Many of his writings, over decades, outlined a profession that would lead education through human growth and development characteristics, the basis for his ideas. Maley's philosophy led to his development of junior high/middle school courses. He titled them *The Anthropological Approach*. This approach used the history of industry and technology as a basis for content in his program. He later developed a high school program that became known as a *futuristic approach*. This approach used the study of advanced technology to solve major technological problems facing society. Using woods, metals, and drafting technical labs, students learned the skills used in industry and technology.

As Maley promoted his ideas about industrial arts/technology education, he was also a recognized leader in the vocational education community. He was known for *The Cluster Concept Approach* to vocational education (Maley, 1975). His ideas were outlined in a book he published with that title. Much of his work can be found in the ITEEA Archives.

Maley's name became synonymous with *The Maryland Plan*, a Grades 7-12 curriculum for industrial arts/technology education based on human growth and development concepts (Maley, 1973). The leading major university departments of the time advocated unique programs to advance their professional philosophy. The philosophies became the reason that graduate students might be attracted to a particular department and program. Maley's *Maryland Plan* was as well-known and competitive as any during those times and attracted outstanding doctoral students nationwide and later worldwide. His department eventually produced over 100 doctoral graduates and thousands of undergraduate and graduate students. Three of those graduates became university presidents. Many others became university deans, department chairs, association executives, Department of Education leaders, as well as other leadership positions.

He was known for promoting his philosophy and profession in any way possible. He was very much a humanist in that he cared deeply for each of his students, encouraging them to exceed their current achievements. He was more interested in their success than he was in his own. He would call his students his "boys" or "girls" and would speak of them with great pride. He exhibited this pride at conferences where he would introduce his students to the leaders of the profession, bragging of their qualities. His students often could not believe how much he cared for them, promoting their careers. Back in the department, he constantly urged them to be even better, but outside the department they could do no wrong.

Maley's sayings were a big part of his teachings, which shaped the philosophy of his students. One example is, "It is not what the student did to a project, but what the project did for the student." He professed that "Teaching starts with the interests and needs of the student to make their education more meaningful." He encouraged industrial arts to be a strong part of general education for ALL students. He also noted that "Students should not be limited to what the teacher knows but have teaching structured so that students are guided to go beyond their teacher's knowledge."

Maley's philosophy and curriculum required teachers to understand human development concepts. Implementation of these concepts in the classroom required an average or better teacher. His curriculum also offered the profession a step beyond the teaching of woods, metals, and drafting, the main technical courses of the time. Maley had his students study the use of technology to solve major societal problems facing humankind. He wanted his students to know about technologies related to manufacturing, construction, power generation, waste and junk disposal, energy, communication, and more. Studying the history of technology was part of Maley's *Anthropological Approach*. His *Research and Experimentation Approach* was one of a kind in the profession. It was unique in the way it attracted gifted students to use the scientific method to solve problems.

The influence of *The Maryland Plan* spread throughout the United States as graduates became leaders in school systems and teacher education institutions. The strongest influence was in the State of Maryland. Incidentally, Maley did not give his program a name. Others referred to his work by referring to it after the university and state where it was created, tested, and implemented.

However, the strongest implementation of his program was in the country of Greece. At one time, it was a requirement for all middle school students. One of Maley's Greek doctoral graduates became a member of the Greece national education body and was influential in making *The Maryland Plan* a country requirement. Greece also sent a student delegation to study with Maley to learn his philosophical ideas. Many of Maley's publications were translated into Greek during this period of history.

Maley was a tireless worker. He never took a vacation, but he did go to his Severn River, MD cottage during the weekends to relax and enjoy boating. He would sleep on the boat deck, which reminded him of his navy experiences.

Maley exhibited all the desired qualities used to describe a real gentleman. He was trustworthy, ambitious, supportive, rich beyond money, and courteous. He could outwork his entire faculty simply because he worked around the clock. He was fond of asking his students "What are you doing at midnight tonight?" The response was usually, "nothing" or "sleeping." The question usually came after he had requested something to be done. He would say that "We'll have plenty of time to sleep after we die." His professional production was phenomenal in an era before computers were available. At one point, in addition to teaching, he was responsible for and supervised over 75 people working in the building or department.

Few people on the University of Maryland campus had the political power that Maley acquired over the years. It may have helped that his close friends were classmates and Vice Presidents of the university. However, he had political relationships that were far beyond the university. For example, he was once President of the Maryland Parent-Teacher Association and served on various education-related committees around the state. He acquired funding from then-Maryland Governor Mandel and state legislators to renovate and expand his department's building. Maley accomplished this in a year when no other building funds were appropriated through state legislation.

His stature within the field of education resulted in his receiving almost every award given by his profession for excellent, respected work. He was also honored by many different national groups for his promotion of education. The University of Maryland recognized him as the first professor to ever receive the Chancellor's Medal for Excellence as an Educator.

When his former students gave conference presentations, Maley would be in attendance as a supporter. He knew what it meant to be supported and returned that support whenever possible.

Maley hosted a Maryland Breakfast at AIAA Conferences. Former students and graduates were invited to a presentation about Maryland (he was the speaker). He asked invitees to bring their outstanding students so he could meet them. The breakfast became a recruitment tool, but also like a fraternity gathering because everyone was featured even though Maley was the draw for the attendance. Attendance ranged from 75-100 people depending upon the conference location.

Maley always had time for students. At one particular conference, an undergraduate student asked Maley if he could ask him some questions for a class assignment. It was the end of the day, and the student was shy about his request. Maley's response was, "Sure if you will let me buy you dinner while you ask the questions, and we have got to have ice cream for dessert!" Maley proceeded to make the student the most important person at the dinner that included other university professors. The other person was always Maley's focus.

He was single, but his extended family was broad. He loved children, was extremely close to family members, and especially nephews who visited during the weekends. He would play with toddlers on his office floor, attend important events for other families, and gave support to their family structure. He knew what family meant and how to help when it was needed. He often responded with such humility that those who received his help never knew that it was he who provided it.

It has often been said that a good teacher is known by the students they have influenced. During Maley's tenure at Maryland, more than 100 students received their doctorates from the department that he led. The number of students who received bachelor's or master's degrees were in the thousands. He was just as proud of the bachelor's degree students as those with higher degrees. He definitely knew the sacrifices needed to receive an education. Maley's chief concern was always THE STUDENT.

Maley's graduates became public school teachers, department heads, secondary and post-secondary school administrators, university deans and department chairs, as well as many different positions in business and industry. Some of his graduates became leaders around the world. He spoke in countries such as Greece, China, and others in South America when international travel was not as frequent or as fast as it is today.

Maley's proudest accomplishments were his students. No professor in his department demanded more from their students. At the same time, there was no professor who was as close to his students. Graduate assistants and instructors knew that he was always there for them. There were situations when he would loan money, buy plane tickets, or provide a job (his house was painted many times more than needed) so that they had enough money to survive the summer. He never gave something for nothing, but the students never expected it either.

His dedication to teaching was seldom matched by anyone at any level. When a student took any of his courses, they could expect Maley to teach every available minute allotted for the course. Students expected assignments that required utilization of the library to conduct a thorough review of the literature, to create solutions to problems, and be involved in class discussions. There was no such thing as a passive student in Maley's classes. Each class presentation was as if he was addressing a major session at a huge conference. You got your money's worth whether you were expecting it or not.

Few people in the industrial arts/technology education profession have ever attained the level of excellence that Maley achieved. The love for his profession translated into a passion for teaching that was always evident. He was one of the few professors and department chairs who taught undergraduate and graduate classes, laboratory and professional courses, and both main campus and University College off-campus courses during the same semester. Upon his retirement from the University of Maryland, he continued teaching classes on a gratis basis. His work did not stop until he died.

The department he built slowly deteriorated over a five-year period following his retirement. The program terminated, and adjustments were made to the building facilities to support the campus engineering curricula. Maley knew this was happening but was powerless to stop the effort. One can only imagine the great disappointment that he must have felt as he watched his life's work slowly eroding. Today, other than selected places in university archives, there is no physical evidence that Maley or his work ever existed at the University of Maryland.

Maley paved the way for change from industrial arts to technology education and played a role in the future development of his profession. His legacy as an outstanding educator will live on through the students who worked with him over the years. His many contributions will probably never be matched or duplicated. He tried to "be all that he could be" and urged others to do likewise.

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Dr. Donald Maley's career occurred mostly during the second half of the 20th Century. He was arguably one of the top higher educators in the field of industrial arts/technology. Dr. Maley's speeches, articles, and books may be found in ITEEA's Archives at Millersville University (Pennsylvania).

The Legacy Project has now interviewed 22 very influential leaders. It is beneficial for current (and future) leaders to read about the issues that existed and how they were addressed "back in the day." If you have a suggestion of a leader to recognize, contact the author with that person's name and contact information.

Johnny J. Moye, Ph.D., DTE, serves as ITEEA Senior Fellow. He is a retired U.S. Navy Master Chief Petty Officer, a former high school technology teacher, and a retired school division CTE Supervisor. Johnny can be reached at johnnyjmoye@gmail.com.

Thomas P. Bell, Ph.D., DTE earned his industrial arts bachelor's and master's degrees from Millersville University where he currently serves as professor in the Department of Applied Engineering, and Technology. Studying under Dr. Maley, he earned his Ph.D. in Technology Education at the University of Maryland – College Park. Dr. Bell is an EPT board member and former ITEEA President. He can be reached at Thomas.Bell@millersville.edu.

Richard P. Bray, DTE was a classroom technology education teacher for 38 years and also served as AIAA Past President. As an active AIAA member and President, he worked with Dr. Maley on numerous projects over a long period of time. During his presidency he also took a sabbatical that allowed him to visit 23 states to speak and advocate for technology education students. He is now retired and lives in Maine.

teacher highlight

Trey Moore

Teacher
New Hanover High School
Wilmington, NC

Trey Moore graduated from North Carolina State University with a bachelor's degree in design and returned later to earn a master's degree in Technology Education. He has taught for 26 years, working with middle and high school students. Apart from his work as a teacher, Trey is also a practicing artist and teaches art at a local arts center.

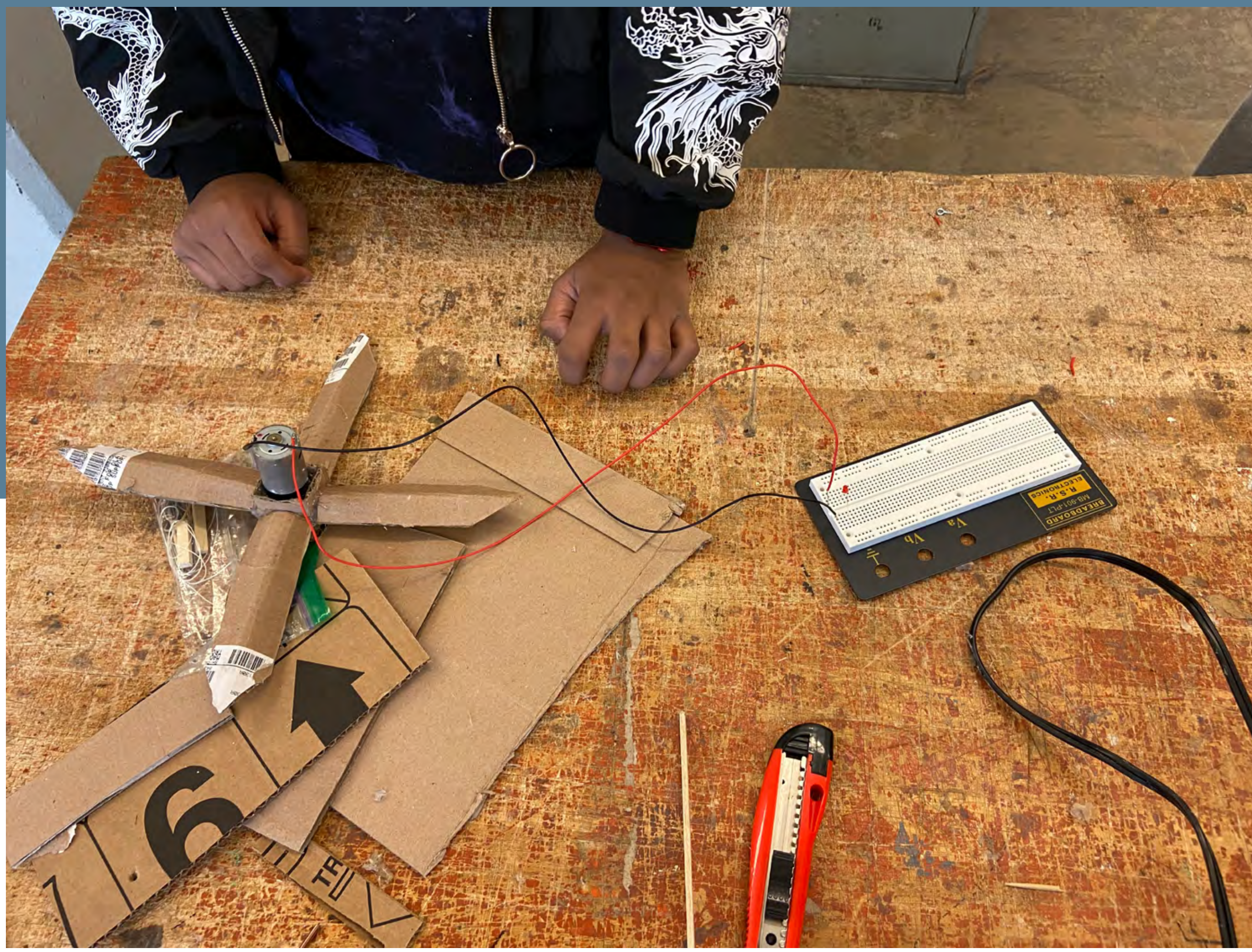
What inspired you to become a technology and engineering educator?

I never considered teaching as a career early on. When I was an undergraduate at the School of Design the notion occurred since I loved the climate of sharing and critiquing ideas. It was always wonderful to see all the work of my fellow students. After a few years working construction and conversations with friends, I moved into education. Technology and engineering education seemed the perfect match for my experiences, and I am so happy I made the decision to teach.

What do you consider your greatest successes in the classroom?

When students become excited about the work we are doing in the classroom and what they have accomplished. When they say they didn't think they could do the work and subsequently see how successful they've been, when they don't want to leave my shop because they are so into the work, and when they realize what they're learning in their core classes has a purpose.

"there is no denying that it is a difficult job, but getting to work alongside students who will enjoy the work as much as you do is such a wonderful experience"



Can you share an example of a classroom failure from which you learned?

I'm not sure it's a failure as much as what feels like a constant shortcoming. For the better part of 10 years, we have been working on a small-scale electric vehicle. We have gone through more iterations than I can recall and have only fully completed one or two. However, each new iteration is a step forward and it's always exciting to see what the students accomplish.

What is the best thing about being a T&E teacher?

Undoubtedly, it's getting to make and build with the students. I love seeing their solutions to the projects and I love seeing them get excited about the work.

What would you say to students today who are considering careers as T&E educators?

Whew…there is no denying that it is a difficult job, but getting to work alongside students who will enjoy the work as much as you do is such a wonderful experience; it will have you coming back every day.

What are you planning to explore and pursue in your classroom in the near future?

I feel like I am behind the curve on this one. We are just getting into robotics, automation, and coding. I have ordered Arduinos and cannot wait for them to arrive. The plan is to extend an automata mechanical toy project I do with the Arduinos so that they become fully automated.

classroom challenge

Solar-Powered Garden Challenge

By Harry T. Roman

Introduction

In this challenge, students/student teams will develop a garden with a solar-powered theme. The garden is itself solar-powered because the sun is the energy source for all the growing things there; but students are free to add solar-powered themes into the garden to enhance or embellish the growing of plants and such. The students/teams all will use a one-acre garden of any shape or perimeter dimensions as their design space. They are free to consider any type of plant to be grown there. The plants may be for food, ornamental, or other purpose; but they should be able to articulate what motivated their choice of plant species.

Developing Ideas

Creativity sessions always begin with free identification and unfettered idea generation, and this design challenge should be no different. Let students freely associate ideas and get them down on paper—for ideas are the fuel for even more ideas, and sometimes even resulting in interesting and unusual combinations.

First, what solar-related technologies could be applied in the garden? Make a raw list, such as the one below:

- solar thermal
- solar electric (solar cells or photovoltaics)
- wind energy
- solar pond
- other?

In what ways can plant growth be enhanced?

- extra water
- nutrients
- night lighting
- warm soil to extend growing season
- low-cost plastic sheet greenhouses
- other?

Do students see any combinations of these two lists that spark some unusual thinking or creations? Could photovoltaics and wind generate electricity that might be used for pumping water around the garden? Could energy generated during plentiful sunlight conditions be used for night lighting of the plants to increase their growing time? Might low-cost plastic greenhouses (solar thermal) keep the plants warm and extend growing season and, in combination with night lighting, significantly boost growth?

What plant-growing techniques have been used by others in the past or are being experimented with now? Research the rich literature that exists, especially that being done by agricultural universities and private companies specializing in greenhouse building, ornamental plant species, food companies, and others.

Is there a component of expertise in your school that can be tapped—like a biology teacher, a technology education program that deals with plants and agriculture, or aquaculture that may be relevant to what your student teams are attempting? Might students from those classes want to join your students/teams?

Is rainfall something that should be allowed to simply happen, or should it be controlled and carefully distributed to the plants to maximize growth? Could solar-powered pumps better distribute water where it is needed? Or should rainfall that has been collected and stored be pumped and distributed at night using stored solar-generated electricity, coupled with solar-generated electricity for lighting?

How does the garden store the rainfall in the first place if most of the space is taken up with plants to be grown? Does this necessitate considering the garden as not just a two-dimensional space, but a three-dimensional design challenge? For example, should there be a water tower to store and naturally distribute water by gravity-fed irrigation? Should there be wells onsite, or should city/town water be used?

Other Thoughts

Could aquaculture or solar ponds be a design theme for the garden challenge? What kinds of crops might students envision for this?

How about the use of nutrients for the plants? How will students make sure their garden is biologically neutral to the surrounding environment, i.e., no leaching of fertilizer into sensitive areas like adjoining properties and local waterways?

Will the garden design incorporate a water feature, perhaps a place for contemplation and relaxation? How does this impact or be impacted by the main theme of a solar garden?

Is there enough space on your school grounds to build student designs, either in full scale or smaller scale to test them out? Might this happen? How could your students propose it? What would be the cost for a full-scale or miniature-scale garden?

Have fun and think green!

Harry T. Roman is a retired engineer/inventor and author of technology education/STEM books, math card games, and teacher resource materials. He can be reached at htroman49@aol.com.

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