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www.asee.org/conferences-and-events/conferences/k12-workshop/2017

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ITEEA Member's Research Featured in Overseas Seminar

Greg Strimel, assistant professor of engineering/technology teacher education at Purdue Polytechnic, delivered a higher seminar on engineering design cognition at the KTH Royal Institute of Technology in Stockholm, Sweden at the beginning of February. KTH is one of Scandinavia’s largest technology institutions and Sweden’s first polytechnic.

During his visit to Sweden, Strimel explored study-abroad opportunities with the institution. He was recently awarded a Study Abroad and International Learning (SAIL) grant to explore opportunities for global and cultural immersions for Polytechnic students.

Strimel was also recently featured in a special issue of the Technology and Engineering Teacher journal. He and his colleagues were invited to publish a viewpoint on better positioning technology and engineering in P-12 classrooms based on their previous publication in the Journal of Technology Education. The special, free issue is available to everyone on the ITEEA website.

Strimel and his co-authors were invited to discuss their publication at a special panel presentation at the ITEEA annual conference in Dallas, Texas, in March.

ITEEA Member Highlighted on "Good Day Connecticut"

ITEEA member and CTEEA President, Bill McDonough, was recently interviewed on Good Day Connecticut along with student Callie Engel regarding a new class on creating apps that he is bringing to Masuk High School. Watch the video at https://www.youtube.com/watch?v=7BBG8zdSPNk.

National Society of Black Engineers Launches Nationwide STEM Campaign

Leveraging the popularity of the hit movie Hidden Figures, the National Society of Black Engineers has launched a nationwide campaign titled #BlackSTEMLikeMe. This multimedia initiative aims to encourage Black students and professionals in science, technology, engineering, and math (STEM) to share their stories and show Black children that a future in STEM is an attainable career path. The campaign is designed to move NSBE toward the main goal of its 10-year strategic plan, which is to lead the U.S. to produce 10,000 African-American bachelor’s degree recipients in engineering annually by 2025, up from 3,501 graduates in 2014.

Hidden Figures, released in theaters nationwide on January 6, tells the story of how three African-American women—Katherine Johnson, Dorothy Vaughan, and Mary Jackson—contributed critical math, engineering, and computer science work to the early missions of the U.S. space program. The movie, which was the No. 1 film at the box office in its first two weekends, is bringing a major focus to the often overlooked contributions of the Black STEM community.

STEM students and professionals can participate in the campaign by sharing STEM stories on Twitter, Facebook, Instagram, Snapchat, or via the BlackSTEMLikeMe.nsbe.org website using the #BlackSTEMLikeMe hashtag. The best stories will be entered in NSBEs national social media webisode series. Visit the NSBE website for more information.
The authors share their experiences from developing a rigorous Integrative STEM Education design challenge that promoted T&E education programs and strengthened community connections.

Introduction

"Crab cakes and football, that’s what Maryland does!" (Abrams, Levy, Panay, & Dobkin, 2005). Although the Old Line State is notorious for harvesting delectable blue crabs, the movie Wedding Crashers failed to highlight something else Maryland does well: engineering design competitions. This article discusses how a multistate engineering design challenge raised science, technology, engineering, and mathematics (STEM) awareness through collaborations with university, U.S. military, community, and industry partners. The design challenge presented here tasked students with designing a remote-controlled, scaled model of a crab boat. Their boat had to maneuver within a Chesapeake Bay course and collect as many miniature crab baskets as possible as quickly as possible. An event highlight video and other resources are available on the competition website (UMES, 2016). The authors also provide recommendations to develop similar engineering design challenges.

Engineering Challenges in Maryland

For a number of years Maryland has developed and hosted low-
cost engineering design competitions. Many of these have been facilitated through the Baltimore Museum of Industry (BMI), located in the Inner Harbor. There were a number of goals behind the engineering challenges, such as creating an awareness of STEM across Maryland, providing a way for students to do more STEM activities beyond their technology and engineering (T&E) courses, and building relationships with local industry and military personnel. Over the years these engineering challenges have provided informal STEM learning opportunities for thousands of children. Currently BMI hosts elementary, middle, and high school level engineering design competitions situated in a variety of T&E contexts (e.g., design a theme park, build a cargo airplane) (BMI, 2016).

In the summer of 2015 teachers on Maryland’s Eastern Shore indicated interest in the state’s engineering design competitions, but the long distance to Baltimore made it difficult to participate. Teachers expressed the need for a challenge unique from popular SeaPerch and robotics competitions, so the Eastern Shore Crab Boat Engineering Design Challenge was conceived. This challenge was modeled after the very successful and rigorous Cargo Ship Challenge facilitated at Baltimore’s Inner Harbor for many years (BMI, 2016). Similarly, the University of Waikato in New Zealand annually hosts a speedboat engineering design competition for its first-year engineering students (University of Waikato, 2015). The speedboat design challenge attracted approximately 40 teams in 2015! The authors believed a design challenge in the context of a crab boat would attract a similar level of interest since many Delaware, Maryland, and Virginia (Delmarva) students are aware of the significant influence that the crab industry has on the Chesapeake Bay region.

Developing the Crab Boat Engineering Challenge

Before advertising the challenge to the public, the authors developed a set of event guidelines and regulations. They used the Cargo Ship Guide (BMI, 2016) as the foundation for creating the Crab Boat Engineering Design Challenge Rules (UMES, 2016). The criteria for testing the boat remained relatively the same; however, some of the boat design criteria (e.g., cabin as opposed to deckhouse) had to be modified to accurately depict a crab boat. The authors met with crabbers in the Ocean City, MD area to discuss crab boat design criteria and help formulate the rules. This was a very informative experience and helped make the competition realistic. It was determined that the Chesapeake Deadrise was unique to the eastern shore of Maryland; therefore, this was the specified design for the competition.

To ensure accuracy of the design criteria, a retired naval architect reviewed the guidelines and provided feedback regarding calculations for the scale of the ship designs, basket rate, metacentric height (stability), and roll period (time it takes the boat to tilt left a specified number of degrees, then right the same amount of degrees, and finally return to stable). Boats were required to be designed and built at a scale of one-inch equals one foot. The vessel could be no longer than 40 inches (including the rudder and propeller); the beam (width of the boat) could not exceed 12 inches; and the maximum draft (portion of the boat under water) could be no greater than two inches when the vessel was empty. The crab baskets, which consisted of metal bird suet cages loaded with rocks to weigh approximately 16 ounces, had to be carefully hand-loaded by students at three distinct dock locations within the course. The full set of rules can be found on the event webpage (UMES, 2016).

From these rules a rubric was developed to help judges easily and accurately rate each team’s performance. This rubric provided scores for four different aspects of the competition: (1) the written report, (2) boat design and construction, (3) student responses to the judges’ questions at the competition, and (4) boat performance. The written report required students to present information regarding the influence that the Department of Natural Resources has on crabbing, environmental impacts of crabbing within the Chesapeake Bay, scientific and mathematic concepts applied in designing and testing their boat, a detailed budget of all materials used, and accurately scaled drawings or computer-generated designs of their vessel. The full rubric can be accessed from UMES (2016).

Inherent in most engineering design competitions is the risk of injury. With this event, there was the possibility of individuals slipping or drowning. To limit their liability, the authors chose to implement risk transfer and risk control methods (Love, 2013). First they inquired about the insurance policies carried by the host site and their school. This is often the most expensive cost associated with engineering design competitions. The authors worked with their school’s attorney to develop safety guidelines and a liability waiver to be signed by all attendees prior to the event. One of the safety guidelines required students and coaches to wear life jackets when near the dock areas.

In September an interest meeting was held at a local high school and streamed online to discuss the rules. At this meeting teachers were provided with resources for teaching STEM concepts embedded within the design challenge and a list of suggested vendors. A hands-on teachers’ workshop was offered in December to demonstrate methods for teaching corresponding STEM concepts and help teams construct various components of their boat. Additionally, a working vessel was launched at the university’s pool so teachers had a better understanding of the procedures for the competition. Throughout the entire process, the authors assisted teachers, and in some instances teams collaborated to share resources (e.g., visits with local shipbuilders). This type of collaboration was encouraged as long as the teams’ boat designs were unique.
Constructing the Crab Boats

One advantage of this engineering design challenge as opposed to other STEM competitions is that it was relatively inexpensive for teams to participate. The authors were able to secure numerous sponsorships to avoid charging a registration fee. Kelvin Educational® donated the boat motors, so, on average, teams only spent between $200-$300 on materials, most of which were reusable (e.g., remote control, propeller, batteries, motor). Some teachers opted to do this design challenge as an after-school club, while others were able to integrate it into their advanced T&E classes because it applies concepts that address an array of standards (Table 1).

Incorporating this design challenge in advanced T&E classes was found to be more advantageous for student participation. Teachers who advertised the design challenge as an after-school club provided opportunities to all students in their school; however, those who integrated it in their advanced T&E courses yielded greater participation, especially from female and minority students. This difference in participation could be the result of a number of factors such as students having other after-school commitments.

Teams used many types of materials to construct their boat hulls. One used Divinycell foam that was donated from a local shipbuilder. The advantages of this special foam are that it is lightweight, buoyant, and can be glued with epoxies that would disintegrate other types of foams. Disadvantages of the Divinycell foam are that it is expensive and difficult to bend when trying to create curved boat hulls. Other teams steamed wood strips to achieve a curved structure and then water-sealed it using fiberglass. Some considered using tin with rivets or spot welds for their hull. The weight of the tin and limited metal working equipment were cited as reasons for not using this design.

One team used a ribbed interior design for its lightweight, yet robust structure. Each piece was designed using 3D software and then printed on paper as a stencil to cut the ribs out of wood. Alternatively, teams could have 3D printed the ribs after designing them with the software. Varghese (2010) described a variety of additional hull designs and fabrication methods used by students in the University of Waikato speedboat competition.

Table 1

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<th>Student Action(s)</th>
<th>Standard(s) Addressed</th>
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| Research ways that crabbing and marine technology impact the environment as well as marine life (e.g., crabs). Provide solutions for reducing these impacts. | STL 5:L  
NGSS: HS-ESS3-4  
NGSS: HS-LS2-7  
CCSS: ELA-Literacy.RST.11-12.7 |
| Research historical information about marine technology and boat characteristics (e.g., hydrodynamics, draft) to inform the design of their own vessel. | STL 18:J |
| Research, design, build, and troubleshoot the boat to increase its efficiency.    | STL 9:K  
STL 10:J  
STL 11:O  
STL 12:M  
NGSS: HS-ETS1-3 |
| Apply integrated math and science concepts (e.g., Archimedes Principle, Ohm's Law) that are necessary for the boat to operate. | STL 3:J  
CCSS: MATH.HSG.GMD.A.3 |
| Apply electronic technology concepts needed to power and remote-control the boat. | STL 16:N |
| Utilize various manufacturing methods to construct the boat.                       | STL 19:M |
| Calculate the basket rate of the boat.                                            | CCSS: MATH.HSA.RELB.3 |
| Communicate information to the class, instructor, and competition judges about how they applied engineering design and STEM concepts throughout the design challenge. | CCSS: ELA-Literacy.SL.11-12.4 |
After their hull was constructed, teams needed to determine how to operate the rudder system, which often proved to be the most challenging task. Some of the more successful boats used a twin rudder design with two paddles that provided more steering stability. This design had two paddles mounted at the center of the boat within a few inches of each other. When remote-controlled, they both moved in the same direction via a servomotor. Some teams separated their rudders, placing one near each of the outer edges of their boat, which made steering more difficult. During construction and testing of prototypes, teams were able to apply the engineering design process to make adjustments and develop more efficient designs.

Propellers were another critical component of the boats. These could be bought from companies selling remote-controlled boat and aircraft materials (ZippKits, 2016), or schools had the option to 3D-print a custom design. There are free 3D printable boat propeller designs readily available online (Yeggi, 2016). For higher-level STEM applications, students could create and test various propeller designs to determine what factors (e.g., pitch, rake [slope of the blade], diameter, number of blades, revolutions per minute) increase efficiency. This could further inform original student designs or the modification of existing 3D printable designs accessed online. Varghese (2010) described a number of characteristics that increase propeller efficiency and presented an analysis of multiple designs.

An additional challenge was ensuring a watertight seal where the stuffing tube (propeller shaft) exited the boat while still allowing the propeller to spin. Leaks in this area could ruin the electronic controls or cause the boat to fill up and sink. Teams were able to minimize leaks by creating a waterproof bulkhead and using a flexible propeller shaft that spun inside of a greased lithium stuffing tube. It was critical for teams to test their boats in a local pool or pond prior to the competition to check for leaks and maximum efficiency.

The electronic components to remote-control the boat were comprised of a pair of six-volt lithium or NiCd batteries wired in parallel to a speed controller or a microswitch, a servomotor for each propeller, a transmitter, and a receiver unit. Students had to design an electronic circuit that could provide enough power to propel and steer their boat via remote control. The propeller speed decreased due to water resistance; however, students found that connecting multiple batteries in parallel would increase the speed of the propeller. The trade-off of this was the weight of the additional batteries. To reverse the polarity of the current to the motor for steering purposes, a microswitch was used. Ensuring that these electronic components were not exposed to water was critical. Some teams built them into small plastic containers directly on the boat deck, while others created a removable deck under which the electronic components were housed.

Integrative STEM Education Applications

This engineering design challenge was embedded with numerous opportunities to naturally integrate STEM content and practices. From a science lens, this activity prompted students to investigate topics such as buoyancy, displacement, stability, and environmental effects of technology. Two excellent videos demonstrating Archimedes’ principle were provided on the event website (UMES, 2016). Teachers were encouraged to use these resources when helping students calculate the volume of their boat hulls, which would be difficult to calculate with a tape measure. Students also had to investigate how their boat hull design would impact its stability. This was essential to ensure that the boat did not tip when loaded with crab baskets and making sharp turns.

To test science concepts and inform their designs, there were a number of mathematical concepts that students needed to apply. As mentioned previously, determining the displacement was important, which influenced modifications to their boat hull and decreased the amount of drag. Varghese (2010, p. 70) provides an example of how to calculate draft to increase boat speed and efficiency. Also during the design phase, students were expected to measure and calculate the angles of the boat hull and propeller blades. Once students understood these basic concepts, they had to apply them to design and construct their vessel to scale. Within their written report they had to calculate a total cost for all materials used. Lastly, students had to determine their ship’s basket rate, which was one of the major judging criteria used to identify a winner.

\[
\text{Basket Rate} = \left(\frac{\text{Fixed Costs} + \text{Operating Costs}}{\text{Baskets Carried} \times \text{Distance Traveled}}\right)
\]

- Fixed Costs = length x width x draft when loaded x $10
- Operating Costs = time to complete the course in seconds x $10 x number of motors.
- Baskets Carried = total number of baskets carried in boat.

One team's design using Inventor.
Technological and engineering practices served as the vehicle for applying the aforementioned science and math concepts. Throughout this entire challenge, students were immersed in the engineering design process. The scientific investigations and mathematical calculations informed modifications to their designs. Students had to utilize 3D software (e.g., AutoCAD, Inventor, SolidWorks, or Google SketchUp) to develop designs for various components of their boat. During the design process some of the teams built miniature prototypes out of styrofoam to examine hydrodynamics, Archimedes principle, draft, and stability. This allowed students to test their designs and easily make adjustments without wasting costly materials. They then had to take those refined designs and turn them into a tangible product using various manufacturing processes. Some teams were able to utilize newer manufacturing technologies, such as 3D printing, and demonstrate how it could be applied to produce parts (e.g., propellers, structural components) with specific functionality characteristics. After their boat was constructed, students had to research what materials or products could help reduce the hydrodynamic friction of their boat hull.

School and Community Collaboration

This event relied upon assistance from numerous sponsors and community members, which also helped foster relationships with the UMES technology and engineering education program. As previously mentioned, Kelvin Educational® donated the motors. The U.S. Army funded the lunches and event shirts for all participating students and coaches. Army personnel helped judge the event and spoke with students about the various STEM career opportunities in the military. The lunches were prepared by a local career and technical high school's culinary arts program.

In addition to this assistance, an easily accessible venue with waterfront access was needed. The University of Waikato holds its speedboat engineering challenge at a lake in the center of its campus. This attracts visitors while also raising university-wide awareness of the engineering program. Finding the proper host site is a key component of any engineering design competition. The authors collaborated with the University of Maryland Center for Environmental Science (UMCES) to host this event. This also provided an opportunity for UMCES faculty to lead a campus tour while educating participants on their renowned oyster farming research.

K-12 T&E education programs and UMES T&E teacher education students also benefited greatly from the event. UMES T&E education students and a local high school teacher with expertise in graphic design collaborated to create the logo and signs for the event. This teacher also assisted UMES students with manufacturing the award plaques using a CNC router. The plaques were intentionally designed to include the UMES T&E education program logo and serve as a free recruitment tool displayed in award-winning schools. UMES T&E education students also helped judge and facilitate the event so that they would be better prepared for helping their future students participate in engineering design challenges. Lastly, these undergraduate students learned about communication technologies while making the event highlight video (UMES, 2016).

In addition to the event website and award plaques, there were a number of other sources that helped advertise the event and T&E education programs. Pre- and post-event articles were published in UMES’s campus newsletter and in PropTalk, a Chesapeake Bay boating magazine distributed throughout Delmarva. Newspapers from the home areas of the award-winning teams (Annapolis and Ocean City) featured articles discussing the results of the event. One of the most notable advertisement opportunities was broadcast by the local television station that interviewed the authors on its morning talk show. All of these media sources publicized the benefits of K-12 T&E education programs and the teacher preparation program at UMES. Free and innovative strategies like these are needed to promote the work of T&E education programs (Caccavale, 2016).
Lessons Learned from the Challenge

Teams found that two batteries connected in parallel to one motor greatly increased the propeller speed. Also, it was known from prior Cargo Ship Challenges that a cordless-drill motor would provide more power; however, they are much more expensive. To make the competition as fair as possible and encourage students to focus on the design elements of their boat, all teams were required to use Kelvin® number 850887 project motors. Pouring rain and strong winds during the competition created choppy water conditions that affected the maneuverability of the vessels due to their light weight. As more crab baskets were placed in the boats, their navigation greatly improved. Teams made some innovative last-minute adjustments to the rudder and weight of their vessels to counter these weather conditions.

Despite students and teachers finding this engineering challenge very engaging and rewarding, there were a limited number of female and minority students participating. Past engineering design challenges hosted at another location (the Baltimore Museum of Industry) attracted more diverse groups of participants. The authors created the engineering design challenge rules and judging criteria to encourage all students to participate. What methods and how much effort teachers put into recruiting female and minority students are unknown. In future competitions the authors plan to invite female and minority naval architects and marine engineers to speak with students about the career opportunities and authentic applications directly related to this design challenge. Teachers should use the inspiring naval architecture video of Emily White (Fisheries and Marine Institute, 2015) to encourage more females to participate. The authors also hope to recruit more schools with female and minority instructors who will participate in the event. These female and minority professionals will serve as role models and should help increase diversity in future engineering challenges.

Developing Similar Design Challenges

Those who reside in landlocked states can still facilitate a challenge similar to the one presented in this article. It can be hosted at a nearby pond or in a school pool deep enough for the boats to maneuver. All potential safety hazards must be considered when hosting an engineering design competition. It is recommended that educators work with their schools’ attorneys (called solicitors in some states) to limit their liability through risk-transfer and risk-control strategies (Love, 2013). The rules presented on the event (UMES, 2016) and BMI (BMI, 2016) websites serve as templates to develop an engineering design challenge in a context that interests students. Similar to the process employed by the authors in designing this event, rules can be modified from other engineering design challenges to create a unique competition.

Conclusions

This engineering design competition started out as a small event but attracted interest from a number of schools and informal STEM programs. Numerous teachers indicated that they read about the results in their local newspaper or PropTalk magazine and would like to enter a team in 2017. The broader impacts of this event demonstrated the benefits that engineering design challenges have for promoting T&E education programs and highlighted how these competitions can be utilized to engage students in applying STEM concepts to design a working technological system. This challenge serves as one exemplar of Integrative STEM Education (Wells & Ernst, 2012/2015) through its ability to naturally address many of the STL technological literacy content standards, as well as some of the Next Generation
the crab boat engineering design challenge

Science Standards, and Common Core State Standards in the context of an authentic engineering design solution. Educators are encouraged to use the Crab Boat Engineering Design Challenge as a foundation for creating their own engineering design competitions.

References

teaching personal skills in technology and engineering education: is it our job?

It is every teacher’s responsibility to prepare youth to be professional and ethical in their future dealings in classrooms or the workplace.

Introduction
Recent papers on career and college readiness have emphasized preparation of secondary students for either future college and/or career choices (Robles, 2012, Rateau, Kaufman & Cletzer, 2015). While technologies used in business change rapidly and make the teaching of job-specific skills somewhat impractical, the foundational skills needed for success in postsecondary education and future work continue to be considered crucial at all levels of society. Foundation skills are those that cross academic and career boundaries. They include basic skills, thinking skills, and personal qualities. This article will explore the inclusion of personal qualities or characteristics that can be taught in technology and engineering education classrooms.

Foundational Skills Rationale
Discussions about foundational skills began nationally with the release of the Secretary’s Commission on Achieving Necessary Skills (SCANS) from the U.S. Department of Labor in the early 1990s (U.S. Department of Labor, 1993). This report was a result of public concern that the American educa-

Photo 1 (above). Meade High School students Devin Hennayake, Deneen Morris, Justin Schwartz, and Rhett Coleman demonstrate self-management and collaboration soft skills while working on their engineering technology project.
tion system was out of touch with the needs of the economy. According to the SCANS Report, schools should be teaching the basic skills of reading, writing, arithmetic and mathematics, speaking, and listening; thinking skills of thinking creatively, making decisions, solving problems, knowing how to learn and reason; and personal qualities including individual responsibility, self-esteem, sociability, self-management, and integrity.

Other organizations and authors have identified foundational skills as well. The National Academy of Engineering (2010) identified engineering habits of mind that included systems thinking, creativity, optimism, collaboration, communication, and attention to ethical considerations. Freifeld (2013) reported in Bridging the Skills Gap that there is a skills gap between what is taught in science, technology, engineering, and mathematics (STEM) and what employers desire. The soft skills identified in this report were in the areas of communication and leadership. This included verbal communication and writing skills, self-motivation, learning agility, self-awareness, adaptability, critical thinking, dependability, the ability to get along with others, and problem-solving skills. Robles (2012) reported on the perceived level of importance of soft skills by business executives. The ten soft skills in order of importance included integrity, communication, courtesy, responsibility, interpersonal skills, positive attitude, professionalism, flexibility, teamwork, and work ethic.

Harris and Rogers (2008) identified sixteen nontechnical competencies and affective domain attributes through a research study of technology education professors from three universities. Selected foundational skills receiving high mean scores were effective communication, honesty, willingness to learn, open-mindedness, problem solving, following directions, public speaking, work ethic, interpersonal communication, organization, and understanding group dynamics. In a study on teaching soft skills for entrepreneurship, Robinson and Stubberud (2014) reported that important foundational skills included the ability to be creative, recognize opportunities, network effectively, and work well in teams.

Whether discussed decades ago or just recently, foundational skills continue to be viewed as an important element of human success. While it may be relatively easy to write lesson plans that include creative and critical thinking, problem solving, organization abilities, and reading abilities, it may be more difficult for a teacher to operationalize intrinsic characteristics in STEM classrooms. For the purposes of this article, the author is grouping these foundational intrinsic characteristics into six categories: self-management, collaboration, integrity, communication, optimism, and adaptability. These personal characteristics can be developed in technology and engineering classrooms and are outlined below.

**Self-Management**
Self-management covers the personal qualities of being individually responsible, self-aware, dependable and self-motivated, having a work ethic, and an ability to follow directions. Freifeld (2013) stressed the importance of employees owning their own work and not being dependent on managers telling them what to do. Individuals who take responsibility are able to take charge of their own work, which contributes to an organization’s goals. Self-managed individuals, whether in the classroom, college, or at work, are able to complete tasks without extra drama and problems. Lawanto (2005) refers to self-management in engineering education as a student’s ability to plan, regulate his/her actions through constant readjusting, and evaluate his/her learning. Successful self-managed individuals are often described as task completers.

**Collaboration**
The second personal characteristic is collaboration. This is described as one’s sociability, ability to work on teams and to get along with others. In Advancing Excellence in Technological Literacy (AETL) (ITEA, 2003), there is a program standard that addresses this attribute. Class activities with work teams are part of AETL P4-A: Create and manage learning environments that are supportive of student interactions and student abilities to question, inquire, design, invent, and innovate. Loveland and Dunn (2014) stress that collaboration skills are important in the global world in which we live and work, with transnational work teams common in industry. Lawanto (2005) reports that engineering education students need to develop collaboration skills to succeed in team-based environments to solve open-ended engineering problems. These skills go beyond individual technical skills to include management of organization through team-building skills.

**Integrity**
Individuals with personal integrity pay attention to ethics in their work and personal relationships, are honest, and show respect for diverse cultures. These individuals are culturally sensitive by being respectful of the many cultures represented in schools, colleges, and the workplace. AETL (2003) Standard P1-E: Assure that the program incorporates suitable cognitive, psychomotor and affective learning elements includes prompts about teachers encouraging students to develop perspective and empathy in class activities. Individuals with personal integrity are careful about what they post in social media and how they respond in emails, Facebook, and Twitter.

**Communication**
Communication is a process that people use to inform, educate, persuade, control, manage, and entertain. As a personal attribute valued in schools, colleges, and the workplace, communication is a person’s ability to listen to others attentively, discuss their own ideas in a cooperative way, be able to write responses to
inquiring that are understandable, and make presentations to
groups. Harris and Rogers (2008) indicate that the most sought-
after attribute in students as indicated by university professors
was being able to communicate effectively through writing and
proper grammar. Individuals are considered to be good commu-
nicators if they meet these criteria.

Optimism
Optimism is tied to one’s self esteem and is seen by others as
friendliness or having a positive attitude. Robles (2012) describes
outward examples of optimism as enthusiasm, encouraging of
others, being happy and confident. Loveland and Dunn (2014) re-
port that optimistic individuals see the world as a positive place,
and this attitude can provide them with benefits. In engineer-
ing, optimism is linked to motivation and persistence in solving
engineering problems.

Adaptability
The final personal quality is the individual’s adaptability or open-
mindedness. How flexible is a person when presented with con-
trary information or other ways of doing things? Does the person
come across to others as rigid in his/her beliefs? Can they adjust
to new realities and be teachable? Harris and Rogers (2008)
reported two competencies with high means that university pro-
fessors deemed worthy in technology education: a willingness to
learn and being open-minded to new concepts and ideas.

Developing Personal Characteristics in
Technology Education
There are ways to enhance and promote these positive character
traits in technology and engineering education students in order
to have a positive impact on their lives and to prepare them for
future college or career choices. The nature of technology and
engineering classrooms lends them to group design activities
in lab settings. Teachers can help develop student abilities to
work effectively by requiring negotiation of solutions in projects
(Robinson & Stubberub, 2014). According to Fox-Turnbull (2012),
action and activity are social undertakings that involve social ac-

The teacher uses guided participation to challenge, constrain,
and support student learners through problem-solving lessons.
This type of teaching provides students with social experience in
working with others in appropriate ways to promote group goals
(Fox-Turnbull, 2014).

Self-management can be enhanced in technology and engineer-
ing classrooms through structured activities with firm deadlines.
The teacher can model how to backdate the starting time and
indicate progress checks in the planning stage with students.
More assessment points linked to meeting deadlines can reward
project completers to help motivate students. Self-management
can be increased by giving students choices within activities and
by assigning manager responsibilities. Lawanto (2005) described
an engineering education project involving the design and con-
struction of a hydraulic bicycle. Self-management and collabora-
tion were assessed by criteria related to team management and
meeting administrative tasks. The results indicated increased
egalitarian spirit, cooperativeness among the students, and
completion of tasks from working together on this open-ended
engineering project. One indication of self-management is com-
ing to class on time.

Another example of teaching self-management might be a
teacher inviting guest speakers from new industries to discuss
the speed with which new products must move from develop-
ment to distribution in order to increase or hold market share. An
example question might be to inquire about what would hap-

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partners. Kelley (2013) suggests technology teachers be purposeful in their approach to grouping students in design teams. Teachers need to teach students how to work effectively in small groups. One strategy is to group students by diverse personality traits as indicated from personality profile test results. Other strategies to enhance collaboration could include creating global projects by working with classrooms in other parts of the country or the world. A technology education teacher in Florida successfully ran a Japan Florida Teens Meet Project (JFTMP) for five years with a Japanese high school class. Projects included multi-language dramatic anti-smoking videos and a scale model International Space Station built by transnational student teams. The American students’ attitudes and abilities increased substantially from working with diverse cultures on this long-term project.

Technology teachers can develop other lesson plans, depending on their program area, that deliberately place students in contact with and in a support role for disadvantaged people in their communities. Service projects like Habitat for Humanity, raising funds or awareness for not-for-profit organizations, developing technological solutions for assistive learning, and other projects can teach technological literacy while including elements of social ethics. Student lives and beliefs regarding integrity can be transformed by these service projects. Student participation in Technology Student Association in-school activities and competitions at district, regional, state, and national levels helps to develop leadership skills, particularly pertaining to the personal characteristic of collaboration.

Communication, especially in public, can be a daunting prospect for youth. To stand up and confidently present a point of view before a group of peers or adults can be stressful. Providing opportunities for small-group presentations can help youth develop these skills to communicate in social situations. Kelley (2013) pointed out that technology education classrooms are natural places for student oral presentations of design results and portfolios. Developing good listening skills in youth is just as important. Other activities that increase communication skills include having students organize a field trip, hold a class debate, and arrange simulated employment interviews. Freifeld (2013) reports that the current educational system does not teach the communication, problem solving, and critical thinking that are required for successful employment. While difficult in most academic subject areas, these skills can be taught effectively in technology and engineering education.

Optimism can be contagious in a technology and engineering classroom through the example set by the teacher. If teachers are optimistic and friendly and provide positive encouragement to their students as they learn and develop, this will help students to be positive. How can projects and learning activities be adapted to help students be more positive? Areas in which teachers have an impact are sequencing lessons to build skills, organizing learning activities to maintain momentum, including formative feedback throughout the process, and designing fair assessments that reward accomplishment and effort. Sometimes thinking outside the box to develop eye-catching and exciting learning activities can promote optimism. Holding celebrations of student accomplishments and posting pictures of successful students in the classroom can help to promote a positive environment.

Adaptability or open-mindedness can be enhanced in people through technological projects and lessons. Strategies to increase inherent flexibility can include problem-solving discussions based on authentic life situations and having students role-play work settings (Robles, 2012). Rateau et al (2015) suggest having students work in teams to solve problems in order to understand divergent perspectives. Harris and Rogers (2008) point out that the use of design activities can force students to work outside of their comfort zones. This experience of adjusting to new things and other ideas to accomplish goals can promote personal flexibility. Teachers should try to teach students that there is value in change.

Summary

Soft skills development in school settings is often difficult to quantify and assess. The results of projects and learning may not bear fruit for many years. Should technology and engineering teachers decide to forgo this part of teaching, they are doing a disservice to their students and society at large. It is every teacher’s responsibility to prepare youth to be professional and
teaching personal skills in T&E Education: is it our job?


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Ethical in their future dealings in classrooms or the workplace. Fortunately, technology and engineering classrooms offer excellent opportunities to inculcate these social and personal skills in students.

References


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Calling All STEM Teachers!

Are your public school students doing hands-on activities in your classroom?

How many? How often?

The Learn Better by Doing Study needs YOU (even if you have participated before)!

The researchers are currently conducting Round 4 of this study, designed to determine the extent to which U.S. public school students are doing hands-on activities in their classrooms.

Elementary and secondary STEM teachers are encouraged to participate in the study by following this link: www.iteea.org/Activities/2142/LearningbyDoingProject.aspx

Participation deadline: April 15, 2017.
At the end of the classic 1971 film, *Willy Wonka and the Chocolate Factory*, Mr. Wonka gives young Charlie Bucket his chocolate factory, noting that he “can’t go on forever” and promises to tell him his “most precious candy making secrets.” (If you haven’t seen this movie, take some time to watch it and enjoy the “Hollywood” technology and engineering being used; it is fantastic for the time).

With more than 40 years in this profession, I have seen a lot of changes, including three name changes and countless curriculum movements (who could forget modules?), and I have worked with hundreds (if not thousands) of preservice and inservice technology and engineering education teachers. Despite the constant change throughout my career, there is one thing I have experienced consistently. There are amazing thinkers, doers, innovators, and even some “tinkerers” who have a passion to provide youth with exciting hands-on, problem-solving learning activities and experiences that promote technological literacy (i.e., the ability to use, understand, manage, and assess technology), career exploration, and opportunities to learn about the concepts and practices used in science, technology, engineering and mathematics (STEM).

by
Edward M. Reeve, DTE
I can honestly say that I have never once dreaded going to work and that I still get excited watching students learn, especially when the “light goes on” (accompanied by a big smile) as they finally get it and understand!

My career has been a fun ride, and I was humbled and honored to be elected President of the International Technology and Engineering Educators Association (ITEEA), as it allows me to follow in the footsteps of so many previous great leaders and visionaries. However, I am getting “older” and I can’t do it alone; I need your help! So, as President of ITEEA, I am doing something a bit unconventional, I am giving you ITEEA just like Willy Wonka gave Charlie the Chocolate Factory! That’s right, ITEEA is yours! When you joined, you automatically got a “golden ticket” as a professional member!

Congratulations, as you are getting a wonderful association (founded in 1939) that includes a network of members (e.g., teacher educators, supervisors, classroom teachers, and collegiate students) and affiliates who have passion for STEM Education, hands-on learning, innovation, and technological literacy for all. You are getting well-written standards-based Engineering by Design™ (EbD) curricula, the STEM Center for Teaching and Learning™, Technological Literacy Standards, exciting professional development and networking opportunities (especially the international conference), a strong Affiliate Network, an interactive modern website, and a fantastic Board of Directors and ITEEA office staff who can help you with your association.

Again, congratulations on getting ITEEA, and don’t worry, I’ll be here all year as President and will help you with the organization! Just as Willy Wonka promised to give Charlie his most precious candy making secrets, I will share below what I believe are my three most “precious secrets” on how to get the most of your organization so that it continues to grow and prosper.

**Secret #1: Encourage Everyone to Get Involved**

Throughout my entire career in ITEEA, I have always been involved. From small projects to large responsibilities, (e.g., serving as an ITEEA conference chairperson), I made a personal commitment to be involved. Why? Because for me it feels good, as I enjoy helping people. I believe it is important to give back to the organizations with which we are involved, and I believe providing service is part of being a true professional.

ITEEA is an organization that works continuously for its members, and you must continuously work to encourage other members to get involved. You must demonstrate the value of being involved and that each voice really does matter. I personally get tired of the excuse “I am too busy”—we are all too busy. Teach members to get involved. Even if it is just something small, just do it! There are many ways to get involved with ITEEA, and here are some examples: join an ITEEA Committee or Council, become involved and contribute to an ITEEA listserv, present at the conference or participate in the STEM Showcase, become involved in sponsored professional development opportunities, write a journal article, or get involved in working with student-related organizations. Email me for ideas!

**Secret #2: Encourage Members to Network With Their Colleagues**

Networking is all about connecting with other “like-minded” colleagues to share ideas, thoughts, and resources, and your ITEEA offers many opportunities to network. In my opinion, the best opportunity is the annual international conference that provides many formal networking opportunities, including conference presentations, professional development workshops, luncheons, and vendor-sponsored activities. However, my favorite networking opportunities almost always occur in non-formal settings (e.g., on a couch in a hotel lobby, or even at a lively restaurant) where you and your colleagues can connect and/or debate on a variety of issues, including opportunities and challenges the profession faces.

ITEEA has many wonderful resources that can be used for sharing information and networking. I wish ITEEA’s IdeaGarden forum had been around when I was a new secondary education teacher because I know I would have used it a lot. I believe this is a fantastic resource for teachers (and others), and it would have helped me get the maximum number of copies from the ditto machine (Google it—it’s the technology we used to make handouts for classes many years ago).

In addition to IdeaGarden, ITEEA has many other publications, including its journals and newsletters (e.g., STEM Connections) and professional communities (e.g., International Centers) that almost always list contact information, and I encourage you to “network” with people with whom you have similar interests or if you need help in answering a question. In my many years of higher education, I always encourage students, especially graduate students, to contact other professionals with similar interests. Although graduate students may feel a little reluctant to do this, they are pleasantly surprised when a contact responds. Remember that education is a “helping profession.” I have found that almost all of those involved in our profession enjoy helping others.

**Secret #3: Promote the Organization**

To actively grow your association, you must actively promote it with others, including those involved in decision making related to technology and engineering education, other organizations involved with STEM, and to the vendors who supply the profession with curriculum materials and experiences.
ITEEA is the professional organization for technology, innovation, design, and engineering educators. Our mission is to promote technological literacy for all by supporting the teaching of technology and engineering and promoting the professionalism of those engaged in these pursuits. As this is now YOUR association, your challenge is to continually promote it. An undergraduate academic advisor recently commented to me that our field of technology and engineering education is a “hidden gem.” She said that as soon as students find out about our major and get involved in it, they become passionate and want to do more. They often comment that they can’t believe they found this major, because this is what they want to do. We are the original “Maker Movement,” and we do STEM Education. It always amazes me when other educational professionals from around campus stop by our labs and witness the activities and experiences we are doing and immediately say “now I understand STEM.” ITEEA is a wonderful organization, and you must take up the challenge of getting the word out by showing others the benefits and services it provides to its members.

So there you have it—as your newly elected President, I have given you the association, and a few secrets to help you keep it moving forward so that it continues to grow and prosper! Also, remember that I, along with the rest of the ITEEA Board of Directors and headquarters staff, will be here to help you. So please feel free to contact us at any time with questions, concerns, etc. I want you to know that I feel GOOD about giving you the association. Over the past few years I have had opportunities to interact with many of the association’s members and future leaders, and I am very, very pleased with what I have seen. I know ITEEA (“the Chocolate Factory”) is in good hands. Please take care of it, and make sure to “turn the lights off” when you leave – OK?

Edward M. Reeve, DTE, is 2017-2018 President of ITEEA. He currently serves as a Professor in Technology and Engineering Education and Interim Vice Provost at Utah State University, Logan UT. He can be reached at ed.reeve@usu.edu.

REGISTER FOR AN UPCOMING I-STEM EDUCATION PLC

The ITEEA STEM Center’s™ PLCs (Professional Learning Communities) are designed for practicing teachers, preservice teachers, graduate students, and other stakeholders seeking a community of practice for successful implementation of Integrative STEM Education. Technology and Engineering Educators can take advantage of this PD opportunity to lead your school and district STEM initiatives.

Housed in ITEEA’s LMS, EbD-BUZZ, and grounded in five monthly interactive online sessions during the Spring 2017 semester, the I-STEM Ed PLC is comprised of presentations, discussions, networking, and Q&A opportunities.

PLC sessions address topics critical to the successful implementation of I-STEM Education. Learn more or register now at www.regonline.com/Register/Checkin.aspx?EventID=1838038 or contact Dr. Jennifer Buelin at jkbuelin@iteea.org.

Member rates apply to ITEEA members as well as EbD consortium state members and EbD Network School members. For more information about membership options, email msato@iteea.org.
Introduction: Sensing the World Around

We live in a sensory world where our vision, sound, touch, feel, and smell make lasting impressions of our awareness about the world around us. Humans and other creatures alike employ a variety of physiological sensory organs and features that enable the navigation and perception of our unique environments as well as our survival. In the human and animal world, there are the senses of sight, hearing, smell, touch, and taste, also known as “the five senses.” As an extension of these senses, we are able to sense and differentiate temperature such as something that is cool or warm as well as a sense of balance and vibrations (Zamorra, 2017).

Today, robots and robotic technologies are becoming smaller and more intelligent. Robots and intelligent machines are moving from the factory floor, where they are used for handling materials and automatic manufacturing processes, into our daily life. We see them in retail stores, homes, and medical facilities attending to the many needs of customers and patients. When we visit a supermarket, convenience store, or home products warehouse, we are likely to see an automated point of sale (POS) display promoting a product or service. One or more specialized sensors that sense the presence of a customer passing by will activate the device and display a product message. These digital POS technologies are capable of displaying video and still images along with specialized audio and video messages. They are changing the way that consumers shop and make purchase decisions for goods and services.

by
Walter F. Deal, III, DTE
and Steve C. Hsiung
One of the newest developments in the family of intelligent service robots is NAVii™ (Figure 1) developed by Fellow Robots, Inc. in Silicon Valley, CA. NAVii™ is an “adult-sized robot” that is being introduced in retail sales environments. NAVii™ can assist customers in providing basic product information, locate products in the store area, perform inventory tasks, and augment the support to customers. Personal service robots can provide interactive assistance to help customers with basic product information and guide customers to the product locations. This enables knowledgeable salespeople to assist customers needing assistance with difficult project needs. NAVii™ incorporates a variety of sensors such as sound (speech) and voice recognition, touch screen and display technologies, and other sensors to interact with customers in an efficient manner. The leading-edge technologies used in the design also enable NAVii™ to interact with customers and sales personnel in multiple languages (Fellow Robots, 2017).

Sensors and sensor technologies are changing the way that we go about our daily lives and activities. Recreation, health, and medical areas integrate a wide variety of new and innovative sensor technologies into medical monitoring and diagnostic equipment to improve health care and fitness. When a person visits his or her family physician for a health check or sports fitness exam, special sensors are used to check vital signs. Sensor technologies can measure heart rate, blood pressure, temperature, oxygen saturation, and perform other tests. Digital scales provide an accurate measure of weight and body mass index (BMI). These kinds of tests provide a measure of a person’s general health. Joggers and running enthusiasts may have sensors placed in their shoes that synchronize with a sports watch or smartphone to measure pace, distance, elapsed time, running speed, and GPS data. These sensors provide real-time information during training to maximize performance and safety. Similar sensor technologies may be found in specialty cyclist computers available at cycle shops. Bikers and cyclists enjoy GPS-enabled route monitoring, speed and cadence tracking, and heart rate monitoring, along with Bluetooth connectivity to indoor trainers.

The digital technological age has brought a new meaning to our definition and meaning of sensory perception. We can no longer look at it as only a physiological phenomenon. Sensors are becoming one of myriad analog and digital sensory devices and technologies that are integrated into the products that we use and interact with at home, recreation, and work. As we look toward technological sensors, we commonly see sensors that sense heat, light, touch (tactile), sound, voltage and current, vision, and mechanical changes (stress and strain). The more we examine the field of sensor technologies, the closer we see on the horizon a broad spectrum of smart and interactive sensors. Smart sensors are devices that take physical environment signals or conditions and perform predefined functions and process the data before passing it on. These sensors have advanced features and signal conditioning capabilities with microprocessor/microcontroller assistance and predefined communication protocols between devices that make them intelligent. We generally think of intelligent sensors coupled with computer functions that are capable of processing and interpreting raw data, making it readily usable. Additionally, intelligent sensors have the capability to perform self-tests and diagnostics and adapt to changing conditions (Techopedia, 2017).

Defining Sensors

A sensor may be defined as a device capable of detecting or measuring physical, mechanical, or electrical properties and responding in a particular manner. A sensor can provide us with information about the state, condition, or event being measured. The result can be some type of movement, motion, distance, or a voltage, current, or resistance.

Several of the most common sensors that we encounter in our daily lives sense heat, light, pressure, humidity, proximity, level, or position. Our homes and apartments are temperature controlled. A thermostat regulates the comfort level in a home or apartment. In the past, thermostats were simple electromechanical/thermocouple devices that would expand or contract based on the temperature changes, activating a mechanical switch to turn on the heating or cooling system until a predetermined temperature was reached. These mechanical devices consisted of a bimetallic spring and mercury switch that changed in a linear manner according to the temperature. As the bimetallic spring changed positions, it would shift the position of the mercury switch. The “closing” of the mercury switch would signal the system to “turn on” and provide heat or cooling.

Today we can readily find smart Wi-Fi thermostats in residential and commercial settings connected to the internet. They can be controlled with smartphone apps or computers. These new thermostats incorporate programmable features for heating and cooling cycles according to time of day, monitor and adjust humidity levels, have proximity sensors that “know” when you are around, and incorporate adaptive technology that learns your habits to adjust comfort levels. Additional features include the capability to send you reports about your energy use based on usage patterns and voice recognition. Overall, these new thermostats can provide a path toward a comfortable environment efficiently and economically.

There are other temperature-sensing technologies commonly used to sense or measure temperature. Several of these include thermistors and solid-state temperature-sensing devices. Thermistors are commonly found in many types of heating devices such as temperature-controlled soldering irons currently found in technology labs. Thermistors are temperature-sensitive resistors where the resistance changes in relationship to the temperature. They may have positive or negative temperature coefficients. The
change in resistance coupled with support of a signal condition-
ing circuit can produce an analog voltage when used with a voltage divider or bridge circuit. The voltage measurement is inter-
preted and displayed as a temperature reading or as data used for control and monitoring purposes. We see thermistors used in microwave ovens, rechargeable batteries to monitor charge and discharge temperatures as a safety measure, electronic circuit protection, and digital thermometers. Figure 2 shows a tiny thermistor.

Another temperature-sensing device is a thermocouple. A thermocouple is an electrical device that consists of two differ-
ent conductors forming electrical junctions at differing tempera-
tures. Thermocouples are used in pyrometers for measuring the temperature of molten metals, flame sensors in gas water heaters and gas furnaces.

There are many applications of infrared (IR-LED) light technolo-
gies. We see IR-LED technologies at work with our smartphones, digital and video cameras, and television and appliance remote control devices. Proximity sensors are used as motion detectors and security sensors in homes and businesses. IR devices consist of Infrared “pairs” where there is an Infrared transmitter and matching Infrared receiver or phototransistor. Usually an Infrared remote sends a series of digitally coded pulses of infrared radiation used to control power (on-off), volume, channel selection, temperature set point, fan speed, or other features that are provided by a device or appliance. The modulated frequency is used to reduce interference, improve range, and as a measure of security. Figure 3 shows several different types of sensors that measure temperature, distance, acceleration, or motion that we encounter in our daily travels.

Today’s washing machines may be smarter than you think! They now incorporate a variety of sensor technologies that maximize washing efficiency while reducing cost and minimizing water and electricity use. Programmable washing cycles address delicate fabrics, size of the wash load, and soil condition of the clothes. Specialty sensors can measure the quantity of water needed for wash cycle, out-of-balance conditions—vibration, load, and revo-
lution sensors—water temperature, and even use a foam sensor to detect if too much detergent has been added (Hitachi, 2017). All of these new sensor technologies are part of a hardware-software system that sets them apart from washing machines of past generations.

Twenty-First Century Sensors

Sensor technology, along with many other technologies, has moved into the twenty-first century with the development of MEMS technology (Micro-Electro-Mechanical Systems). MEMS devices are based on microfabrication techniques that use electro-mechanical elements to convert measurable mechanical signals into electrical signals to sense real-world temperature, pressure, inertial forces, chemicals, magnetic fields, and radia-
tion. MEMS devices are used in military, automotive, medical devices, appliances, toys, entertainment products, and real-world applications that affect our daily life. Examples include airbag restraint systems in automobiles, motion and orientation detection sensors in smartphones, blood pressure measurement, intelligent and high efficiency washing machines, flying drones in military and civilian applications, ink jet print heads, gyro and accelerometer, and many other products. Today all automobiles are equipped with air bags that deploy in collisions. Seat and air bag sensors provide information to electronic control modules.
that determine the size, weight, and position of an occupant for proper deployment of an air-bag system and safety of the passenger.

Have you ever noticed a little “tire and exclamation point” pictogram or symbol on an automobile dashboard or display? That little symbol represents one of many sensor technologies used in automobiles and is called a tire pressure monitoring system or TPMS. Each automobile wheel is fitted with a TPMS sensor that sends real-time data to the driver indicating a “low tire pressure” condition. The sensor also sends diagnostic information, battery life, temperature, pressure, and unique sensor identification. Other TPMS technologies are dependent on the moving dynamics of tire size and speed to determine low-pressure conditions. The purposes of the TPMS technology are driver and passenger safety, to reduce accidents, to maintain fuel economy, and to reduce tire wear (BartechAutoID, 2017).

MEMS sensors may be based on special types of silicon, polymers, metals, or ceramics (Wikipedia, 2017). The MEMS sensors are micro-miniature mechanical products manufactured at the micron level. These micro sensors such as multi-axis accelerometers and gyros may have moving elements similar to much larger physical components found in traditional sensors that have moving parts (Figure 5). A MEMS sensor may have moving parts made from polysilicon that possess capacitive properties. The tiny movement and capacitive nature of the materials provide the capability to interpret the changes in capacitance as a value that corresponds to some movement, orientation about some axis (x and y), or change in position (acceleration) (Weinberg, 2017).

MEMS sensors are an important part of all smartphones today. The picture and video resources in technology and engineering

The signal output of MEMS devices is electrical, so almost all the related MEMS applications are associated with embedded systems. These sensors, coupled with microcontrollers and microprocessors, use a defined communication protocol between devices such as SPI (Serial Peripheral Interface) bus and I2C - Inter Integrated Circuit bus. The embedded applications result in intelligent sensors that use MEMS to sense different real-world environment information in a variety of formats to meet the needs of individual products or machine applications.

It is important to note that MEMS sensor technologies integrate the sensing technology with the signal conditioning and processing technology. Sensors that combine these functions are called intelligent sensors. These intelligent sensors may combine several functions such as a MEMS accelerometer, three-axis gyroscope, and temperature sensor all in one package coupled with digital signal processes signal capabilities. Many smartphones such as iPhone® and Android® have a number of sensors such as a proximity sensor, an ambient light sensor, temperature sensor, gyroscope, accelerometer, and GPS packaged in a small footprint (Costello, 2016). These sensors, along with the devices’ software and accompanying apps, make a smartphone smart! Similar devices are used with other technologies such as drones, robotic toys, and other electronic appliances. An example is the WowWee® MIP® or Mobile Inverted Pendulum shown in Figure 4. MIP™ has seven game modes plus the capability to interact with other MIPs. MIP™ uses similar gyros, accelerometers, and Inertial Measurement Units (IMU) that are found in sports fitness technologies as well as health monitors, autonomous robots, and virtual reality devices.

A Sharper Image

The world of photos and videos has undergone a quantum change in the technologies that we use to capture a moment in time with a photo or video. Not too long ago the term “selfie” was unheard of! Digital imaging technologies have become so pervasive that they are found nearly everywhere. Image sensors are important parts of all smartphones today. The picture and video...
Two of the most common image sensor technologies are the charge-coupled device (CCD) and complementary metal oxide (CMOS). In the early 1980s NASA used the CCD image sensor technology to document and record data from space missions. The CCD technology was costly and not very efficient. NASA engineer Eric Fossum thought there was a better way to capture images. His work paved the way for many developments in CMOS imaging. At the time, CMOS image technology was in the early stages of development and was moved to another microprocessor platform that allowed each pixel to serve as a charge amplifier. The result was an image sensor that used less energy and made each pixel more sensitive. NASA uses the CMOS sensors extensively in its space programs. Soon the CMOS technology mushroomed into the most widely used imaging technology for consumers, business, industry, and medicine (NASA, 2017). Today most smartphones and many digital cameras incorporate CMOS image sensors (Figure 6). The advent of digital imaging technologies began the retirement of traditional film and paper photography in the consumer market.

A Smarter 3D Rover—3D Rover Project Revisited

A previous issue of Technology and Engineering Teacher included a description of the 3D Rover that was based on developing a 3D printed rover. The goals focused on the design, problem solving, and production skills to make a rover using 3D printing technology. Additionally, the rover platform was integrated with a drive system and microcontroller technology. The introduction of the Arduino UNO®, Integrated Development Environment (IDE) software and 3D printing experience facilitates STEM technology-based critical thinking and problem-solving skills for technology and engineering students. The 3D Rover introduced 3D printing concepts, basic programming skills, and the integration of Bluetooth smartphone control technologies.

The new 3D Rover design incorporates a smart sensor—an ultrasonic range finder—to provide a degree of autonomy. It was back to the "drawing board" to design a simple mount to secure
the ultrasonic sensor to a model servo. The ultrasonic sensor was carefully measured using a digital caliper and machinist’s scale to produce dimensions for sketching designs. Several of the criteria for the mount were to require a good fit for the sensor, easily attachable to servo, and minimum ABS material and printing time as shown in Figure 7.

The redesigned 3D Rover platform features a cutout for a standard model R/C servo and changing the drive motor mounting arrangement. Alternatively, a smaller 9g micro servo can be used in place of a standard servo. Additionally, there were changes in the electronic controls used with the revised 3D Rover to simplify its design and fabrication. The revised 3D Rover components incorporated the original drive motor and wheel assemblies and Arduino UNO board. However, the motor controller and battery system were changed. An Arduino L298P motor shield was selected to eliminate the separate 9-volt battery supply for the Arduino UNO and provide a means to control the drive motors. The motor shield is a miniature add-on board that plugs into the Arduino UNO. Additionally, the motor shield simplifies the wiring and input/output connections to control the motor direction and speed. Two 18650 3.7-volt lithium polymer (LiPo) batteries, battery holder, and off-on slide switch provide the necessary power for the rover.

**How 3D Rover Uses Ultrasonic Data for Navigation**

The Arduino ultrasonic sensor consists of two small transducers. A transmitter and receiver pair work together to send and receive a 40-KHz signal at specific intervals. The basis of operation relates to the time that it takes a sound wave to travel to an object and return. The transmitter unit sends a “chirp” (pulse of energy) and an echo that is returned to the receiver unit. The result would be the total time to and from the object.

There are several insights to consider. We can think of a sound wave as a pressure disturbance that travels through some medium by means of particle-to-particle interaction. As one particle becomes disturbed, it exerts a force or pressure on the next adjacent particle. The disturbance of one particle to the next particle transports energy through the medium. For our purposes, the medium is air at room temperature. It is important to note that the medium (a gas, liquid, or solid) and temperature have a significant impact on the speed of sound a sound wave. Like any wave, the speed of a sound wave refers to how fast the disturbance is passed from particle to particle (Physics Classroom, 2016).

The relationship of speed of sound can be expressed as speed = distance/time and distance = time X velocity. The following events illustrate how the Arduino software routine determines the distance of an object obstructing the travel of the 3D Rover.

- Initialize the Ultrasonic sensor.
- Send a 10 uS wide pulse to the sensor Trigger Pin. (The sensor will automatically send out a 40 kHz signal.)
- Begin monitoring the sensor output from the Echo Pin.
- When the Echo Pin goes high – begin a timer.
- When the Echo Pin goes low – store elapsed time from the timer. (Use conversion formula to calculate distance in cm.)
- Distance (cm) = (elapse time in microseconds * velocity in cm/microseconds)/2

The distance in cm must be divided by 2. Remember a pulse is triggered and sent, and an echo is received. The sensor returns the time it takes to make a round trip, which doubles the distance the sound travels. Note that the sound velocity = 340 meters/second, and by converting to cm we have 0.034 cm/microseconds. The obstacle distance is easily calculated as distance = time X 0.034 cm/microseconds/2.

Our Arduino needs to be programmed to use the sensor data (distance) derived from our ultrasonic sensor to control the direction and state of the drive motors in an obstacle-avoidance program. If the 3D Rover encounters an obstacle in front of its travel path, then the 3D Rover should stop “looking around” for a...
clear path. Subsequently, the 3D Rover should back up, turn left or right, and travel in a clear path or direction. Should a simple increment counter loop be included with our avoidance program to enable the 3D Rover to avoid making the same avoidance mistakes repeatedly? An increment counter can be used to make the 3D Rover try an alternate path that is free from obstacles and obstruction!

There are many other sensors that can be added to the current 3D Rover platform. The use of an IR sensor will eliminate the sensitivities of the ultrasonic sensor that is too sensitive to the light source or materials used in the room. Note that soft surfaces reflect sound differently when compared to hard surfaces. A wireless camera can provide pattern recognition input for the microcontroller to guide the 3D Rover as an obstacle recognition and avoidance capability. An IR sensor transmitter-receiver pair can add a line-tracking feature where the 3D Rover will follow a line all by itself. Adding a Lidar detector or GPS tracking capability are also choices to make it autonomous and not restricted to following a line or indoor environment. Additionally, adding a MEMS gyro and accelerometer to the 3D Rover can enhance the balance control that enables it to be operated over rough terrain environments rather than a level floor or surface.

Summary

Sensors of all kinds play significant roles in the way that we use and interact with technological devices today. Smartphones, household appliances, automobiles, and other products that we use every day incorporate many different kinds of sensors. While the sensors are hidden from view in the products, appliances, and tools that we use, they nonetheless extend our senses in unique ways. Image sensors, accelerometers, gyros, temperature, motion, and proximity sensors and other types of sensors all work together to enable us to work smarter and enjoy a productive and healthful life.

This article is just a start to integrate the currently available sensor technologies into a STEM project that can be used in the classroom. The introduction to different sensor technologies, particularly smart sensors, will encourage students to think about using off-the-shelf, readily available technical devices. Many different kinds of sensors can be added in a useful manner to projects such as the 3D Rover. The introduction and modification of the 3D Rover concept can be used in a variety of classroom activities and project designs. The 3D Rover can introduce students to a variety of sensor technologies that can be useful teaching tools in learning about our technological world.

Reference


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Many vocational education, 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 tenth 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 and scope of this Legacy article are Jack Wescott and Don Smith from Ball State University.


by Johnny J Moye, DTE, Jack W. Wescott, and Donald F. Smith
Ball State University has had a national reputation for producing industrial arts and later technology education teachers for decades. The department was equally noted for producing strong teachers, administrators, and teacher educators. What ideas were working to produce these educators? Describe the characteristics of the type of educator that you desired to prepare through your undergraduate program.

The characteristics of the educator that the undergraduate program desired to prepare were derived from the following questions: (1) What are the essential qualities of a good technology education teacher? and (2) How can we assist the individual to become a good technology teacher? Although not intended to be all-inclusive, the following is a short list of characteristics that were desirable for the undergraduate program.

**Technical skills.** Possessing a technical skill set has always been a major focus of the undergraduate program, since the learning experience has always been activity/laboratory-based. For several decades prior to the early 1980s, students developed technical skills by taking coursework in unit shops such as woodworking, metals, plastics, electricity, and drafting. This was appropriate, since most of the graduates would be hired into public school programs offering courses in these areas that were taught in facilities similar to those they experienced at the collegiate level. As the profession began the transition to a technology emphasis, technical courses were implemented, with the emphasis placed on the areas of technology that included manufacturing, construction, communication, and transportation.

**The act of teaching.** The professional sequence courses focused on the "act of teaching." The program has always recognized that prospective teachers needed to be just as knowledgeable about how to teach as what to teach. Likewise, it is critical to the success of any teacher education program that graduates were able to enter the ranks of teaching having mastered the basic skills of teaching. The professional sequence addressed such topics as teaching strategies, course planning, classroom management, and facility planning. In more recent years, a special emphasis was on placing the undergraduate student into the public schools prior to student teaching. These public school experiences would provide the prospective teacher with the opportunity to actually plan and teach a unit of instruction.

**Self-learners.** It is more important than ever before that prospective teachers are able to teach themselves. The undergraduate student should not stop learning simply because he or she graduated. This is a characteristic that has been emphasized for years at the undergraduate level. An example of this need is that the public school teachers of industrial arts and later technology education have always been faced with the challenge of remaining knowledgeable of the content they teach. The increased use of computers and other emerging technologies has forced teachers to constantly teach themselves.
Interest in students. Possessing a genuine interest in students is a key ingredient to any teaching-learning process. Alumni, as well as current and emeritus faculty, have consistently expressed a genuine interest in the program. Although showing an interest in students was covered in classroom discussions, faculty members were able to demonstrate through their actions a genuine concern for students. Faculty members were able to demonstrate their genuine interest in students by the following:

- Serving as faculty sponsors for student organizations (student competitions such as Technology Education Clubs of America).
- Serving as mentors to students interested in pursuing a career in education.
- Actively interacting with students at events such as state and national conferences, campus-wide activities, and activities sponsored by student organizations such as professional honoraries and technology clubs at the local level.
- Inviting students to collaborate on professional activities and/or research projects.
- Encouraging students to copresent with faculty members at conferences.
- Nominating and recognizing students in awards programs at the local and national levels.

Ball State was known to have a strong faculty from the early part of the last century. Who were a few of the most outstanding people who built the department before and during your administrative experiences, and what were they known for doing?

The long-term success of the teacher education program can be traced directly to the faculty. Over the years, faculty has created an outstanding record of successful teaching, scholarship, and professional service. As a group, the faculty possesses the following attributes that made it successful: (1) expertise in a content area relevant to the preparation of technology education teachers; (2) willingness to remain current in the trends and issues facing the field; (3) sincere interest in the success of students; (4) ability to effectively interact with colleagues in the department; and (5) ability to conduct and present research findings.

Faculty contributions to the field at the national level were numerous. A good example was service to the Council on Technology Education (CTTE, now CTETE), specifically the CTTE yearbook. Since the early 1970s, nine individuals served as editor or co-editor of a yearbook. Even more impressive was that 22 chapters of yearbooks were authored by Ball State faculty. Four faculty members provided leadership to the organization by serving as elected officers in the organization. Furthermore, eight graduates of the department served as editor, co-editor and/or author of a yearbook. Faculty members also made significant contributions to the Mississippi Valley Technology Teacher Education Conference by serving as invited presenters and serving as appointed members of subcommittees.

Yet another example of the faculty's contribution to our field was the Manufacturing Forum. During this time of curriculum change, it was determined that teacher education and public school teachers needed new sources of curriculum for teaching manufacturing in a laboratory setting. Thomas Wright, Donald Smith, and Richard Barella planned the publication and alternated as editors. Beginning in 1976, three issues were published each year. Distribution was by subscription for the cost of the materials.

A final example of service and scholarship at the national level was the involvement of faculty with the International Technology Education Association (ITEA/ITEEA) and its predecessor the American Industrial Arts Association (AIAA). In addition to serving as elected officers for the organizations, faculty members served as chairs of committees, committee members, presenters, and organizers of national conventions. Faculty members were mentored and encouraged to participate and make presentations at regional and state conferences. The following is a list of faculty and a brief description of their expertise:

Teacher Education Faculty
- Richard Barella (deceased): Professional sequence courses
- Sam Cotton (active): Career and technical education, Department Chair
- James Flowers (active): Graduate Coordinator, using and assessing technology, rapid prototyping
- Richard Henak (deceased): Constructions, professional sequence courses
- James Kirkwood (retired): Elementary school technology education, graduate seminar, graduate history
- Jake Reams (retired): Professional sequence courses
- Mary Annette Rose (active): Graduate research and statistics, environmental sustainability, energy
- Richard Seymour (active): Teacher education coordinator, mentor/advisor to student organizations, elected officer in numerous professional organizations
- Ray Shackelford (retired): Materials processing, teaching methods, facility planning, teacher education coordinator, Department Chair
- Donald F. Smith (retired): Manufacturing, Department Chair, Dean
- Jack Wescott (retired): Construction, research and statistics, Department Chair, Associate Dean
- R. Thomas Wright (retired): Manufacturing, graduate curriculum, textbook author, elected officer in several professional organizations
Your tenure at the university covers many decades. How did the curriculum change over the years, what changes did that cause with the faculty, and how did your position within the university change as a result of your department’s directions?

The early 1980s were the beginning of a significant change in our profession. The change was the transition from industrial arts to technology education. As a result, the Ball State program made the decision to revisit how teachers were prepared at the undergraduate and graduate levels and also made a commitment to provide in-service education for existing teachers at the public school level.

At the undergraduate level, the technical courses made the transition from traditional unit shops such as woodworking, metalworking, and drafting to the technology areas of communication, manufacturing, construction, and transportation. The teacher education faculty made the decision to teach the technical courses in the content areas of technology, since it was thought that the undergraduate students would teach as they had been taught. This was quite different from the approach of other similar institutions of higher education where teacher education students were taught technical courses by faculty in other technology programs, and their only experience with technology education was during the professional sequence (teaching methods, curriculum development, classroom management, etc.). A major challenge for several years was the renovation of facilities to meet the changing curriculum needs and new majors within the department. The program has been at its present location since the early 1950s when it housed the industrial arts department, business education, and home economics. Over the years, the building has undergone several updates and renovations to support program revisions. The reallocation of laboratory space was always a point of discussion due to fluctuations in enrollment and new technologies, especially since the facility included additional technology-based programs such as manufacturing engineering technology, graphic arts management, computer technology, and construction management. The name of the building was formally changed to the Applied Technology building in the late 1990s and continues to house the departments of Family and Consumer Sciences and Department of Technology. A major renovation of the building is currently in progress.

It was also during this transition that The Center for Implementing Technology Education (CITE) was established under the leadership of Dr. R. Thomas Wright. The Center provided public school teachers nationwide with teacher and student activity guides for public school teachers and administrators. This effort to assist public school teachers and administrators in making the transition to technology education was significant, since many of them had little or no experience with teaching and/or implementing a technology-focused program. Additionally, Ball State was instrumental in providing the leadership for writing and distributing curriculum guides for middle school and senior high schools in the State of Indiana.

Your graduate program was known for being just as strong as the undergraduate level. What type of education did a person earn who received a graduate degree from your department?

The graduate program in technology education has experienced several decades of success. Graduates had a long record of providing leadership and direction for the field at the public school level and institutions of higher education. In addition, graduates have also held key positions at state departments of education.

During the 1970s, the graduate program offered a series of required core courses as well as the opportunity for students to select a limited number of electives. The required core courses included offerings in the traditional areas of advance methods, research, curriculum, history and philosophy, as well as seminar (selected topics) courses. A thesis option was also provided for students who had an interest in conducting research or expressed a desire to continue their formal education by pursuing a doctorate. Students were also given the opportunity to work closely with an advisor to select graduate courses outside of the department in an area of special interest. It should be noted that a review of course offerings for a master’s degree at similar institutions during this time period would indicate that the plan of study described above was not unique to our field. So it begs the question, if the courses in the program were not unique, why was the program so successful? There were three major factors that contributed to the success of the program.

Faculty. First and foremost is the outstanding quality of the graduate faculty in the teacher education program. Over the years, approximately 6-8 faculty members held graduate faculty status. In most cases, these members possessed expertise and experience related to a required course in the program. As a result, the faculty member took ownership in a course and spent a significant amount of time assessing the course and making revisions when needed. But being an expert in a content area was not enough. The graduate faculty members were expected to meet as a group on a regular basis and cooperatively interact to assess the program and discuss possible revisions and improvements. It was also common practice for faculty members to present their course for peer-assessment purposes. The discussions that followed were often lengthy and rigorous. Speaking as a department chair, the teacher education faculty was greatly appreciated for its cooperative efforts in responding to challenges and administrative requests in a prompt and thorough manner.

Graduate assistantships. Traditionally, the department regularly offered graduate assistantships to students who were interested
Development of an online graduate program. The development and implementation of a graduate program that was offered 100% online was a defining moment for the graduate program at Ball State. The 1990s began a period of declining enrollments for face-to-face graduate education. It is difficult to determine exactly why the graduate enrollment declined, but it appears to be a reflection of declining undergraduate enrollments across the nation as well as universities dropping face-to-face technology education graduate programs. It also became an issue of economics, as public school teachers were unable to leave their teaching positions to pursue a graduate degree full time. The faculty promptly recognized the problem and met as a group on a regular basis to discuss possible options, one of which was offering the program online. After much debate, the faculty made the unanimous decision to offer a master’s degree in technology education and career and technical education 100% online. It is safe to say that several individuals expressed serious concerns about the effects of an online delivery of the program and the effect it would have on the quality of the graduates. As discussions continued, it soon became evident that the program might not survive if changes did not occur. To complicate things, the faculty had little or no experience teaching online. But when the smoke settled, the group was willing to move forward. This was yet another example of the faculty working cooperatively as a team to take a "leap of faith" for what was in the best interest of the program. Under the leadership and expertise of Dr. Jim Flowers, the faculty began to address the issue of strategies for teaching online. The entire faculty agreed to meet as a group with no stipend during a summer to learn about online course organization and instructional strategies. Each faculty member was assigned the task of developing an online delivery of the core course that they were currently teaching face to face. The end result of faculty efforts was the creation and implementation of the first master’s degree in technology education program to be offered 100% online.

Of what achievements from your department are you most proud?

This is easy—we were most proud of the people at Ball State—faculty, students, and alumni. We always believed and will continue to believe that our position as department chair was about assisting faculty and students to reach their goals in the areas of teaching, scholarship, and professional service. There was great pleasure in attending conferences and meetings across campus and across the nation to observe the success of the faculty, students, and alumni. For us, accomplishments were not so much about awards and resumes and promotions, but how we were able to make a difference in someone’s career.

Any department chair would be proud of what was accomplished by the faculty as a team—a team that was composed of individuals from different backgrounds and academic interests, yet a group that was always willing to work together to address the issues related to the preparation of technology education professionals and make timely decisions that were always in the best interest of the program.

Thank you Doctors Wescott and Smith for your service to the profession and for sharing some of the highlights of your work at Ball State University. The Legacy Project has now interviewed ten 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.” In a few months the next interview will appear in this journal. If you have a suggestion of a leader to recognize, contact the author with that person’s name and contact information.

Note: All Legacy Project articles are posted on the ITEEA website at www.iteea.org/LegacyProject/44141.aspx#tabs.aspx.
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All teachers, regardless of grade level and subject area, have a basic responsibility to provide a safe learning environment for their students. In addition to an instructional space such as a classroom, many technology and engineering teachers have a laboratory area that can contain a variety of tools, machines, materials, and supplies for use in instructional activities. These items can make for potentially hazardous situations if the teacher is not observant and diligent at all times with respect to their proper use, maintenance, and oversight. When it comes to the provision for a safe learning environment, technology and engineering teachers have a higher standard to uphold compared to other academic areas.

Related to this higher standard, technology and engineering teachers need to have an understanding of the basic tenets of liability with regard to their classrooms and labs. Liability is a part of tort law, which addresses civil wrongs and generally examines harm inflicted on one party by another. Technology and engineering teachers need to be aware of the fundamental premise of tort law, which states that individuals are liable for the consequences of conduct that results in harm to others. The teacher could be held liable for any injuries the student incurs, and the teacher may have to pay some type of restitution to the student who was harmed. This is usually accomplished through a lawsuit or litigation, and financial damages could be awarded or the teacher could possibly lose his or her teaching credential. With respect to torts, there are two basic types: negligence and intentional torts.

Negligence relates directly to a teacher’s responsibility to provide a safe learning environment and has four components: A duty of care, a breach of duty, an injury, and proximate cause. A simple example can illustrate how negligence can occur. A teacher is assigned to restroom duty in between class changes and decides on one day to skip his/her assignment. On that day, a fight breaks out in the restroom, and one student strikes another, breaking a nose. The teacher had a duty of care to be present in the restroom, and chose to breach that duty by not showing up. An actual injury occurred, and a court of law would likely determine that the proximate cause of that injury was the teacher’s lack of presence in the restroom.

Negligence cases have occurred many times in technology and engineering labs. For example, a Tennessee technology teacher was found guilty of negligence when he did not instruct students in the proper use of a specific drill bit, had not warned of the dangers associated with its improper use, and was absent from the lab when a student was injured. It is particularly imperative that teachers document safety instruction in their lesson plans and never let students operate equipment and machines for which they have not been given instruction and “checked off” on its proper use.

Intentional torts are, quite simply, intentional acts by one person, and can go in both directions. A teacher or a student could be found guilty of an intentional tort (Zirkle, 2016). There are specific types of...
intentional torts, including assault, battery, false imprisonment, infliction of mental distress, and defamation. Assault is a threat to do harm. A student may threaten an instructor, either verbally, through words, or exhibited through actions (Essex, 2012). The mere threat to do harm can be sufficient grounds for assault charges to be brought forward, and while most school discipline policies have provisions for assault, more serious charges than a school detention or suspension can be levied. Battery is the actual physical act and can range from a simple, seemingly harmless act of a teacher hugging a student, to a student actually striking a classmate or perhaps a teacher.

Every year, across the United States, we read about a teacher who, in dealing with a particularly restless student, felt it would be appropriate to tie the student to a chair or tape the student's mouth closed with duct tape. While most technology and engineering teachers know the acceptable uses for duct tape, this situation is not one of them. This is an example of false imprisonment, or detaining someone against his or her will. Another recent example was when a student was locked in a coat room for a “time out” and the teacher forgot about him for the entire day (Associated Press, 2012). In cases of student misbehavior, teachers are reminded to follow the school board (and attorney or solicitor) approved discipline policies for their school and not try to be “creative.”

Infliction of mental distress is a growing concern for all educators, especially given the issue of bullying. This tort can occur when an individual engages in “extreme and outrageous” conduct that intentionally or recklessly causes severe emotional distress to another (Johnson-Hurtado, 2014). While many may see this as solely a student-to-student issue, teachers must exercise care in their conversations with students. While humor can be effective in establishing positive teacher-student relationships and fostering a “fun” environment for learning, it can also backfire when teachers fail to realize that not everyone may get their joke. Some teachers also believe teasing and sarcasm can be effective motivators for some students; research states otherwise.

Defamation can take two forms: spoken (slander) or written (libel) statements that damage a person’s reputation. Verbal or written statements can be defamatory if they expose another individual to hatred, shame, disgrace, contempt, or ridicule (Stimmel, Stellman & Fischer, 2010). At times, teachers unwittingly commit this intentional tort by making statements about a student’s behavior, academic performance, personal characteristics, and the like to other students. Instructors need to realize these types of comments can be broadcast (and likely exaggerated or blown out of proportion) through the student pipeline. Keeping student performance data private and shared only with individuals who have a legal right to it is also a key provision of the Family Educational Rights and Privacy Act (FERPA).

In today’s litigious society, where individuals can be sued for any perceived infraction, it is imperative that technology and engineering teachers, particularly given the nature of their instruction, safeguard their classrooms, labs, and instructional practices from potential pitfalls. Awareness and knowledge of legal liability can assist teachers in developing sound classroom and laboratory practices to keep themselves out of hot water.

References

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Have questions or a safety issue that you would like to see addressed in a future Safety Spotlight article? Please send them to Dr. Tyler Love at tslove@umes.edu.
Introduction

In Wikipedia, the opening portion of the entry on time capsules begins, "A time capsule is a historic cache of goods or information, usually intended as a method of communication with future people and to help future archaeologists, anthropologists, or historians."

Time capsules always intrigue people, perhaps because they contain that tantalizing taste of the unexpected. One wonders what our ancestors were thinking back then. How could they make such predictions of the future? What factors were uppermost in their minds? Politics? Economics? Environment?

Challenge your students to create a message(s) that they might want to leave for future generations to discover. Here is an excellent way to get those creative juices flowing—have student teams design time capsules that could be left behind for future generations.

by

Harry T.
Roman
Getting Started

Start by doing some initial research, learning about where and how time capsules originated. Is it a universal activity done by all cultures? Is it a regular event or guided by specific events?

What have been the general experiences with time capsules? In addition to what might have been inside, how did the capsules fare against the natural elements of time, temperature, moisture, natural calamities, or war? Is there an optimum number of years that must pass before a time capsule is opened?

What were the sizes and shapes of capsules? Were some larger, maybe more accurately described as time vaults? Has anyone in your class witnessed the opening of a capsule...or have you? Are there firsthand accounts of how people felt about the event?

When time capsules of the past were designed, what methods of gaining public input as to what should be included inside were employed? Have companies ever developed time capsules? If not, why?

There have been time capsules of a sort aboard NASA Pioneer and Voyager space probes. Pioneers 10 and 11, which preceded Voyager, both carried small metal plaques identifying their time and place of origin for the benefit of any other spacefarers that might find them in the distant future. NASA placed a more ambitious message aboard Voyager 1 and 2, a kind of time capsule, intended to communicate a story of our world to extraterrestrials. The Voyager message is carried by a phonograph record: a twelve-inch, gold-plated copper disk containing sounds and images selected to portray the diversity of life and culture on Earth. Check this out on the internet.

The Time Capsule Teams

Here we go: What are the concerns with designing a time capsule? Discuss the typical design parameters below and any others your student teams feel are important.

- Where would the capsule or time vault be located—the physical location.
- What would go into the capsule/vault? How would this be determined?
- How long before the time capsule or vault is to be opened?
- What is the general theme of the message your teams wish to leave to future humans?
- What media will you choose to leave—paper, digital, combination? Other?
- Should past humans make predictions of what may be realized in the future?
- Should heartfelt letters of the time be included?
- How should the capsule/vault be designed for long-term integrity?
  - Underground location or inside a building/wall?
  - Active monitoring of the vault?
  - Provision for anti-theft?
  - If above ground in a building, how would it be protected against fire/flood, etc?

If a magnetic or digital medium is selected, there may be limits to its data integrity with time. How might this be overcome?

Should the site housing the historical legacy be advertised for all folks to know?

Should the capsule/vault be located in a museum or library?

Good luck to you and your students, and try to have a little fun thinking of an impactful message to share with future generations.

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