100+ Activities

to Bring STEM to Life

for Classrooms and

Student Project Teams

by
Harry T. Roman

Author Harry Roman is a regular ITEEA contributor and author of the long-time "Classroom Challenge" feature in *Technology and Engineering Teacher*. As a retired engineer and inventor, Harry likes teaching teachers, students, and school leaders about STEM and its applicability.

To support the important work of ITEEA's Foundation, Harry is permitting this publication to be downloaded at no cost to all—but asks that anyone who downloads consider making a donation to the ITEEA Foundation.

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Introduction

This book is presented in two parts:

- STEM activities for use in the classroom.
- STEM activities for use by project teams.

Please feel free to mix and match these activities as justified by your local classroom specifics—and add some new ones, too. In fact, ask your students to suggest activity ideas, too. You will be surprised what interests them.

Always encourage students to ask questions and seek perspective as they try to creatively respond to these challenges. Make sure they use math as a way to gain perspective and investigate possible solutions. Do your best to banish the math bogeyman!

I learned how to solve design challenges from an inspirational high school teacher who taught STEM concepts and processes back in the 1960s. He was way ahead of his time, revolutionized my world view, and taught me to think multidimensionally. I was not only prepared for college courses in engineering, but also learned the joys of teaching. Whenever I write, lecture, or teach, it is the memory of that marvelous teacher, lifelong mentor, and friend that I celebrate.

Harry Roman

Background

The word STEM has become ubiquitous within discussions about the national economy, entrepreneurship, and world competitiveness. It truly is a curriculum for all students, because it mimics life on the job—something with which all students will be involved for decades after graduation. STEM is a life skill, immune to obsolescence. It is the relevance that students and their parents seek. Every employer wants creative ideas that can be turned into profitable products and services. STEM feeds off creative ideas and teaches how to move those ideas toward realization, i.e., innovation.

STEM is a powerful paradigm, and when taught correctly it:

- Teaches students to think in a multidimensional/multidisciplinary way.
- Integrates the curriculum.
- Fuses content and process.
- Reinforces brain-based research—head and hands.
- Helps banish the "math bogeyman."
- Brings a consideration of the arts into problem solving.
- Fosters confidence and self-esteem, and removes the fear of problem solving.
- Empowers students to embrace failure and vigorously learn from it.
- Shows the relevance of school-to-work activities.
- Shows that solving problems in the real world is similar to creating new products.
- Prepares students for a globally competitive workplace.
- Mimics the essence of America's economy.
- Has the rapt attention of employers.

STEM unleashes the creative talent of students in a focused manner, prompting them to:

- Work cooperatively with team members.
- Communicate and write well.
- Ask tough questions and thoroughly query problems to be solved.
- Naturally present their ideas in an efficient manner, and to justify them.

This book celebrates all this as a practice manual for STEM design challenges, because as we all know, practice makes perfect!

Classroom STEM Activities

Entrepreneurship

- Use the internet, articles, and popular press to identify young entrepreneurs. Discuss what new businesses and products they developed and how these innovations have or will impact the social, environmental, economic, and cultural sectors of our civilization. Study these entrepreneurs and determine the common characteristics they display; for example, how (why) they:
  - Originally came up with the idea for their new product.
  - Felt the need to create the product.
  - Planned and organized work activities to make the product.
  - Selected people to work with them.
  - Overcame obstacles.
  - Handled failure.
  - Etc.

- What are the skills entrepreneurs need in order to be successful? Research the literature to identify key skills and where such skills can be obtained. How are the skills affected by having initial technical skills or not, and discuss where entrepreneurs generally come from today. Can engineers become entrepreneurs? Who else could become an entrepreneur? What do companies look for in business applicants—and why?

- Examine the country's founding fathers…how many of them were entrepreneurs? Did they own their own businesses? How did their entrepreneurship skills influence their design of our nation? Many leaders of the new world of America were natural inventors as they tamed a new land, creating their own equipment and solutions to unique problems. How might this have influenced their business/entrepreneurial interests? Catalog those founding fathers who invented new devices and services. Then ask yourself…do those inventions exist today?

- Identify how entrepreneurs obtain funding for their new products. List sources of funding and examine how those sources may be tapped. How does someone working inside a company as an entrepreneur (commonly known as an "intrapreneur") obtain funding for new products?

- Survey the class to determine students' ideas for new businesses they would like to see started. Ask them to explain why they think such businesses should be started: what is the problem to be solved? Who should be involved in starting such new businesses? Develop a list for each suggestion about the kinds of skills and disciplines people should have in order to be part of the team that develops the new business. Have students justify their choice of skills/disciplines needed.

Technology

- What does the word "technology" mean to students? Can certain definitions and quotes help shed some light on this question? Students should develop their own meaningful definition. Is a computer "technology" or a product of different "technologies" engineered to work together?

- Solar photovoltaic cells were first demonstrated in 1954 at Bell Labs. Trace their development over the intervening

decades and describe how they came to be so visible today. Do all new technologies take decades to become used and useful by the general population? Cite some examples.

- War is a huge catalyst of new technologies. Examine World War II and identify resulting technologies that came from that conflict and explain how they have benefited humanity. How were these technologies viewed by people at the time? Which had a distinct science fiction aura then? World War II is often referred to as the "gizmo" war—why?

- Can students identify distinct time periods in America's technological development, from colonial times to the present, and associate certain technologies with those time periods?

- Write an article about how engineers, inventors, and entrepreneurs have changed the world for the better—citing where their accomplishments have saved lives, improved the environment, advanced the economy, and helped peoples in developing countries. How have these professionals improved our national security, given us abundant energy sources to draw upon, and made our lives free from toil and drudgery?

- What was the value of the U.S. space program of the 1960s and later Shuttle flights? What did we learn, and how has that passed down to society? How could a value be placed on all this exploratory activity? Try itemizing the benefits, products, materials, etc. that came from the space program. Hit the internet and publications that could be of assistance.

- Why does there seem to be no "middle ground" for nuclear energy? People seem to like it or hate it; why is this so? It is a very valuable energy source, especially as it produces no carbon dioxide. How might it be made more acceptable to the public?

- Examine the possible legal costs and ramifications for implementing electric vehicles on a wide-scale basis—looking at such major topics as:
  - Accidents and the breakage of batteries and spilling of battery liquids.
  - Charging the vehicle's batteries in a garage.
  - Manufacturing the many batteries that will be needed, as well as their post-use disposal.
  - Other?

- Consider a new technology that allows people to conduct medical tests at home and transmit their data to their doctor—perhaps through some sort of blood testing or scanning device. What might be the legal implications of such a device?

- Many companies have the ability to track employee presence within company facilities—for security and safety reasons, in the case of fires, accidents, and security breaches. Should technology like this be developed for students within school buildings—especially in light of events of school intruders and shooters in our schools? What kinds of technology do your students envision being used, including but now limited to:
  - Extensive camera surveillance.
  - ID passes.
  - Card swiping.
  - Radio tracking.
  - Image recognition.
  - Combination of the above.
  - Other?

  What do students see as the social/institutional/political/governmental/regulatory/legal ramifications of this technology? Get ready for some spirited discussions!

Engineering

- Survey engineers in nearby companies to determine what they do and why they became engineers. Develop a survey form for this activity and identify the companies to which the form will be sent. Sample survey questions could include:
  - What in their lives motivated them to become engineers?
  - What impresses them most about their profession and why?
  - What advice would they offer to students considering the profession?
  - What processes have they used to solve problems?
  - What engineers in history do they feel are important and why?
  - Would they do anything different if starting out today? If so, what?
  - Other questions?

  Send your survey form out, analyze the information returned, and write a summary of the findings.

- What are some of the other skills engineers must learn and master for the kind of work they will do? Here are three hints upon which students may build:
  - Project management
  - Leadership
  - Communications

  Why are these, and other skills that students will identify, important to an engineer's daily work?

- Identify and describe the economic impacts and value of STEM to our nation. How do STEM skills:
  - Improve problem-solving capabilities?
  - Lead to higher salaries?
  - Boost our economy?
  - Help create jobs?
  - Influence invention/innovation?
  - Help developing countries and cultures?
  - Relieve suffering in the world?

  - Provide comfort and aid after natural disasters?

- Research the different kinds of engineering that exist today and discuss them in class. Hint: there were originally five types of engineering: mechanical, electrical, chemical, civil, and industrial. However, over the last century, the groupings have become hybridized. Enjoy the search and discovering how engineering fields have merged and developed into…entirely new fields. Students might also benefit from researching the many different professional engineering societies for more information.

- What subjects do engineering students study to prepare them for working as an engineer? Research the literature and sample some college websites to discover how the education of an engineer progresses. Invite some engineering college students in to speak to the class and discuss why various subjects are important to an engineering career. How many years does it take to receive a degree in engineering? What is the average starting salary for a graduating engineer?

- Engineers often patent their new creations, inventions, and systems. Since patents are a very important aspect of a technology-driven economy like ours, explore this topic. What are patents? Who can own a patent? What are the advantages of owning patents? How have patents grown over the last 200 years and why? What are the top five states in which citizens have been awarded the most patents?

- What are the origins (etymology) of the term “engineer”? From what root words does it come down to us?

- Over the course of centuries, there have been a variety of definitions of what engineering is. Try to identify definitions that span the last century as well as specific decades to compile a snapshot of what engineering is. You will be surprised at the definitions. Don’t be afraid to try coining your own definition.

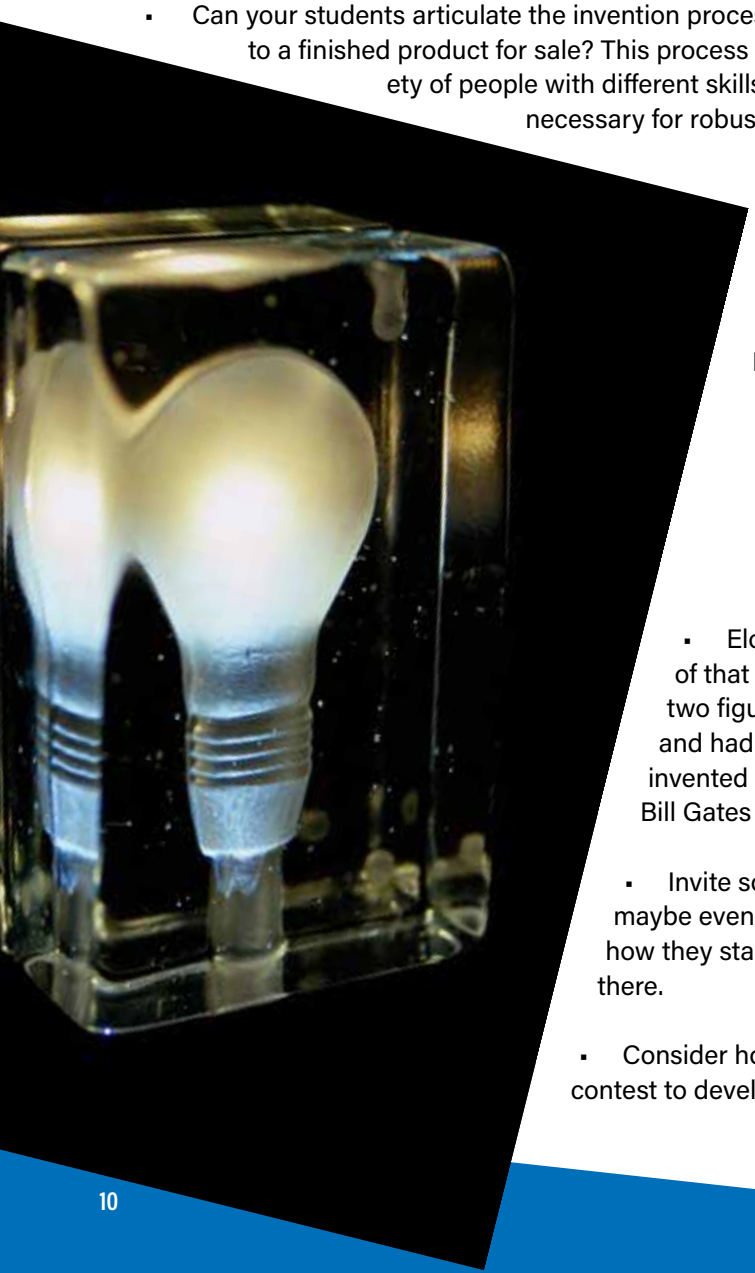
- Identify famous U.S. engineers and summarize what they have done to improve the quality of life and advance our country's standard of living. It may be easiest to start in your own state and then move on to other locations. Students may also enjoy reading general books, published by engineers, about engineering and related subject matter.

- Five American presidents received an engineering-style education. Who were they? (Hint: land surveying was considered one kind of engineering education.)

- Suppose your students are challenged to clean oil and hydrocarbon wastes off city streets before it finds its way into sewers, either by spills or rainwater runoff. Have student teams develop ideas and systems that could be used to accomplish this. Once the designed systems collect the wastes, how would they be transported and disposed of?

Invention

- Can your students articulate the invention process—the discrete steps that an inventor might use to take a raw idea to a finished product for sale? This process usually occurs within a project-team setting and involves a variety of people with different skills and expertise. Discuss why a diversity of people and talents are necessary for robust, new product design.



- The late 1880s represented a renaissance for team-based problem solving and the integration of invention into American manufacturing. One key figure was Thomas Edison, whose accomplishments then are still responsible for over $10 trillion of the world's $80 trillion annual economy. Ponder these stats about Edison:
  - What do you consider his key inventions and why?
  - Why were his legendary West Orange Labs so key to America's technology-driven growth and what we call "progress" today?
  - Name some of his contemporaries.
  - Why were Edison and Ford such close friends?

- Elon Musk is often compared to Edison as a modern-day example of that inventive and entrepreneurial spirit. Compare and contrast these two figures. They both established huge battery-manufacturing facilities and had powerful reasons for promoting electric vehicles. Why? Both men invented a broad range of technologies. Would you include Steve Jobs and Bill Gates in with these two giants? Why nor why not?

- Invite some inventors into the classroom to talk with the students and maybe even bring some of their inventions along for discussion. Talk about how they started with a problem that needed to be solved and proceeded from there.

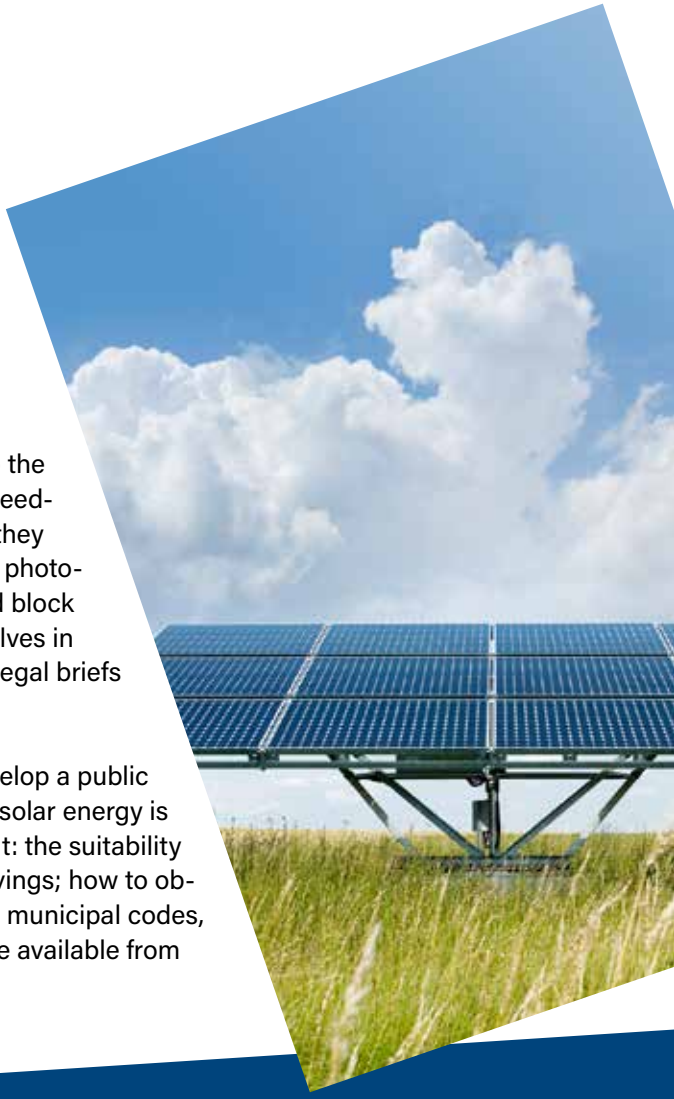
- Consider hosting an invention day at school. Student teams can engage in a contest to develop solutions to problems that either exist at the school or out in

the world. Teams of students can develop models of their solutions and display them for all students to see. This exercise should emphasize detailed activities that need to be undertaken to solve the problem—like an action plan.

- How can communities respond to storms and natural disasters? Student teams should ponder what might typically happen in a hurricane, addressing key areas such as:
  - Communications
  - Boat or other forms of rescue
  - Ability to locate survivors
  - Hospital/injured care
  - Emergency food/medical supplies
  - Clean water
  - Aerial surveillance
  - Massive storm damage
  - Lengthy utility infrastructure outages
  - Other?

  From these concerns, students could develop strategies to be ready for such social disruptions prior to a storm's arrival.

Energy



- How has solar energy affected our civilization from the early sun-worshipping cultures to our present-day interest in making the technology an energy workhorse? Are there any popular songs that celebrate the sun? Are there any words whose etymology refers back to the sun, or terms that have been coined in the industry? What new words has solar energy introduced to our language?

- Tackle the problem of solar rights. Do homeowners have a right to the sunlight that falls across their property? Can they bring legal proceedings against those who abridge those rights? For example, could they charge that their right to generate electricity from a roof-mounted photovoltaic system is harmed by tall trees or that a new building would block the light they are now receiving? Ask your students to put themselves in the place of a judge and perhaps even make connections to how legal briefs and motions are written and filed.

- Ramp up those communications skills. Teams of students can develop a public information brochure or booklet that helps homeowners decide if solar energy is right for their home. The publication can provide information about: the suitability of solar energy for homes; how to evaluate potential costs and savings; how to obtain bids and choose from multiple contractors; how to meet local municipal codes, etc. Students are free to look at other such documents that may be available from governmental agencies or state/municipal sources.

- Alternate energy technologies, including solar/wind alternatives, are a popular topic for many. They can be utilized in many locations throughout the country, but they require large sections of land. What kinds of social/environmental impacts could this present, possibly including:
  - Visibility issues (especially for wind).
  - Covering large portions of land (solar panels).
  - Bird kills (wind).
  - Accidental falls.
  - Electrocution.
  - Amount of energy needed to produce these systems (net energy).
  - Hazards to navigation (onshore and offshore wind).
  - Noise (wind).
  - Sunlight reduction to lakes (water-based solar panels).
  - Other?

- How has energy use varied over the decades? Construct pie charts illustrating the contribution of various energy sources to the national energy economy. Create pie charts for 1950, 1960, 1970, 1980, 1990, 2000, 2010, and 2020, comparing how contributions from each source have changed, and discuss why this has happened. Also show the nation's total energy use for each year.

- Using pie charts as in the previous example, show which energy sources have been used for the same years for the generation of electricity.

- What are the major energy resources used for the transportation sector? How might this change in the future?

- The story behind the national energy history of our country has been to use ever more dense energy forms (more Btu per pound of fuel), from wood to coal to oil and gas to nuclear fuel forms. Why did this happen? Now, as we move toward more use of solar and wind resources, we are using much less dense energy forms. What does this mean, and what are the impacts? Quantify the energy density of the fuel forms such as in the case of the solid fuel forms. What is the Btu content per pound of fuel? How would you measure the energy density of solar and wind?

- The generation of carbon dioxide with the burning of fossil fuels is a big reason many advocate for more use of solar and wind energy resources. What if society could harness that carbon dioxide and use it for something very important? Study the

different uses we could have for large quantities of this waste gas. What kinds of systems do your student teams envision being used? Develop charts, sketches, diagrams, and other visual aids to portray the systems envisioned.

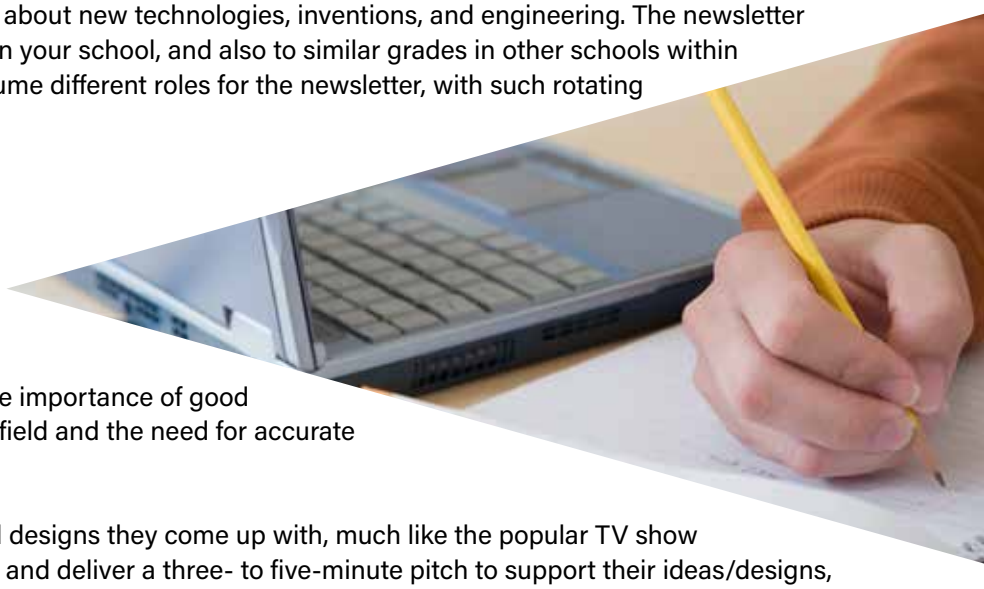
- In the aftermath of the use of nuclear weapons in war, many agencies attempted to identify peaceful uses of nuclear power. Some have advocated that homes could have miniature nuclear reactors, with enough fuel to run the tiny reactor for seven or more years, and with virtually no pollution emitted. During refueling operations, the old reactor would need to be removed and a new one installed. This proposal dates to the early to mid-1950s. What does your class think of this concept today, after it's dusted off and updated? What might be the social, economic, environmental, political, and other concerns that would come into play?

- With the advent of large-scale solar and wind energy use and possible other alternate energy-producing technologies, how do students envision the electric utility industry of tomorrow? Study the modern utility industry: what key topics are driving its change and what might be practical in the long-term, perhaps 20 years from now? Allow plenty of time for discussion; solicit ideas for things that would need to happen today to be prepared for the changes envisioned.

- Think futuristically about the automobile. Imagine that tomorrow's cars could be developed with very clean-burning engines like fuel cells or hydrogen-burning systems. While parked, these cars could generate base load electric energy with little environmental impact. Wherever such cars are parked (work, leisure, or at home) they could add considerable clean electricity to the nation's electric lines (and change the normal flow of electricity on those lines). Examine how this might change the modern conception of the utility grid, both during normal operation and following storms and natural disasters.

Communications

- Design an electronic school newsletter about new technologies, inventions, and engineering. The newsletter should be available to classmates within your school, and also to similar grades in other schools within your school district. Have students assume different roles for the newsletter, with such rotating roles as:
  - Reporter/writer.
  - Graphic designer.
  - Editor.
  - Layout.
  - Headlines.
  - Other.



- Using the experience above, discuss the importance of good communications in a technical subject field and the need for accurate reporting and writing.

- Have students do a "pitch" of ideas and designs they come up with, much like the popular TV show *Shark Tank*. Student teams can prepare and deliver a three- to five-minute pitch to support their ideas/designs, and then answer questions from other students/teams. Oral communication skills are essential in the business world to present ideas and gain funding. Practicing this powerful skill in school will also help students plan and

organize their work and thought processes. Using a video recording device so students can see themselves later is a great way to improve these activities. Practice, practice, practice makes for good presentations.

- The basis for recording and establishing new discoveries is an experimental notebook, which is kept by scientists, engineers, and inventors. Develop a notebook that students can use when they develop their new product ideas and inventions and research the kinds of things usually recorded there. This notebook can be formed into an electronic format for all students to use. Thomas Edison, one of the world's all-time greatest inventors, kept about 4,000 notebooks and documented his raw ideas religiously, later becoming the raw material for filing his 1,093 patents.

- Identify how the internet has improved communications for:
  - Scientific and technical professionals.
  - Doctors and medical specialists.
  - Poets and writers.
  - Teachers and students.
  - Continuing education.
  - Other aspects and professions.

- How has the advent of word processing impacted the professions of writing, authorship, and composition—examining the question from the perspectives of:
  - Speed of publication?
  - Efficiency?
  - Time and ease of completion?
  - Detection of errors in grammar and spelling?
  - Ability to share work with anyone on the earth?
  - Copyright?
  - Other?

The Arts

- Examine stage plays over the last 125 years, considering how technology has changed this artistic form, looking at:
  - Sound effects.
  - Movable sets and props.
  - Lighting.
  - Special effects.
  - Voice amplification.
  - Stage design.
  - Coordination of electronic operation.
  - Other?

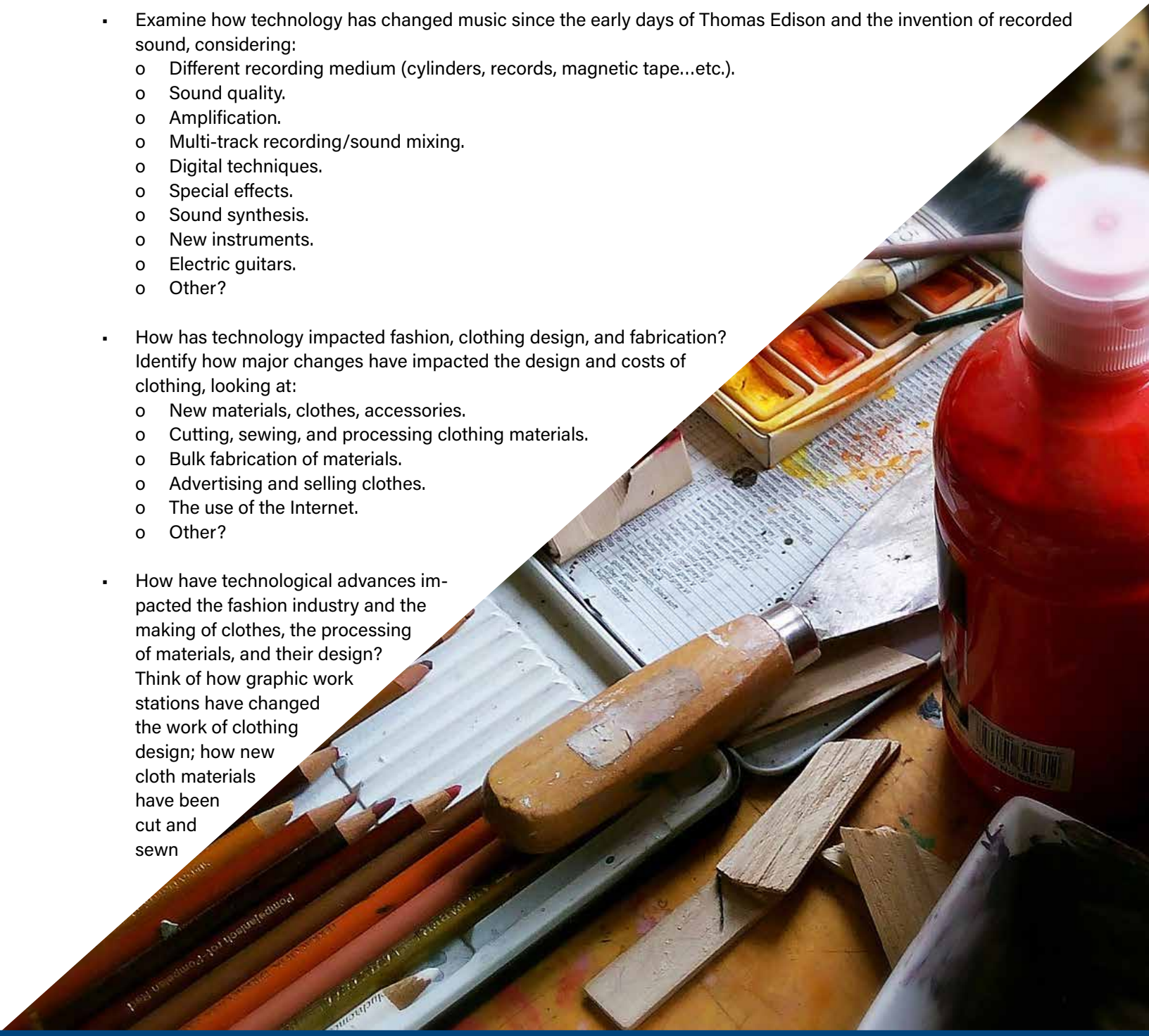
- Examine how technology has changed movies since the early days of Thomas Edison and the invention of motion pictures, looking at:
  - Length of movies.
  - Lighting.
  - Special effects.

- Morphing.
- Dubbing of sound.
- Sound effects.
- Inclusion of film and sound together.
- Visual formats (film size, videos, digital techniques…etc.).
- Other?

- Examine how technology has changed music since the early days of Thomas Edison and the invention of recorded sound, considering:
  - Different recording medium (cylinders, records, magnetic tape…etc.).
  - Sound quality.
  - Amplification.
  - Multi-track recording/sound mixing.
  - Digital techniques.
  - Special effects.
  - Sound synthesis.
  - New instruments.
  - Electric guitars.
  - Other?

- How has technology impacted fashion, clothing design, and fabrication? Identify how major changes have impacted the design and costs of clothing, looking at:
  - New materials, clothes, accessories.
  - Cutting, sewing, and processing clothing materials.
  - Bulk fabrication of materials.
  - Advertising and selling clothes.
  - The use of the Internet.
  - Other?

- How have technological advances impacted the fashion industry and the making of clothes, the processing of materials, and their design? Think of how graphic work stations have changed the work of clothing design; how new cloth materials have been cut and sewn



into exciting and comfortable clothing; and how the internet has made it possible to advertise and market new products and fashions. Have students bring in samples of clothing to illustrate their thoughts, comments, and concerns.

- With solar and renewable technologies so prominent in the public's mind, how could these energy concepts be integrated into the fashion and accessories scene (think of how jet designs influenced automobiles in the 1950s/1960s). Have students develop some creative and artistic concepts, sketches, and drawings of their visions.

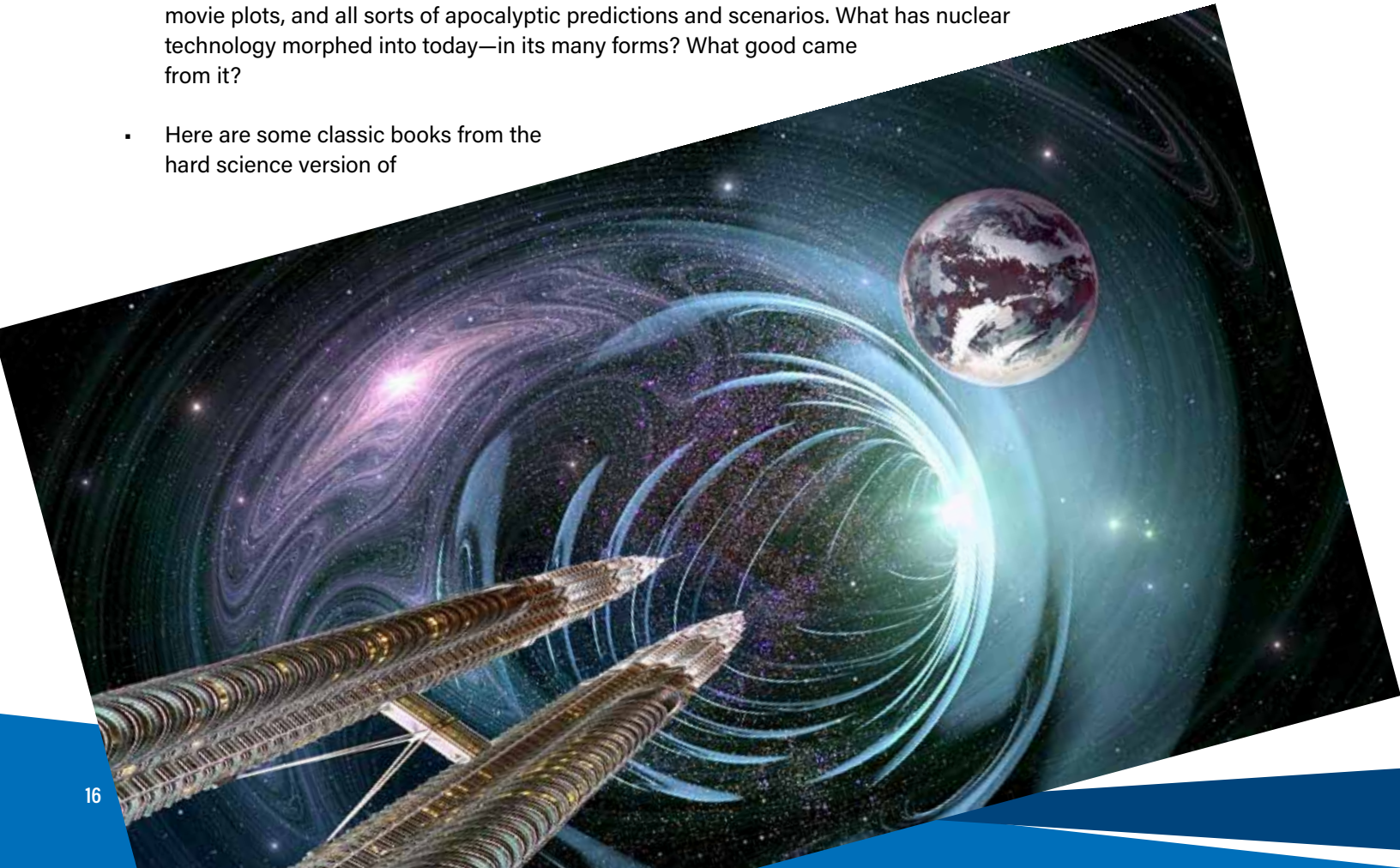
Science Fiction

- Integrate some science fiction and literature into your Integrative STEM studies. How about a:
  - Poem about a robot.
  - Short and humorous story about a technology gone haywire.
  - Play that examines a jail for misbehaving robots.
  - Read some of the great robot stories of Isaac Asimov and how his work influenced scientists and engineers to study and apply robots (what about his three laws of robotics?!).

- The great 1956 movie classic, *Forbidden Planet*, has a fascinating message about us in it. Where did this incredible storyline originate? Robots premiered in the American psyche at this point as well. How might this have influenced how we envision robots today? Watch this movie in class for lots of suspense and discussion!

- The science fiction aura of the atomic bomb led to many concerns, 1950s and 60s science fiction movie plots, and all sorts of apocalyptic predictions and scenarios. What has nuclear technology morphed into today—in its many forms? What good came from it?

- Here are some classic books from the hard science version of



science fiction, circa 1950s/1960s. Discuss what they are trying to tell us:
- *The Moon is a Harsh Mistress* by Robert A. Heinlein
- *I, Robot* by Isaac Asimov
- *A Canticle for Leibowitz* by Walter M. Miller, Jr.
- *The Martian Chronicles* by Ray Bradbury
- *A Fall of Moondust* by Arthur C. Clarke

Who are the great science fiction authors today and what are they writing about?

- Three of the great science fiction writers, Asimov, Heinlein, and Clarke, wrote some of the really great stories of their time. Research what else these men did and how those activities might have influenced how and why they wrote what they did.

- How are science fiction and fantasy alike and different? What do you prefer and why?

- What literature classics of yesteryear would be termed science fiction today? (Hint: One is *Frankenstein*).

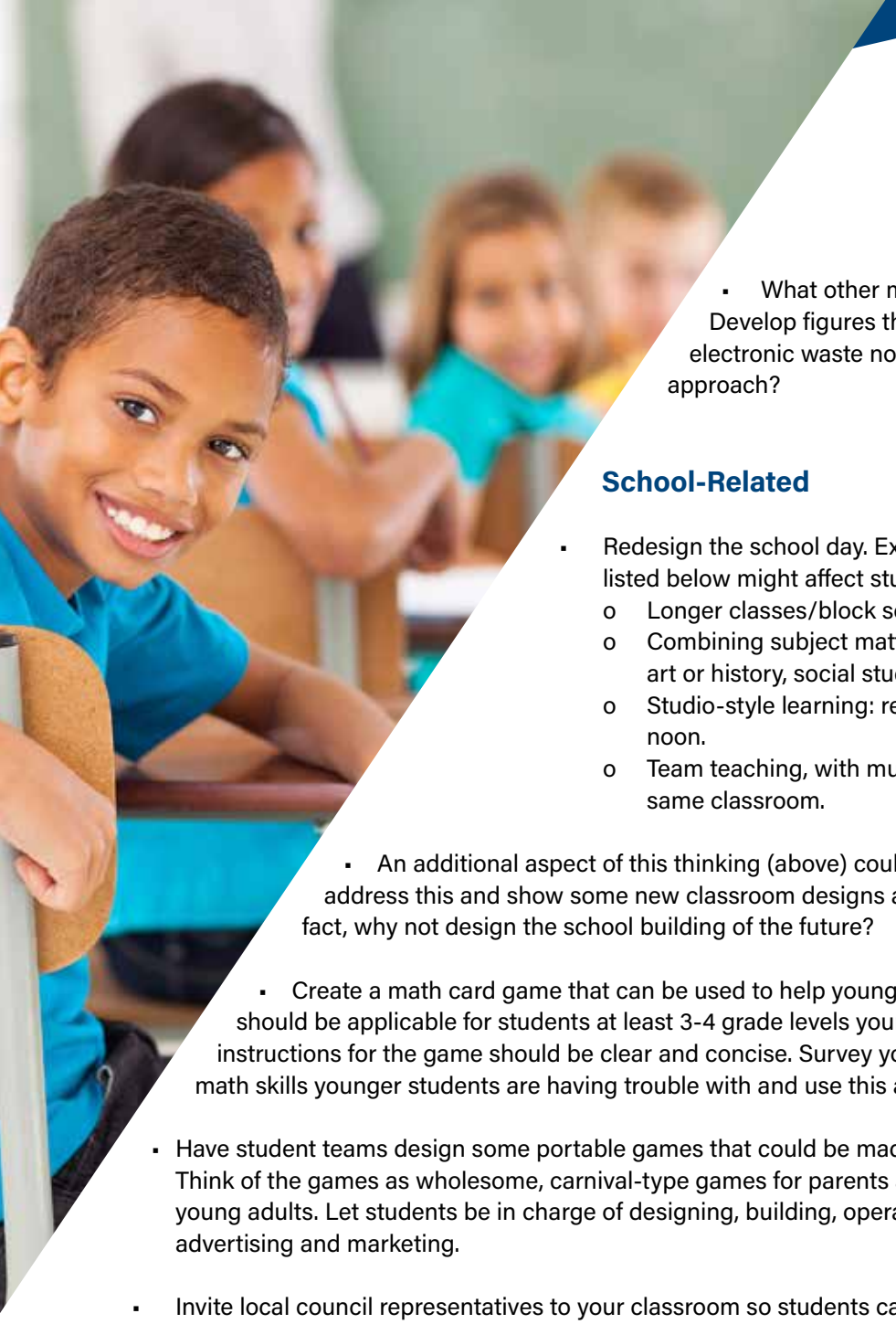
- What science fiction movies are your students' favorites, and why do they find them interesting? What are their messages to us? If students could make their own movie, what would it be about, and what would be the point of the movie?

Recycling

- Challenge students to think out of the box with creative uses for commonplace items. For instance, what can you use these items for after their primary purpose has been fulfilled?
  - Plastic soda bottles
  - Rubber bands
  - Pencil stub
  - Paper clips
  - Old pieces of cardboard
  - Empty glass jars

- Students can analyze the waste streams generated throughout the school and, acting as efficiency experts and engineers, suggest ways the school can recycle these waste streams. Using math, students can attempt to calculate the savings that could be accrued through recycling. Waste streams could include, but not be limited to:
  - Paper and other physical streams
  - Energy usage
  - Water

- In what instances do your students think we should substite recycled materials in place of natural products, and why? Give specific examples for discussion.



- What other materials should we be recycling, and why? Develop figures that justify student responses. How about all the electronic waste now littering our planet? What would be a viable approach?

School-Related

- Redesign the school day. Examine and evaluate how alternatives like these listed below might affect student learning:
  - Longer classes/block scheduling.
  - Combining subject matter in the classroom (e.g., science, math, music, art or history, social studies, language, and civics).
  - Studio-style learning: recitation in the morning, application in the afternoon.
  - Team teaching, with multiple teachers of different specialties in the same classroom.

- An additional aspect of this thinking (above) could change the physical layout of classrooms—address this and show some new classroom designs and support why the changes are needed. In fact, why not design the school building of the future?

- Create a math card game that can be used to help younger students improve their math skills. The game should be applicable for students at least 3-4 grade levels younger and designed for 2-4 players. The written instructions for the game should be clear and concise. Survey younger grades and teachers to find out what math skills younger students are having trouble with and use this as a design basis for the game(s).

- Have student teams design some portable games that could be made to celebrate a school fundraising event. Think of the games as wholesome, carnival-type games for parents and grown-ups to play along with children and young adults. Let students be in charge of designing, building, operating, and planning out the event, including advertising and marketing.

- Invite local council representatives to your classroom so students can learn how multidimensional decision making directly affects their communities. Encourage students to ask questions about how issues come before the town council and how citizens find out about them and can appear to voice their opinions.

- Examine how the use of laboratory equipment and school labs themselves impact the insurance costs for the school. How might these high costs impact the next generation of science/STEM students?

- Sixty years ago, students took shop classes and home economics classes, experiencing a time-honored “head and hands” curriculum. These classes have been replaced by newer curricula. Talk about the importance of head-and-heads learning for all students, not just those who excel in technology and engineering. This is a powerful issue in schools today. Research and discuss this!

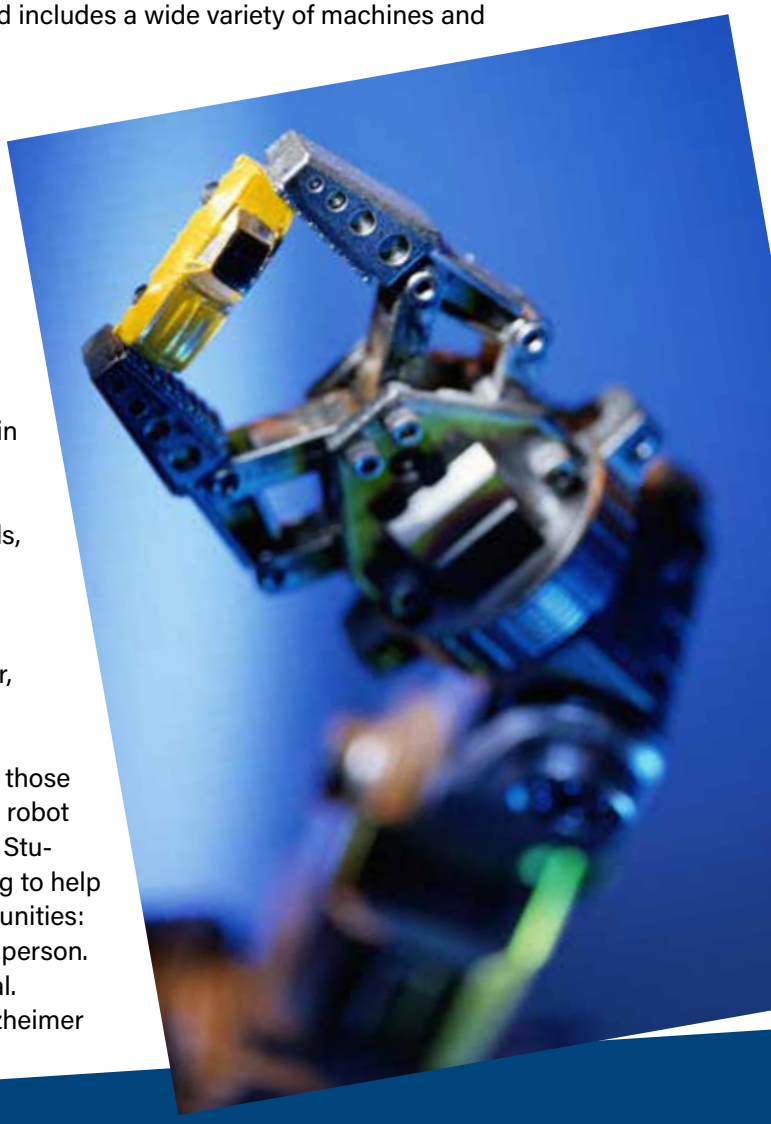
Robots

- Robots are typically a very popular discussion topic. Challenge your students to examine how different cultures and countries view robots and how that view affects a country's acceptance of the technology into their society. For instance, how do the societies of the United States and Japan view the implementation of robotic systems into their cultures? Are robots likely to look like humans in either culture? Is it necessary or nice to have human attributes? How many robots are now in use in either country? Are robots strictly used for applications, or do they perform other important functions in these societies, such as human companionship, health aids, and service tasks? What cultural concerns might motivate how robots are used in these two societies? How do other societies see robots integrated into their cultures?

- What makes robots such a widely popular topic for students to discuss and even attempt to design? Survey the class and develop some statistical data about this topic. Can a histogram of the data tell your class something? Can students research this phenomenon from the vantage point of other countries to see similarities and differences in the perception of robots?

- Service robots are one of the largest application areas and includes a wide variety of machines and special uses. Here are several typical application areas:
  - Pipe inspection
  - Surface cleaning
  - Nuclear plant inspection/surveillance

  Have students identify more service robot applications as well as other large groupings of robot uses. Also, have students identify the generic major components or subsystems of robotic devices.



- Challenge students, working in teams, to develop some robot concepts and designs for:
  - Surveying and plotting the area of contaminated soil in a brownfield site.
  - A firefighting robot.
  - The cleaning and inspection of large tanks holding oils, water, and other liquids.
  - Nuclear power plant robots to inspect contaminated water/liquid leaks.
  - Inspecting interiors of large pipes that transport water, gases, and liquids.

- Can robots be designed for helping the handicapped and those with limited mobility? This is an excellent example of how robot technology can be used for socially relevant applications. Students enjoy and welcome the opportunity to do something to help others, so challenge them with these robot design opportunities:
  - A robot that can be used to help a wheelchair-bound person.
  - Robots that can deliver supplies throughout a hospital.
  - Robots that can be companions to senior citizens/Alzheimer patients.

- Should robots be used to fight proxy wars between nations? In theory, this would reduce or eliminate a human toll, and the urge to settle differences in a physical manner might be done "safely." Examine this from the viewpoint of the robot designer as well as various members of society like military leaders and others.

The Internet

- Examine the social impacts of the internet and itemize where there have been both positive and negative impacts on society—a kind of pro vs. con analysis. Use a combination of research and discussions with different age groups, including parents, grandparents, friends, teachers, and others. How might the bad things be negated or turned into good things? What other conclusions do students draw from this activity?

- How has the internet impacted companies in their daily operations and communications both internally and externally? Examine how specific job functions have disappeared while new ones have appeared. How did the internet improve the economic situation of existing companies and spur the emergence of many new small companies? What updated skills are needed in modern corporations that were not prevalent 25-50 years ago?

- Webinars have made it possible for many professionals to benefit from courses, seminars, and workshops from the convenience of their office or home, negating the costs and problems related to traveling long distances. How has this capability impacted continuing education, travel costs, absence from the workplace, ability to learn quickly and efficiently, and staying current and improving one's resume and education?

- Online education is possible where students do all their work from a computer terminal or even a handheld device. Would this format be comfortable for all learners? Discuss this with teachers and peers and identify both pro and con aspects of this technological revolution. Also, what does it mean for the traditional college course, professors, and the college campus itself? How does this impact how college students meet and discuss ideas, face-to-face communications, and resulting social development for the future world of work?

- Ponder this scenario: We can now work from home with amazing internet speeds and bandwidth, negating longer commutes to cities and population centers where corporate buildings reside. How does this impact a region's:
  - Traffic patterns?
  - Energy consumption?
  - Need for residents to maintain a home office?
  - Savings to residents on car insurance?
  - Air pollution savings?
  - Other?

  Here we just touch the surface of myriad issues that could come into play with a major change to traditional lifestyles. Take some time to address other important issues and how technology impacts can "rumble" through an economy and society.

- Challenge your students to envision a new kind of internet application and then ask them to develop a ten-slide PowerPoint presentation that they will use to sell the idea to a venture capitalist or corporate executive for funding. Make sure the presentation captures the essence of their idea and that it's presented using good oral communication skills. This is exactly how ideas are presented and funded in the business world!

- Each student is to describe in a short essay how blogging has affected their life. To the extent possible, students are to shoot for a balanced approach—both the positive and negative impacts.

- To build interview and oral communication skills, students are to talk to parents, family, and older friends about how they see the internet and its use in their lives. How do they use the internet and why? A summary of all interviews is to be compiled, with meaningful conclusions shown.

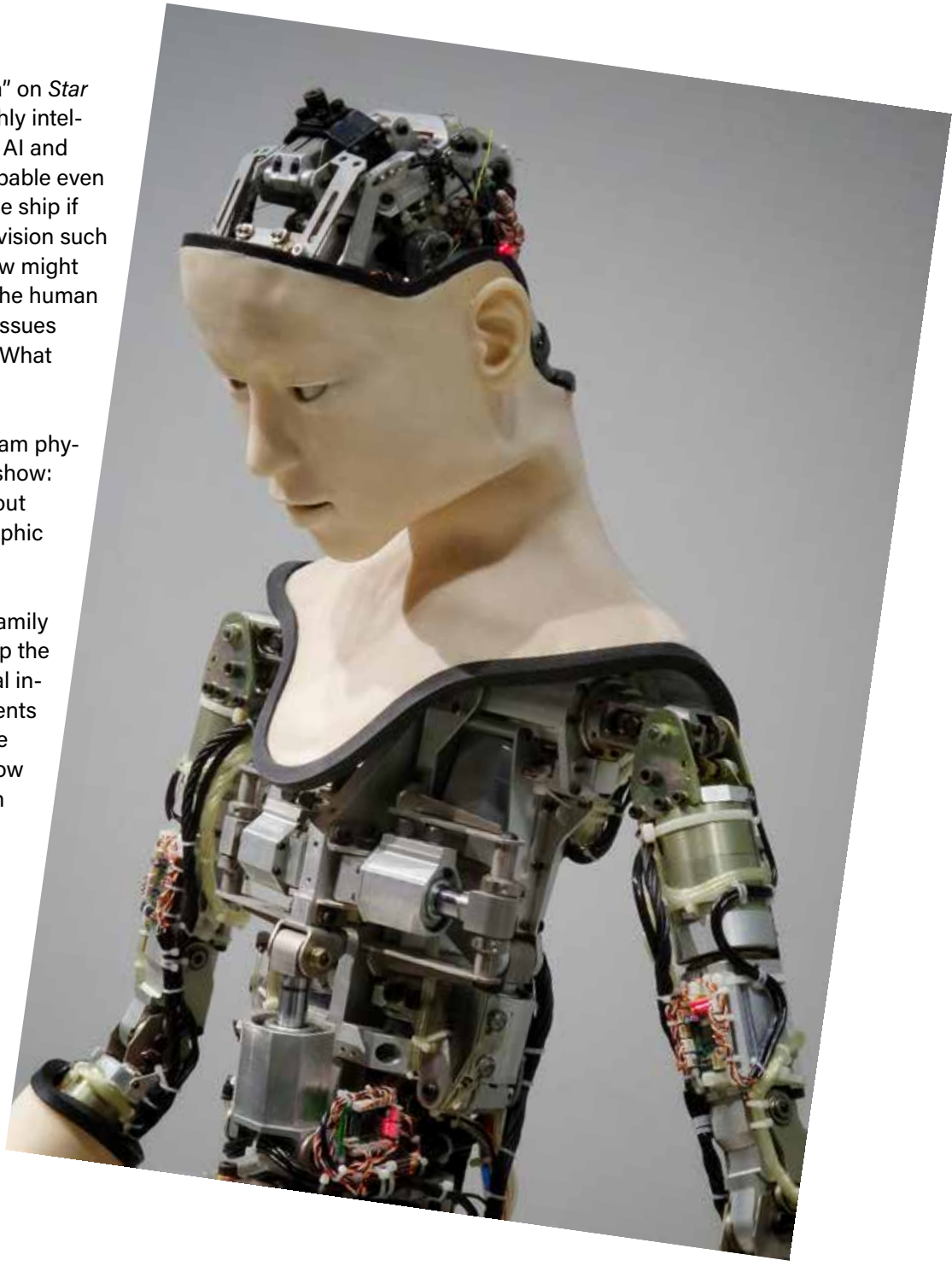
- Science fiction is a rich literature that explores future worlds and the advance of civilization and cultures, often with a strong technological component. Are there books that have explored worlds where massive telecommunication is available? What has been the "moral" of the stories they told? With massive telecommunications functionality in place, might a society also have the ability to follow the actions of its citizens all day, every day? What does this mean? Are there elements of this monitoring already in place today?

- What will the advent of 5G capabilities mean for the internet? What will it be capable of with such telecommunication speeds and bandwidth? Do some research here!

- How has the internet influenced the advances of developing countries? Is there evidence that providing unprecedented access to information has altered the way world governments respond to their citizens? For instance, how has the internet changed the way governments of China, North Korea, and Cuba have treated their citizens, versus, say, Brazil, France, and Sweden? Does restricting access to certain websites help the situation? Perhaps access to information in the long term brings countries closer together. What do your students have to say about this?

- Do students believe it will ever become possible to use the internet for voting in local/national elections, especially after the sweeping coverage of possible Russian meddling in the 2016 U.S. election? Have the class first discuss the social/political/legal concerns they may have and then propose some "technical fixes" that could be implemented to secure the validity of internet voting and results tabulation.

Artificial Intelligence – AI



- Think of the character "Data" on *Star Trek: Next Generation*: a highly intelligent machine, loaded with AI and advanced programming, capable even of assuming command of the ship if necessary. Can students envision such a machine in their lives? How might they think this could affect the human spirit and emotional/social issues that might be engendered? What about trust issues?

  Also, think about the hologram physician on another *Star Trek* show: how might students feel about their doctor being a holographic image?

- Have students identify the family of technologies that make up the modern definition of artificial intelligence. In doing so, students may comment upon how the family was organized and how they understand it. Where in the U.S. is major work in AI being conducted?

- Would students feel safe in an AI-commanded, driverless car? Why/why not? What has been the experience to date with such efforts in driverless cars? How might this technological advance influence:
  - o Road design?
  - o Insurance rates?
  - o Car design?
  - o Travel times?
  - o Accidents?
  - o Other?

- Voice synthesis is an AI application, and we have all experienced it when calling certain companies. Is this an application people really want? It seems to grate on the nerves when consumers would rather talk to a human, rather than a machine or synthetic voice. What are the pros and cons of this technology application?

Team STEM Activities

In assigning these projects to student teams, it should be emphasized that each team must:

- Articulate the problem and details of the project.
- Perform the necessary research.
- Plan the solution and identify the best design.
- Execute the design using math to embellish it and provide perspective.
- Project the cost and benefits of their design.
- Keep notebooks of the team's ideas, diagrams, and clearly written text.
- Pitch their final design in a *Shark Tank* format.
- Answer questions from fellow students and teachers.

Stay true to the engineering design process!

Underground Home

Design an underground house with particular attention given to:

- Orientation of the home to a southern exposure.
- Insulation value of the home.
- Passive versus active solar system use.
- Living space and use of natural versus artificial lighting.
- Annual energy needs of the home.
- Other?

Man-Made Island

Design a man-made island (near shore) to function as a manufacturing/industrial facility while keeping in mind concerns such as, but not limited to:

- What manufacturing/industrial processes could be located there.
- Size of the island.
- Type of construction.
- Means to get to/from the island.
- Cost of the facility.
- Ability to weather storms.
- Environmental impacts of the island.
- Other?

Educational Van

Design van-type vehicles for educational purposes, equipped with visual and computerized systems that could travel to schools, public meetings, and conferences/seminars for topics such as:

- Solar energy applications.
- Astronomy.
- Environmental testing.
- STEM topics.
- Other?

Solar Charging Station

Design a solar photovoltaic charging station for electric vehicles parked at your school, with typical concerns:

- Size of the facility; physical dimensions and number of possible cars.
- Size of solar panel array.
- Construction and design of facility.
- Connection to local utility grid or school power system.
- Cost of facility.
- Other?

Brownfield Robot

Design a robot that can be used to map a brownfield site to determine what might be buried or lurking below the surface, considering:

- What type of robot would be used...why?
- Control and navigation of the robot; and location determination.
- Sensing package to be used on the robot.
- Cleaning or decontamination of the robot (if needed).
- Cost of the robot and accessories.
- Other?

Credit: NASA Images - Space colonization, manufacturing habitat, and lunar base.
Artist: Rick Guidice.

Lunar Base

Design a lunar base for manufacturing, considering:

- Use of launched or in situ raw materials for buildings.
- What would be manufactured there.
- Size of the facility.
- Oxygen and food supplies.
- Sleeping, sanitary, and medical facilities.
- Lifetime of the facility.
- Other?

Packaging System

Design a packaging system that would allow the mailing of something fragile, like a container of Pringles potato chips, through the U.S. Mail, considering:

- Materials to be used.
- Size of package.
- Weight of package.
- Cost to mail the package.
- Develop a figure of merit to determine success of system.
- Other?

Processing Ship

Design an ocean-going vessel that can load raw materials in one port and then, while en route to a final destination, process the raw materials into a finished product for sale, with the following considerations:

- What raw materials are to be used?
- What products are to be made?
- What kind of ship/vessel will be used? Old or new?
- Propulsion for the vessel.
- Time of travel needed to process raw materials.
- Possible use of alternate technologies on board.
- Cost of vessel?
- Other?

Soda-Bottle Filter

Design a soda-bottle water filter system—a large soda bottle packed with materials to clean the water that is poured into it, considering:

- Modification of existing soda bottle.
- Selection of filter materials.
- Measuring the purification of the exiting water.
- Cost of filter.
- Other?

Consider these challenges as well…..

The Old Ship Challenge

Large, ocean-worthy ships are expensive to build, rugged, and capable of supporting many different functions. Doesn't it make you wonder if they have another life after their original mission is over? In this challenge, student teams can explore new missions for these ships, using creativity and imagination to envision what other applications they might fulfill. Challenge your students to justify why they propose specific repurposed applications. How did they choose the application? Is there an economic or social purpose served? Where and how is such an application justified? Work in some math and marketing attention here and justify the application as much as possible. Encourage students to think like both inventors and entrepreneurs!

Credit: Joe Mabel, Wikimedia Commons.

Repurposing Railroad Boxcars

Rugged big boxes on wheels deliver bulk goods around the country. There are probably close to one million boxcars now in service. These cars are generally 50-60 feet in length and may be as large as 85 feet. The carrying capacity of boxcars may be 50-70 tons. In this team-based design challenge, students can explore ways such boxcars might reused. There is no limit on imagination, so empower students to think out of the box…so to speak! And while the students are developing new application ideas, take some time to study how the boxcar evolved.

Structures That Can Change Shape

What if a building could change its shape in response to an owner's wishes or to survive in a storm or other potential catastrophe? Sound like an out-of-the-box challenge for your creative students? Start with a structure like a single-family home and then look at larger structures. What mechanisms could be built into the structure to promote shape changing? What economic factors would work against and for this type of structure?

An Offshore Wind-Power Farm

Design a wind-power farm that would occupy a one-square-mile area of ocean about two miles offshore. Have your students identify and evaluate the technological, economic, environmental, safety, aesthetic, legal, and social issues involved. How many wind turbines could be placed on this farm? How would the turbines be electrically linked together, and the power brought to shore?

Credit: Unsplash - Photo by Nicholas Doherty.

Credit: Unsplash - Photo by Carl Raw.

School Greenhouse

Using your school as a design basis, develop a design for a large greenhouse, at least 50 feet by 25 feet in size, that could be attached to the school. This design is totally up to student teams, so encourage creativity and out-of-the-box thinking. What might be the issues to be addressed in building and operating this facility? What kind of subject matter could be taught in this school addition? Have students develop sketches, diagrams, and concept drawings to articulate the team designs.

Photovoltaic System

Design a 100 kW photovoltaic system that could supply clean electricity to the school. Students can develop a plan for locating the system anywhere on the school site in or the school building itself. Have your students identify and evaluate the technological, economic, environmental, safety, aesthetic, legal, and social issues involved with this design concept and include the concerns of people living in the area of the school. What would be the cost of such a design?

Technician installing a solar system. *Credit: Pixabay - Image by Alex Csiki.*

A PDS Automatic Weather Station at a dam located near Brisbane, Australia. Automatic Weather Station consists of a DT50 data logger, solar panels, radio modem and meteorological sensors. Source: Pacific Data Systems Pty Ltd, http://www.pacdatasys.com.au. *Credit: Wikimedia Commons.*

District Weather Network

Design a weather station network for your school district to be located at each of the schools in your district. What use would it serve for those who work in, and travel to, the schools? Might there be other uses for the network such as school closings/late starts, local businesses, forecasting storm conditions, traffic control, etc.? Could this network interface with other larger networks, such as state and regional weather stations? Could the network serve an educational purpose as well? If so, how?

Robotic Wheelchair

Design a robot that can be integrated with a wheelchair to move people around automatically. How might navigation for this hybrid vehicle work? What other features might you design into it for the person in the chair? If the robot loses power, how does it get back to a safe docking site? Would you build a communications package into the vehicle and, if so, what would it be able to do?

Image by Espressolia from Pixabay.

Suggested Reading

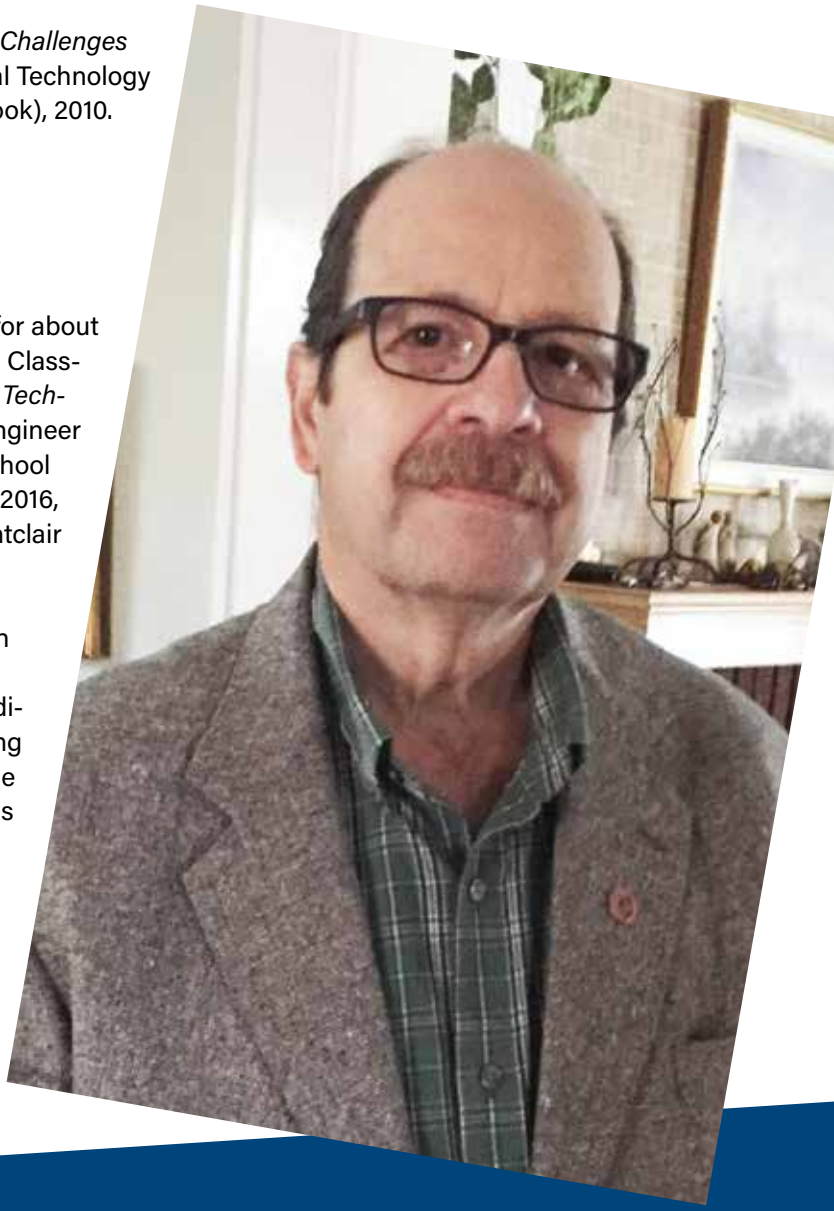
In addition to his extensive article writing for ITEEA, below are books Harry Roman has published under the ITEEA imprint. These books also contain classroom activities:

Engineers and Engineering: A Review; International Technology and Engineering Educators Association (ITEEA e-book), 2014.

Classroom Challenges: Environment, Energy, Invention, and Safety; International Technology and Engineering Educators Association (ITEEA e-book), 2012.

Classroom Challenges: Problem-Solving and Design; International Technology and Engineering Educators Association (ITEEA e-book), 2012.

Alternate Energy Technology Design Challenges: Design Challenges for Tomorrow's Green Energy Engineers; International Technology and Engineering Educators Association (ITEEA e-book), 2010.



About the Author

Harry T. Roman has been an ITEEA book and article author for about 20 years; and for the last 13 years has been the author of the Classroom Challenge feature, which appears in every issue of the *Technology and Engineering Teacher* (*TET*) journal. As a retired engineer and inventor, Harry likes teaching teachers, students, and school leaders about STEM and its applicability. Between 2012 and 2016, he created and co-taught graduate courses in iSTEM at Montclair State University's teaching college.

Harry also is an educational author and advisor to the Edison Innovation Foundation and writes many articles and books about the great inventor. Often, he lectures at the Thomas Edison National Historical Park in West Orange, NJ. Prior to being involved in modern STEM activities, Harry was involved in the launching of Technology Education in NJ schools in the 1980s and is considered a leader in technology education in that state, accumulating many awards and top honors during his 30+ years of service.

He has received numerous industry awards and professional recognition during his 37-year engineering, invention, and patent career, and was instrumental in establishing the NJ Inventors Hall of Fame to celebrate the state's many inventors. Harry holds 12 U.S. Patents.

Author Harry Roman is a regular ITEEA contributor and author of the long-time "Classroom Challenge" feature in *Technology and Engineering Teacher*. As a retired engineer and inventor, Harry likes teaching teachers, students, and school leaders about STEM and its applicability.

To support the important work of ITEEA's Foundation, Harry is permitting this publication to be downloaded at no cost to all—but asks that anyone who downloads consider making a donation to the ITEEA Foundation.

The ITEEA Foundation is in the middle of a Capital Campaign, with a goal of raising $250,000, which will allow it to continue providing much needed support to current and future educators, as well as to those in our communities who are in need of assistance. Without the continued support of generous donors like you, these needs will regrettably go unmet.

ITEEA's Foundation is depending on your assistance and generosity. Please enjoy these activities and donate today to pledge your support. Be assured that your contribution will be put to good use to support tomorrow's problem solvers today!

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