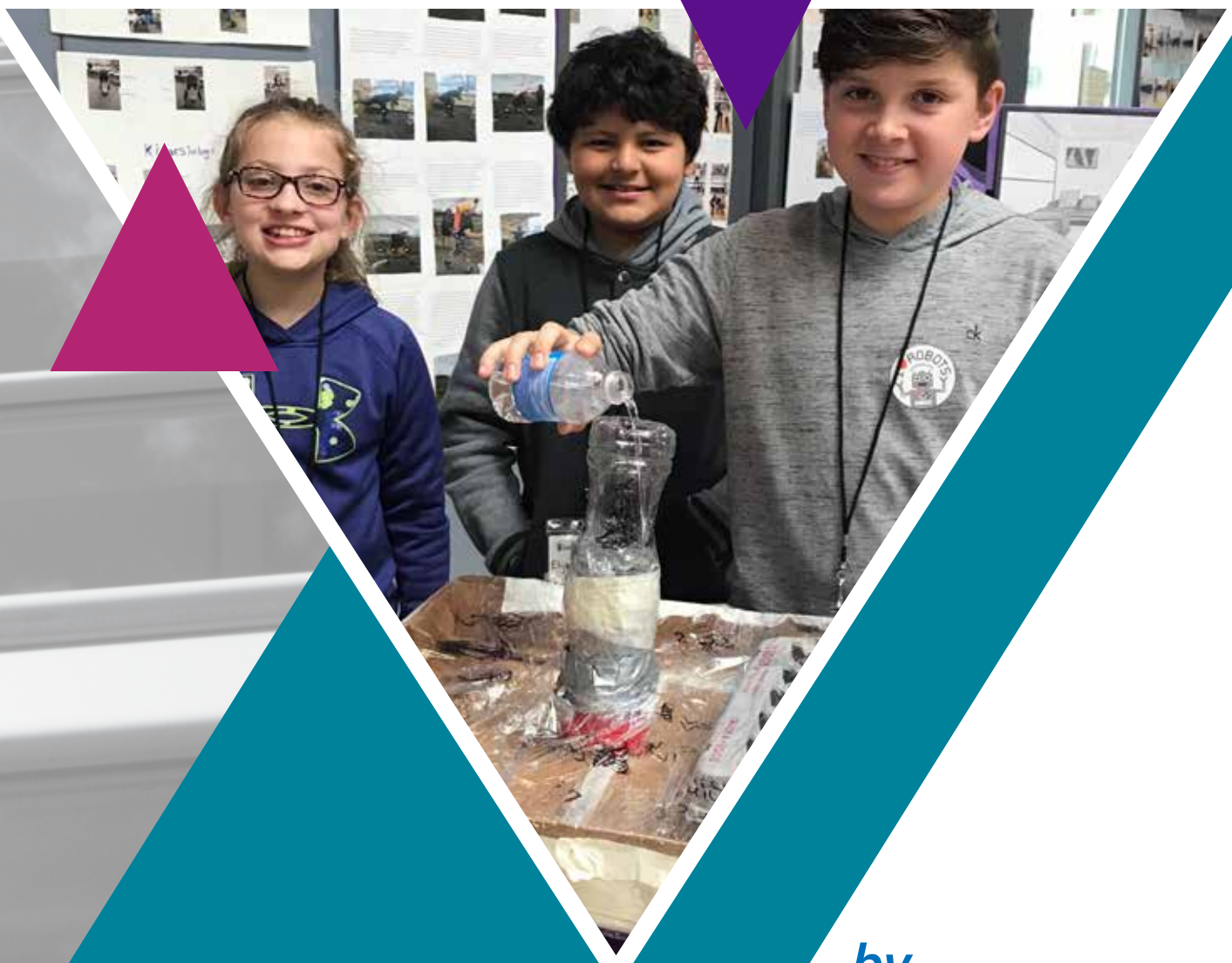
Super Book of 180+ STEM Classroom Activities to Stimulate Student Thinking and Creativity



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.

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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ITEEA

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Introduction

Here I am again, with yet another collection of STEM activities for the classroom. I just cannot resist these little compendiums of fun for students and teachers.

The format herein mirrors that in my previous classroom activities books. Don't be afraid to add your own ideas and topical areas to those in the following pages.

My best teachers were the ones who stretched me in new directions—deviating from the normal academic day, giving out those special projects and term papers. How I lived for those assignments and the chance to do something new, special, and creative! I know your students will enjoy the same things that motivated me...and my classmates. So have at it.

Enjoy the fun that certainly will unfold. Give the students plenty of room to blossom. Remember—the real learning begins when students get up from their desks and engage in teamwork!

Harry Roman

Image credit: Gary Wynn.

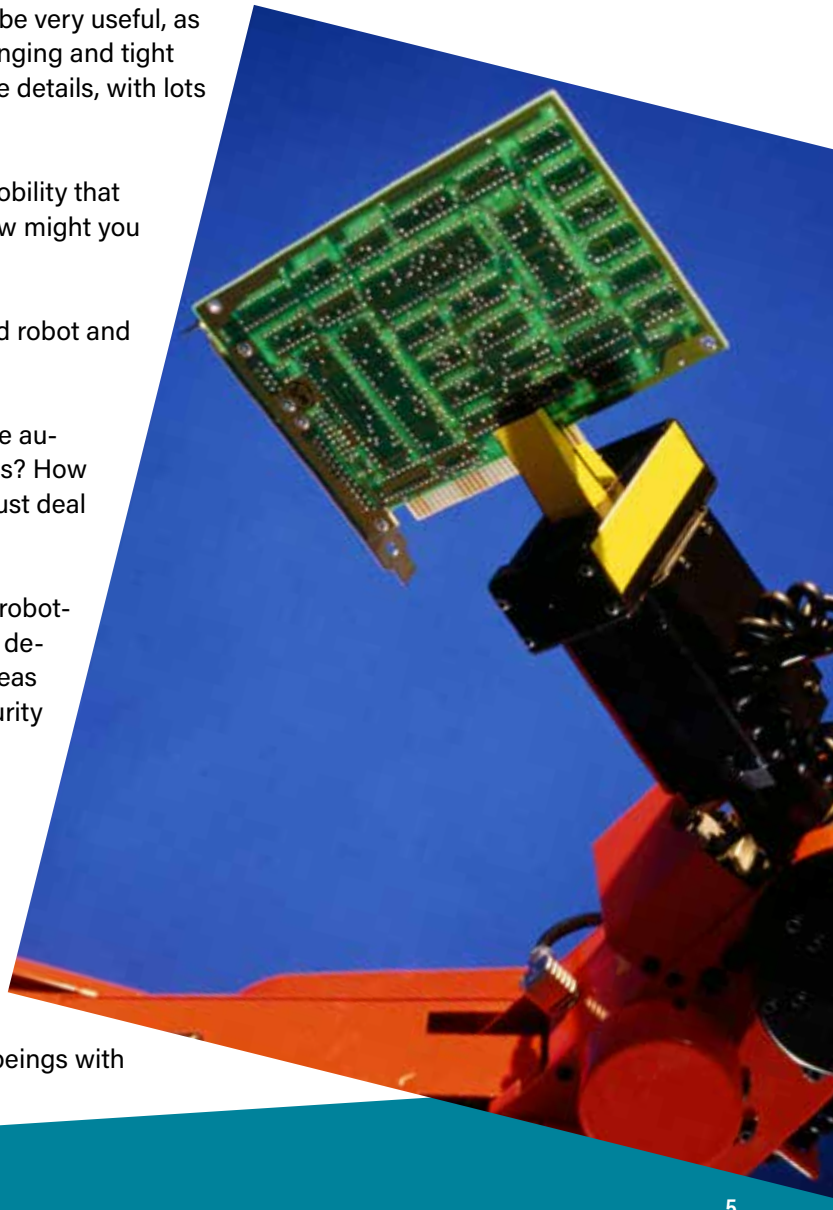
Image credit: Brad Thode.

Activities

Here in the following pages are a variety of classroom activities across a range of technical subject areas you can use to creatively engage your students. You are certainly free to embellish these suggested activities and make them as intense as your classroom dictates. Also, add more of your own activities from your readings, studies, and accumulated experiences.

Robots

- Suppose you were challenged to design a mechanical hand. What design philosophy would you employ? How would your design change if the hand could only have three fingers? Four fingers?
- How would you approach designing a robot that could be used to access and/or clean large vertical surfaces? What else might such a robot be used for? Could it be applicable to building window washing...how so?
- It seems that a robot that moves like a rolling ball might be very useful, as it would be omnidirectional, able to get into many challenging and tight spots. How would you approach this design? Discuss the details, with lots of sketches and drawings.
- Is it possible to develop a chair for a person of limited mobility that can transport them upstairs and negotiate landings? How might you design such a mobile chair?
- What are the differences between a mobile tele-operated robot and an industrial robot for assembly?
- Can a garbage truck be "robotized"...to be able to operate autonomously and collect garbage from in front of buildings? How would you do it? What are the design constraints you must deal with?
- When your school is closed at night, could autonomous robotic devices roam the floors and clean them? Would these devices be battery powered and recharge at designated areas during the day? Could these robots double as night security for the school as well?
- Could an overhead robotic device be used as a security system at night and during events when unauthorized people get into the school? What might be the capabilities of the overhead device, and how could it help students?
- What are the differences between a robot, an android, and a cyborg; and what are the implications for human beings with



artificial devices implanted in their bodies? Is someone with a cochlear implant to allow them to hear better considered a cyborg? What about dental implants? How about an insulin pump? Or a pacemaker?

- What, if any, are the moral implications of using robots in warfare—or having only robots fight wars?
- How would you deploy robots in an airport? What tasks do you envision, and why use them within the facility?

- Let's think of a drone delivery vehicle as a kind of robot. What might be the social, political, regulatory, and legal impacts of the widespread use of this technology?
- When designing a mobile tele-operated robot for use in a nuclear power plant, what concerns would be on the designer's mind? Review the literature.
- If you were tasked to design a pipe-crawling robot with a tether to inspect large-diameter pipes, what kinds of concerns would you consider?
- Conceptualize a robot and system that would allow for delivery of U.S. mail. Outline the main concerns such a system and robot would need to address.
- If you were designing a robot to be submerged in fuel oil to inspect fuel-oil storage tanks for possible floor leaks, what concerns would you have when planning the design of such a robot? Try listing these concerns and sketching out a rough design for the robot and the system to support it.

- What might be your design concerns for an exoskeleton to help people with handicaps walk? Can you sketch out a possible design?
- When astronauts suit-up to walk in space, is their suit comparable to an exoskeleton? Discuss the similarities and differences. Is an automobile a form of exoskeleton? How about a bucket truck for working on high-voltage power lines?

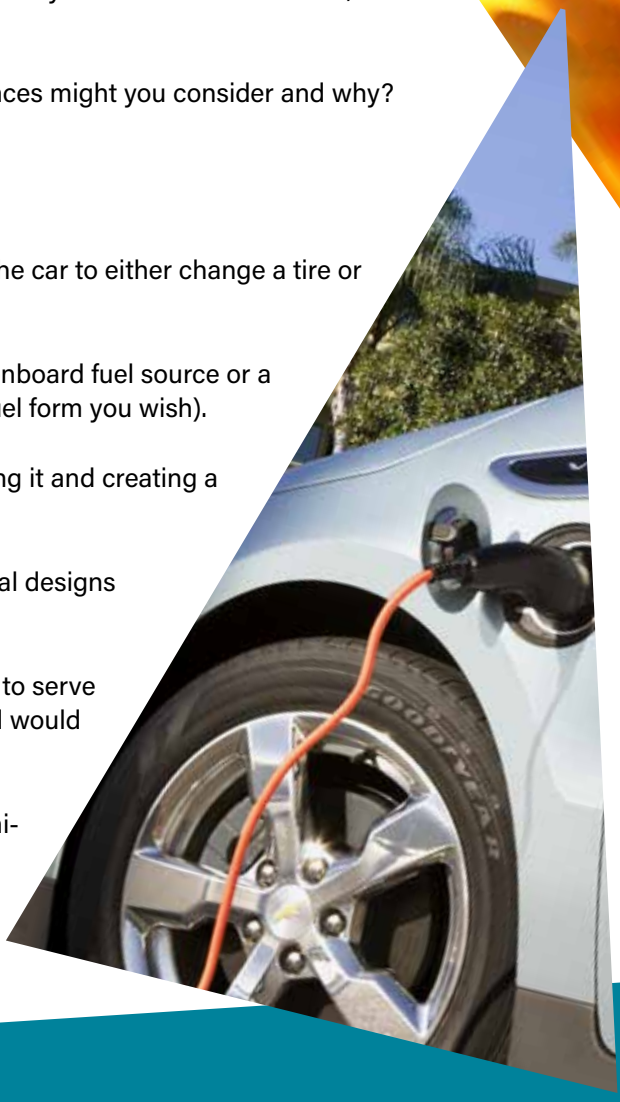
Safety

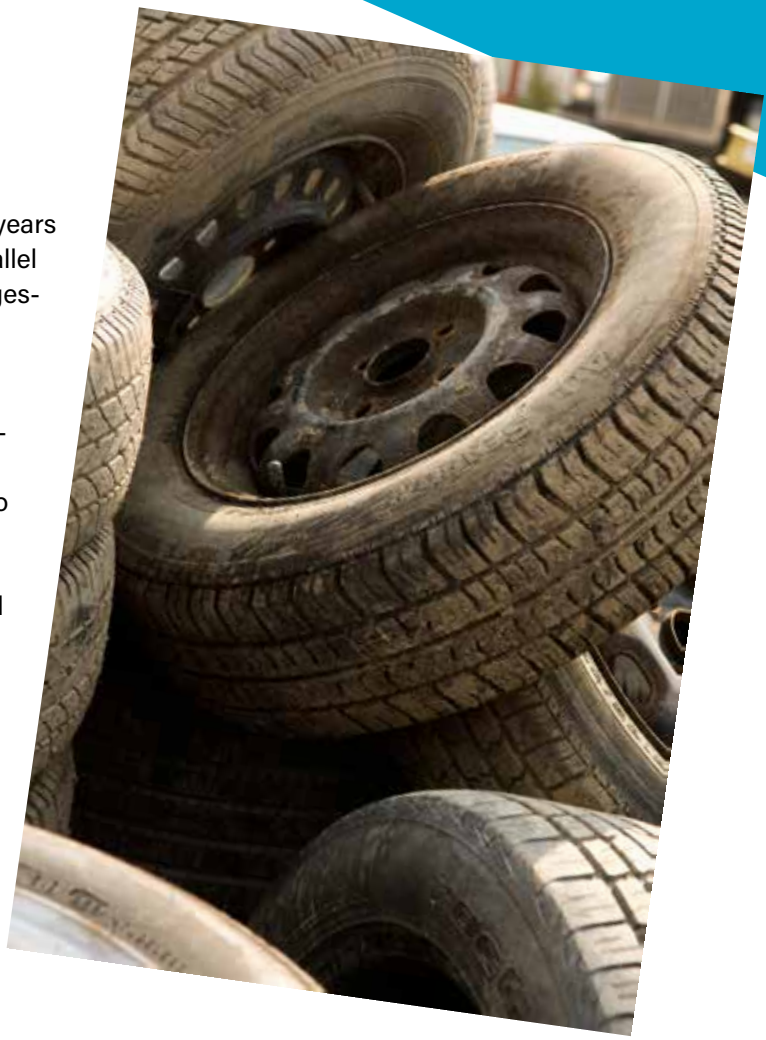
- Fires in skyscrapers are terrible to deal with. Firefighting apparatus is limited to the first few floors. Can you develop some ideas to get people out of multistory buildings easily and quickly in the event of fire?

- Let's entertain the thought of a "smart cane." How would you make a cane smart? What capabilities would it have and why? Can it remain the same size, or must its profile change?
- Firefighting robots are making their appearances. One was used in the recent fire at Notre Dame Cathedral to fight the fire inside the church. How might you design a firefighting robot? What subsystems would need to work together?
- How would you use robots to improve safety? Where and how could you apply them?
- Can homes be made to resist the high winds that hurricanes and tornados present? What unusual designs could you envision for futuristic homes that are hurricane and tornado proof?
- Electric vehicles can be subject to electrical fires due to battery problems. Such fires can be hard to predict and extinguish. Can you envision an onboard system to quench such a vehicle fire?
- Might you envision a human safety belt that could measure your body's physical stress so that an alarm could be sounded before you potentially hurt yourself by lifting loads incorrectly? What would it look like, and how might it be equipped with "sensors" to detect trouble?
- Instead of using water and chemical foam to fight fires, what other substances might you consider and why?

Automobiles

- Design a jack built into the undercarriage of an automobile that can raise the car to either change a tire or make repairs.
- Modify cars so they can generate clean electricity while parked, using an onboard fuel source or a plug in external fuel source (hint: you can consider any kind of engine or fuel form you wish).
- Is it possible to disable a speeding car or one eluding police without chasing it and creating a dangerous situation? How would you do this?
- How could passenger buses be made less traffic-congesting? What unusual designs would you make for buses on busy city streets?
- How would you view electric vehicles if you are a utility executive who has to serve this heavy battery-charging load? What aspects of this kind of electric load would concern you?
- What in your opinion would be needed to accelerate the use of electric vehicles? Identify the factors and discuss them in a logical and straightforward manner.





- Angle parking of cars at curbs was very popular about 50-60 years ago and still exists in places. What caused it to change to parallel parking, and how might we bring it back again to reduce congestion and offer more parking places in dense city and business areas?
- With over 250 million vehicles of all kinds on the road and registered, that means lots of worn out tires. Identify the way we recycle tires today and offer some unusual ways we might also recycle them.
- Are you an advocate of driverless cars? What are the pros and cons of this form of transportation?
- How would you modularize automobiles so at the end of their useful life they could be disassembled and recycled easily?

Recycling

- Scraps of treated and untreated wood from construction projects are a common material often dumped in landfills. How could they be recycled?

- Plastic soda bottles are already recycled, so what new ways do you envision for reusing the plastic?
- A huge source of construction debris is roofing shingles, and they are often attached to roof wood that comes off with them. How would you recycle this composite debris?
- We create a great deal of electronic waste of many different kinds. How would you recycle old computer CRTs and monitors?
- Wallboard is another large volume construction debris material. Can this be recycled?
- How would you propose recycling electric vehicle batteries; or mobile phone batteries?
- How would you recycle old railroad boxcars and other vehicles?

Electronics

Here are some interesting topics for your class to engage in and gain perspective:

- Consider inviting technical experts from the professional and academic communities into the classroom to augment information exposure for your students.
- Discuss how microelectronics has changed our lives and impacted society. Take special care to examine this from both pro and con aspects.
- Take apart some electronic items—maybe a mobile phone or computer—and identify the integrated circuits and components inside. If possible take apart electronic items at least 10-20 years old and compare their electronics to more modern ones.
- Why are robots so crucial to the manufacture of computer chips and other electronic equipment?
- When folks talk about electronic products being smarter...exactly what do they mean? Where does the smartness reside?
- Who were the great inventors (1900 to present) that changed the course of electronics? What did they do, and what were the impacts of their work?
- Why were the first electronic computers built, and what were they used for? How well did they work?
- What are the primary differences between digital and analog circuits and systems?
- As scientists and engineers discuss the longevity of Moore's Law, what do they see as its limitations...and can these limits be surpassed? What previously envisioned limits to the law were overcome?
- What is nanotechnology, and how do your students think it will affect the future of microelectronics?

- What might be the ethical, legal, and moral concerns with augmenting human capabilities with plug-in devices to the brain—possibly artificial intelligence software?

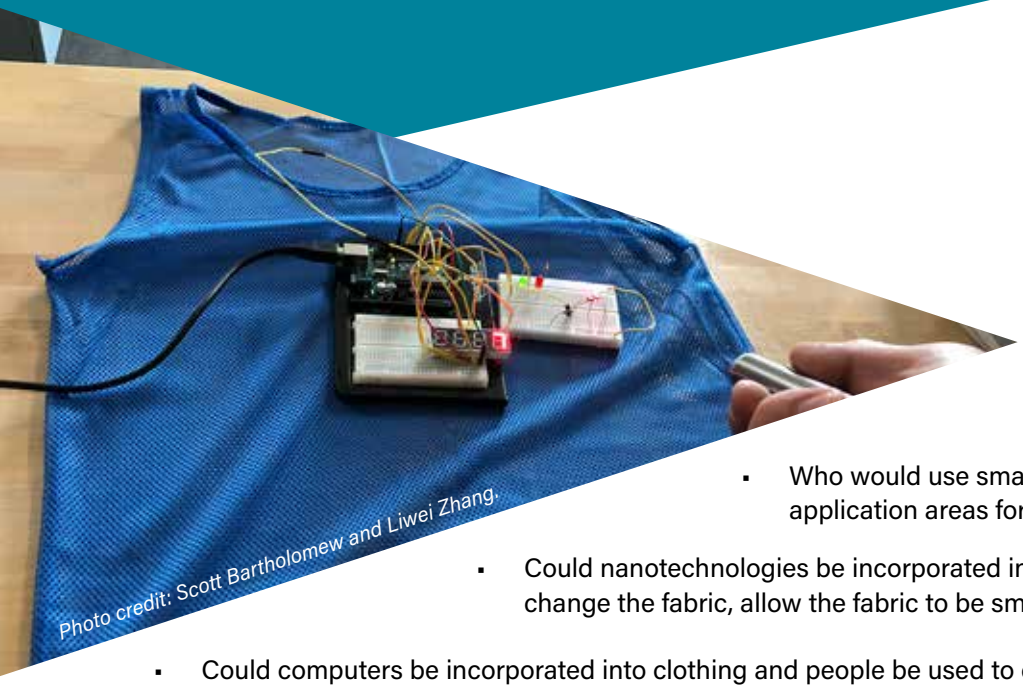


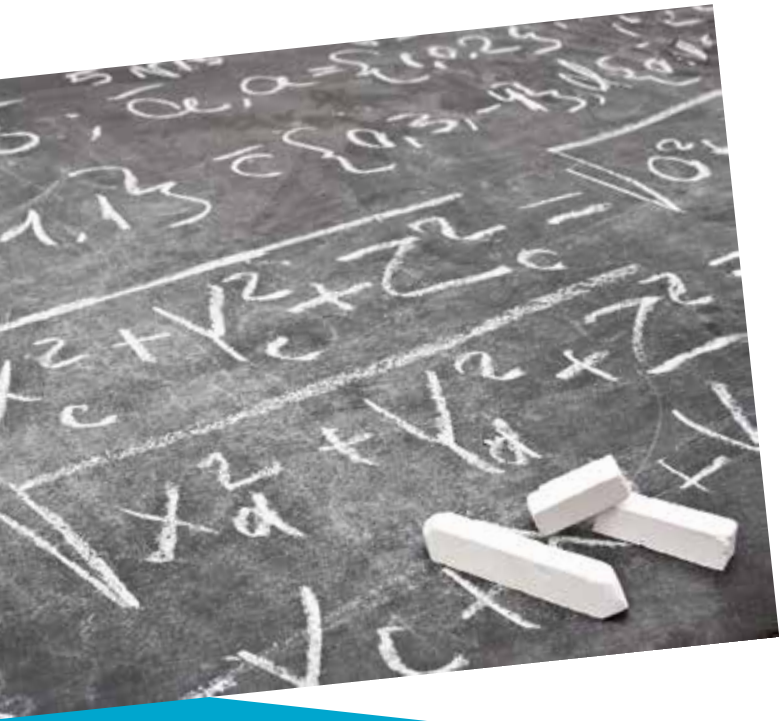
Photo credit: Scott Bartholomew and Liwei Zhang.

Clothing

- How would you make clothing smart? What would it keep track of, measure, monitor and why?
- Who would use smart clothing and why? Make a list of possible application areas for the clothing and discuss why.
- Could nanotechnologies be incorporated into clothing? And what would it do? Might it change the fabric, allow the fabric to be smart, or something else?
- Could computers be incorporated into clothing and people be used to create a self-organizing network? What might this be useful for?
- How would you incorporate solar cells into clothing to make the fashion have a solar theme to it?
- Could 3D printers be used to create things like earrings? What would you use to make this happen, and how would you program the printer? What other things would you try making?
- What would be the benefits of having clothes or parts of clothes change color with temperature?

Math in Action

- Since the advent of the internet for email and social media, the amount of letter traffic via the U.S. Postal Service has radically dropped. Can you try calculating the amount of liquid fuel energy saved through people communicating by email and social media instead of by pen and paper the old way?



- The internet also allows us to shop without having to go to a store and instead have those purchases delivered directly to our homes. What kinds of transportation fuel energy are saved by us? How much fuel is saved in total for all customers because one delivery vehicle can make many deliveries to a geographic area?
- Try calculating the amount of transistors the world makes every year and the impacts on recycling this imposes?
- Develop a chart that shows the energy content of the different fuel forms the world uses. Express this on a common basis like energy content (Btu) per gallon, per pound, per liter, etc.
- What common mathematical expression is used to determine the shape of a street?

- What kind of game would you develop to reinforce mathematics to young folks, and at what grade level would you introduce it? Want to try and actually develop such a game, perhaps using cards and maybe dice; and writing the instructions for the game?

- How much more energy (Btu) is there in a pound of oil than a pound of:
  - Coal?
  - Wood?
  - Refuse-derived fuel?

- How much more energy in Btu is it possible to harvest from a pound of nuclear fuel than a pound of oil?

- If a 3 kW solar system on the roof of a home requires about 300 square feet of surface area, how much surface area (either located on a large roof or mounted at ground level) would be needed for an 85 kW solar system?

- If drones are used to deliver packages instead of ground delivery vehicles, how much energy savings, if any, is achieved? Assume a five-pound package.

- Those high electrical transmission lines bring large amounts of electric power and energy to population centers. Those lines or conductors assume a natural shape as they hang between towers. What is the mathematical shape called?

School-Related

- Do you think schools should be teaching something like entrepreneurship or starting a business? What grade level would be appropriate to start these kinds of learning activities? What topical areas should be taught?

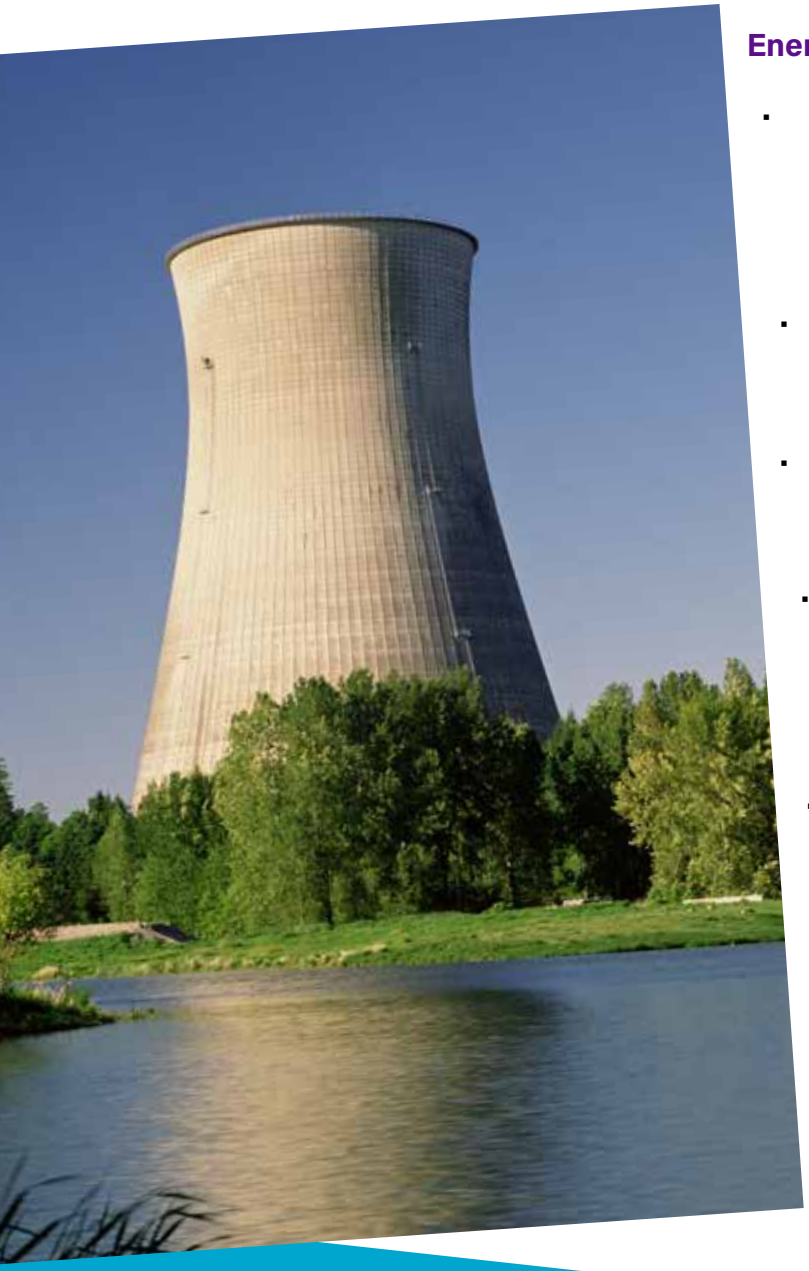
- Studies show that students are losing their natural dexterity, or ability to manipulate things with their fine motor skills. Research this area and develop some ideas about kinds of activities that students should do in school to address this.

- Keep a diary that daily tracks when students feel most creative and alert to developing new ideas. What is the consensus, if any, among students? How could the results of this activity affect the way the school day is carried out?

- Would you welcome working with local businesses and solving problems in the workplace as part of your normal school day? What are the pros and cons of this? At what grade level should something like this happen?

- Design an invention competition for the entire school to take part in. This competition would involve student teams and be mindful of the following:
  - In what areas or technologies might the students invent?
  - What would the rules of this competition be?
  - How much time should teams be given to complete their designs?
  - How are the students to present their inventions?
  - Who will judge their inventions?
  - What prizes would the top places receive?

- How would you bring the excitement and knowledge of the real world into your classroom and studies? What programs and types of presentations would you propose? How might you interact with the outside community?



Energy-Related

- Spinning flywheels rotating at very high speeds can store a great deal of energy and provide electrical power/energy to a home as they wind down. What kinds of concerns might a homeowner have with such a dynamic device in the basement of the home?

- Why aren't tides or river currents used more often as an energy source? What are the main reasons for this; and are there some ways to ameliorate these limitations?

- Fuel cells were important energy systems on the manned Apollo moon missions. Identify where such clean-energy systems might be used on Earth.

- In the 1970s America's utility companies ordered many nuclear power plants. What were the reasons for doing so back then? Are the same reasons active today, or have other reasons surfaced to make nuclear energy interesting again?

- Research the total energy use of the U.S. (in quadrillions of Btu) by year and make a chart for 1950, 1960, 1970, 1980, and on up to 2020. What do you notice about the progression of numbers?

- Do this yearly analysis (above) again, but this time construct a pie chart for each year showing the amount of the different energy forms that were used.

- Offer a rationale for countries using ever more dense fuel energy forms. What do solar, wind, and other renewable energy forms do to this trend? What challenges does this portend?

Railroads

- Prior to the great changes of the late 1880s brought about by Thomas Edison and others, the nation's railroads were the innovative sector of the American economy. Examine the different aspects of RR technology and how that has come down to us today.
- How can you use model trains to develop an educational paradigm concerning transportation and its impact on communities? Develop a lesson plan(s) for use in the classroom.
- What were the main reasons steam locomotives were replaced by diesel and electric trains? What is the next big change you can foresee to bring train engines to another prime motive force?
- How did RR technology influence the big push to automobiles in the early 1900s?

- Many old industrial spur lines fed now-empty factory buildings that stand idle today. Can you envision ways to use those old factory buildings; and maybe even revitalize those old spur lines?
- What were "gandydancers" on the old railroads? How did their teamwork influence work songs and R&B music?
- If you came upon a large cache of old railroad freight cars that no one wanted, what could you make out of them...repurposing them for other applications?

Solar Energy

- Design a solar heating system for the sunroom of a home to be used as supplemental passive solar heating. How can this be done? What hardware modifications must be made to the room to get that collected solar heat into the rest of the house? Use diagrams and sketches to illustrate and explain your ideas. Does all this happen automatically, or must someone do certain things during the day to make this work?

- Can you devise a system that moves the captured solar heat inside a car into a nearby home to supplement its heat? Like the previous example, how would this heat transfer into the home work? How much heat energy could your family car's interior generate for the home during the sunny part of the day with the car parked nearby?

- A Trombe wall is an architectural feature that uses mass to capture solar-induced heating inside a home to later reradiate that heat into a room after the sun goes down. Using your home as an example, how would you retrofit a Trombe wall into the structure. Use diagrams and sketches to illustrate and explain your ideas.

- If, in the Trombe wall technique above, you cannot accommodate this kind of wall design, how else would you retrofit heat-absorbing mass into the home's current design? What materials would you use and why?

- Solar swimming pool heating is a rather simple solar application. The objective is to warm the water to make it more comfortable. Using simple materials, how would you do this for a typical above-ground backyard swimming pool? How would you measure the performance of the system? Would the performance of your design vary across the country? Why? What else could you do to conserve the added heat your system put into the pool water after the sun goes down?

- It is known that large solar arrays can be constructed on land to turn the sun's radiant energy into electricity. Design a system whereby the panels float on water and the electricity is delivered to shore for use. Consider the possible ecological and environmental impacts that could be of concern.

- Design a simple experiment to show why the same object, in a different color, collects more of the sun's radiant energy. Why is this so?

- If your home could not accommodate solar electric panels mounted on the roof, what other options would you offer for their installation? Use sketches to illustrate your installation options.

- Today, many solar advocates want to make our nation's electric supply totally dependent on solar and wind energy to generate the electricity needed. Is this the proper way to guarantee the reliability of the nation's grid and our telecommunications network? How would you design the future electric energy supply for our country?

- Design an addition to your school that contains passive solar design principles. Use drawings, sketches, and computer-generated art to show its design in detail. Would this part of the building be isolated from the rest of the school to conserve solar collected energy? If not, why not?

- A significant concern with installing solar systems is the potential for worker falls. What form of safety equipment or procedures would you suggest to reduce this concern?

Homes

- How would you increase the energy efficiency of your home? What techniques would you apply to reduce the amount of energy consumed? Which techniques would give you the biggest return for the money spent and hence the first you would do? How could you determine the before-and-after energy consumption for a final comparison?

- Thomas Edison pioneered the building of concrete homes in the early 1900s using metal forms into which he poured his concrete. How would you build concrete homes? Would you use metal forms or choose another technique to build the walls of the home?

- One of the worst after-effects of a disaster or bad storm is the lack of shelter for the survivors. Can you design a cheap, but effective form of temporary housing that

Photo credit: Wikimedia Commons - Kuste

could be easily transported to a needy area for families to use for shelter?

- Should we use different building materials than the ones we use now for constructing homes? If so, what materials would you suggest; and what are the benefits of using these alternative materials?

- Very small houses are being seriously considered as primary living residences. What kinds of designs would you propose? Are there existing containers we use today that could serve as models for these small homes?

- Design a hurricane-resistant home that could be used near bodies of water like rivers and oceans and bays. Use sketches and diagrams to illustrate your thinking and designs.

- How would you retrofit insulation to the walls of an existing older home to reduce heat loss?

Safety

- Every parent's nightmare is to have a child snatched on the street. What precautions could be put on their bodies or into their clothing to track their location if someone did successfully snatch them? How would you do this? What devices or combination of them would you employ?

- Using radio-frequency technology, design a system that could track the location of students within the schools and determine who has left the building. The system should consist of door readers and a reporting system for use in normal tracking, fire drills, and emergency lock-downs as well as a wearable student identification card or badge.

- In a burning high-rise, escaping from floors that are taller than fire department rescue trucks is a big concern. Are there ways for occupants to safely escape from upper floors? What kinds of designs would you select for development or implementation?

- In cars where there is a crash and a possible fire situation, what safety systems can be engaged either automatically or by occupants to remove this threat, or possibly even extinguish a fire that has started?

- Dealing with battery fires is not easy. How would it be possible to determine if a battery pack aboard an electric vehicle was having problems that could possibly result in a catastrophic fire? What parameters of the battery system should be monitored? If a fire would erupt, in what ways could it be dealt with and extinguished?

Photo credit: Scott Bartholomew.

Drones

- Might drones be used to inspect crops for disease and other problems? In addition to monitoring and diagnostics, could the drones also be used to deliver highly targeted pesticides, fungicides, and other remediation? Would the drone management be accomplished by a human operator(s) or would it be accomplished autonomously via artificial intelligence techniques?

- If children were equipped with tracking devices in their clothes, could drones be used to locate them if they were abducted or lost? What concerns would there be?

- How would you use a drone population, or swarm, to locate survivors after a bad storm or natural disaster? What other functions could this drone swarm also provide?

- Electric utilities have large service areas to maintain and monitor. How do you envision them using drone technology? What applications do you think might occur first?

Smart Stuff

- Can you design a smart refrigerator that alerts you when your favorite foods and spices are running low? How would it communicate with you? Would it be able to automatically contact the grocery store and place an order for more? What else would your refrigerator design be capable of performing?

- Much is being discussed about how AI will change our world. How would you apply it right now...what sectors of the economy or in specific applications can you see AI providing benefits?

- Could you foresee a smart electric utility, one that can predict and prevent major problems that lead to customer outages? What kinds of sensors, monitoring equipment, and AI would be needed to integrate this together? Are some utilities moving in this direction now, and what are their ideas and strategies?

- Can you envision how AI technologies would be used someday to help diagnose student learning problems and how to correct them? Give some examples and your reasons for suggesting them.

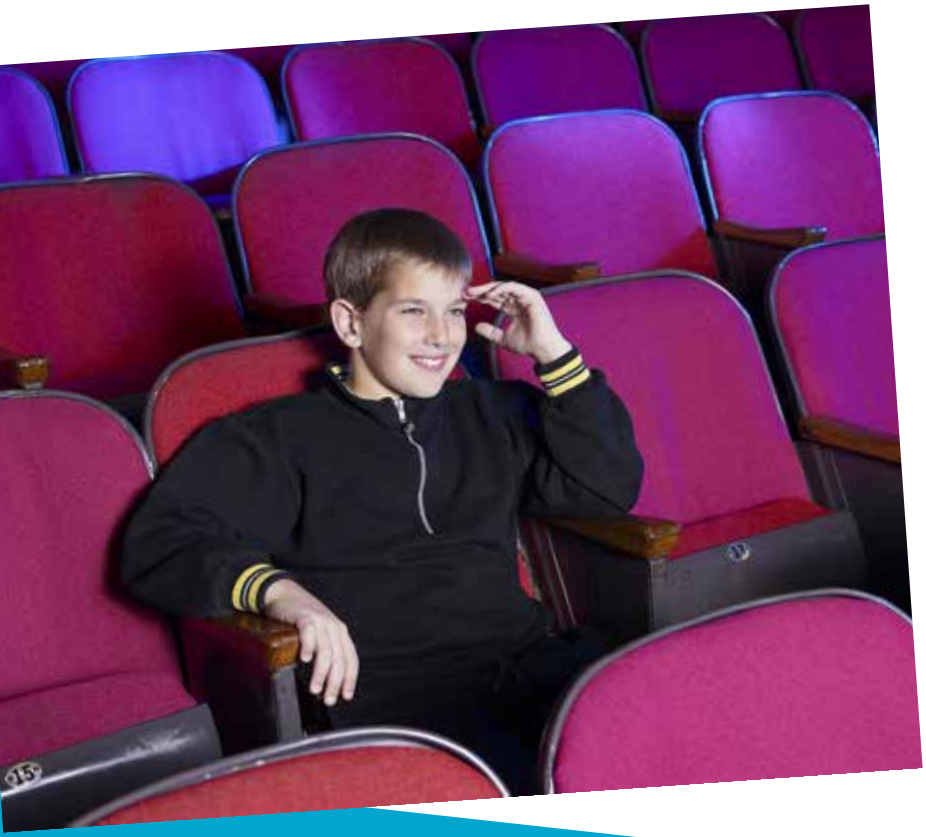
Invention and Creativity

- Describe the differences and similarities between creativity, invention, technology, and innovation. Is there is a firm hierarchy between these terms?

- How would you define creativity, and how would you measure it? What traits characterize creative people? Can creativity be taught—how would you do it? Construct a test you would use to identify creativity in people.

- Compare and contrast Thomas Edison with modern inventors and entrepreneurs like Elon Musk and Dean Kamen. How are they similar and different?

- How are art and invention related? How does the term "creativity" enter the discussion? Defend your thoughts and conclusions.



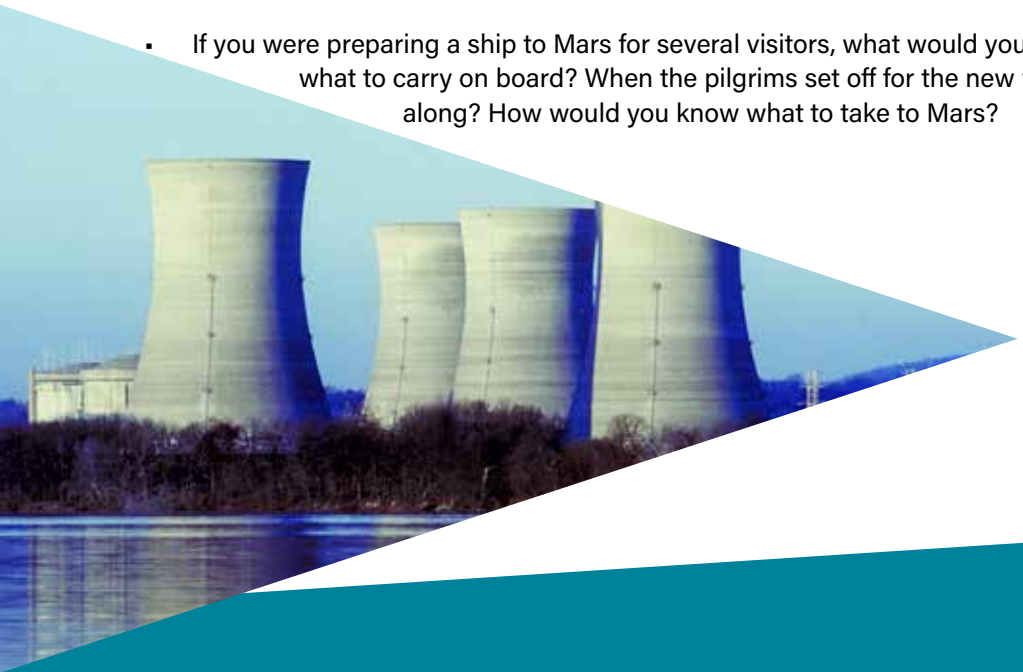
- Lots of folks like to comment on the Edison-Tesla competition. Compare and contrast the invention styles of the two great men—and the kinds of inventions they developed.

- Many companies today are considering no longer asking for the academic credentials of potential new hires. How would you as a hiring manager for a high tech company select new employees in this kind of an environment? How would you be able to determine their ability to invent valuable new products for the company and the creativity they possess?

- Is it possible to enhance movie watching by somehow adding aromas and distinct smells to the experience? In the movie theater this might be easier to accomplish. How would you do it for the at-home movie viewer?

Out of This World

- You are asked to develop a planetary probe to Mars in advance of a manned landing a year later. How would you design the probe, its various instrumentation packages, communications with Earth, fail-safe systems, and such?
- You are part of a team to develop a moon-base design. What would you be considering as possible energy systems for the base...and why?
- If we did have a moon base, how would we use this base to move outward to other planets?
- Some advocates have proposed giant solar collectors orbiting in space to beam electricity back to Earth. How big might such an orbiting platform be, and where in space would it be located? How would it be built, and out of what materials would it be constructed?
- Could we use the moon as a repository for spent nuclear fuel...or a place to reprocess it to useable fuel once more? The reprocessed fuel could be used for what, either on the moon or shipped back to Earth?
- With all the communication satellites orbiting earth, many will need to be maintained. How would you retrieve them or work on them easily and safely?
- Could products be manufactured on the moon and then "shot back to Earth" by exploiting the gravity well between Earth and the moon? What products could be made on the moon? What might be the safety concerns with shooting materials back to earth?
- If you were preparing a ship to Mars for several visitors, what would you pack on the ship? How would you justify what to carry on board? When the pilgrims set off for the new world, how did they know what to take along? How would you know what to take to Mars?



Nuclear

- How would you use nuclear energy in our world, beyond the current uses? Why would you propose these applications?

- Is there a possibility for nuclear fuel to be used in homes to provide a long-term supply of energy. How would you design such an application, its safety systems, and routine monitoring?
- Why is nuclear fuel reprocessing so controversial? What are the major hang-ups, and can they be overcome?
- How much more energy is possible from a nuclear fuel mass than an equivalent mass of various fossil fuels?
- Nuclear reactors have been used aboard naval vessels, where sailors are always in close proximity to the reactor, since the 1950s. Why are people afraid of commercial electric utility nuclear power from plants located far away? How can fear of nuclear power be lessened?

Miscellaneous

- Develop a way to load passengers aboard an airplane without the jostling and crowding that always occurs. Could passengers be preloaded somehow, maybe outside the plane and everyone inserted into the plane at the same time? What new ways can you envision?

- Using a large, empty soda bottle, design a compact water purification system that can be carried into wilderness areas. How would the filter be packed and with what cleansing materials? How long would the filter last before it needed to be regenerated?
- Design a classroom that could fit inside a large shipping container as an add-on to an existing school building or as a separate stand-alone facility. Can you envision an attractive stacking of these container classrooms to facilitate an appealing structure for learning? Use diagrams and sketches to illustrate what you envision.
- Can you design a man-made lake for a new park? The lake will be approximately 1000 feet long and approximately 250 feet across in a rounded oblong fashion; but the dimensions and shape of the lake may be varied a bit. Various features within and on the lake may be considered in the design.

- Design a maker space for your school and describe the types of equipment that would be incorporated there. For what grade levels would this maker space be used? Can you describe the kinds of activities that would be undertaken here?

- Plan the landscaping of a small knoll on which a residential home rests. The knoll is 50 feet long and approximately 6 feet tall from the sidewalk with a gentle upward slope with clay-type soil. Determine the plantings that would keep the slope stable throughout the entire year. Use sketches and drawings to illustrate the suggested design.

- Select an old red brick manufacturing building and develop designs to repurpose that structure for another new use. Use lots of graphics and diagrams to illustrate what you were planning. Integrate renewables technology and perhaps gardens on the roof.

- You are now in charge of designing and building artificial reefs. What existing objects would you use to create such reefs, and what newly designed objects would you also employ and why?

- With the massive expected increases in electronic device waste, how would you suggest this waste be managed and disposed of? Can useful products be made from this waste stream? Are there possible environmental impacts to be avoided or better manufacturing processes in the first place to make recycling easy at end-of-life?

STEM Design Challenges

- If you could redesign a cargo ship into a floating factory that picks up raw materials in one country and while en route to its port in the U.S. makes a finished product that is unloaded upon its arrival…what would you make and what kinds of design would this vessel have?

- Have the class use an abandoned commercial building in the district as an example, and redesign it for another use. Can an old school building (or even your building) be redesigned as a maker space for new businesses?

- Instead of building a hydroelectric facility, what if you built a device that moved heavy masses up and down a steep hill? In the evening, excess electricity could move the device up the hill; and during the day the device would move down the hill, generating electricity. What might this system look like in concept and some rough design?

- Old railroad rights-of-way to spur lines are corridors between places. If these corridors were no longer needed, what could they be used for? Identify possible uses and develop a pro-and-con statement for the various ideas generated.

- For vessels that ply the oceans and burn hydrocarbon-bearing fuels, what alternatives to this level of pollution are possible? Are old-fashioned sails or their modern equivalent feasible? How about alternate technologies? What might an alternate-powered vessel look like, and how would all this technology come together to power it across the oceans?

- If you live near picturesque mountains in a rural area, and a wind energy company wants to locate tall wind turbines on those mountains because wind speeds are quite high there, what would be your concerns and questions to ask this company at a public hearing? Would your questions be that much different if you lived near the shore and the wind company wanted to locate the turbines just offshore?

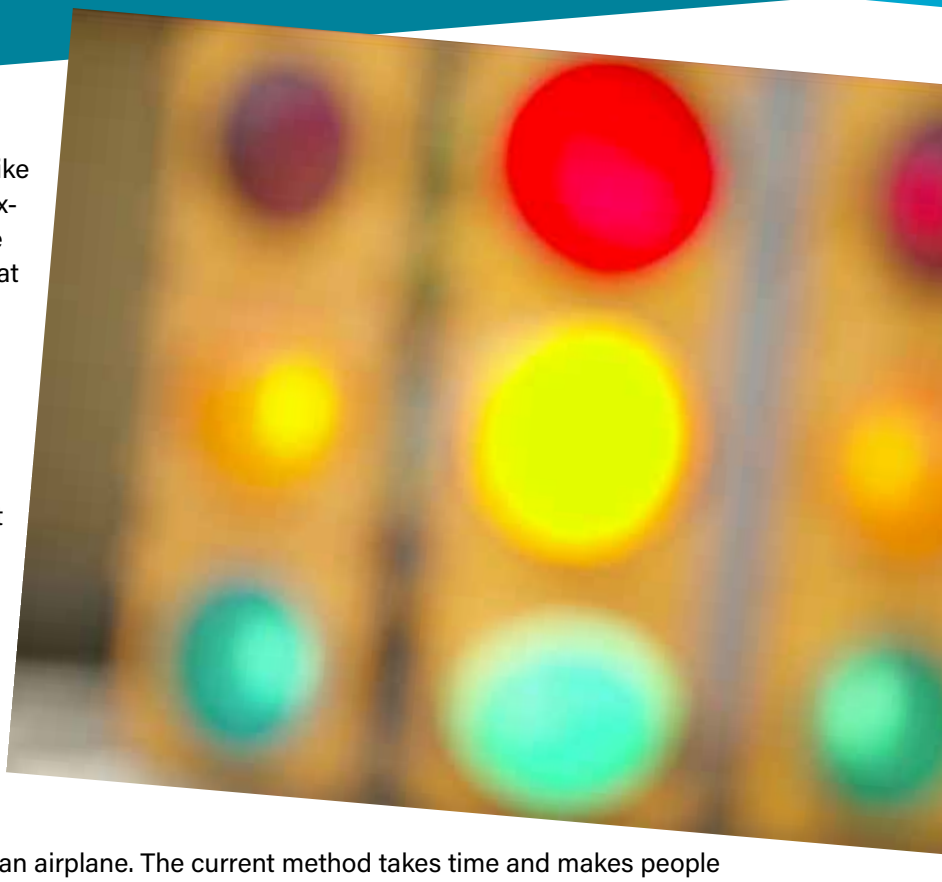
- Design a muffler that can scrub the carbon dioxide from the exhaust of an internal combustion engine, thus blocking it from getting into the air in the first place. What would this mean to the design of a traditional muffler, and how would one dispose of them?

- How would a facility look that processes the carbon dioxide emissions from a natural gas power plant and uses that carbon-rich gas stream to feed a large adjacent greenhouse? What kinds of plants would you grow in this kind of greenhouse, and what design and operational concerns would drive your design? How big would the greenhouse have to be and why?

- What would be the building and construction concerns with constructing homes that have an active roof for growing plants and shrubs to put more oxygen in the air and remove carbon dioxide?

- Microwave towers are often tall and disguised to look like trees. Are there other potential uses for these towers? Develop some conceptual designs.

- Design a smart refrigerator that can survey its contents periodically and automatically order replenishments that would be delivered from a local store.



- Is it possible to create artificial trees that look like the real thing but can remove more carbon dioxide from the air than a regular mature tree? Are chemical removal processes available today that could make such artificial trees possible?

- Radioactive waste is routinely shipped in accident-proof containers—resistant to both fire and impact. Do you think miniature reactors made from small amounts of nuclear waste could be used to power electric vehicles? What kinds of concerns would you or the public have?

- During electric power outages, traffic lights are out and accidents at intersections increase. How would you design a system that provides emergency power to keep the traffic lights functioning?

- Design a better and more efficient way to load an airplane. The current method takes time and makes people unruly. What futuristic ways would you envision to load an airplane?

Bonus Section: Communications Challenges

Oral and written communication skills are very powerful ways to advance a career in STEM. They are often underplayed in relation to STEM subjects, but must be emphasized more. The activities below combine a bit of fun and practicality to help make students more receptive to these important skills.

Where Am I Going?

Have students think and write about what they plan to do once they get into high school and beyond—where they envision their life will be headed and how they see themselves getting there. Have they thought about the specific career they envision? Do they see themselves at a certain college/university? Maybe a certain industry or business choice is in their thoughts? Perhaps they could lay out a timeline or develop a PowerPoint presentation to help organize their thoughts and future actions—all nicely developed into a plan of action they see for themselves.

Technology Epitaphs

All technologies grow up, mature, and die…or are replaced by other technologies. Identify some technologies that have been superseded and write an epitaph about their passing. It can be serious or humorous, but gets to the point of why they were superseded. Here are a few to get the juices flowing:

- Slide rules
- Wall phones
- Buggy whips

Energy Debates

Nothing stirs up discussion like the energy situation, alternate technologies, nuclear power, and climate change…so let's have a class debate, backed up with a thorough research effort to develop cogent arguments both for and against. Teams of students can use various methods to express their viewpoints like tried-and-true oral discussion, visual displays, PowerPoint presentations, etc.—whatever best suits their style. The point here is on doing serious research followed by excellent planning/presentation of viewpoints. The ability to answer questions and think on one's feet is also important for teams to be prepared for.

Writing to STEM-Based Companies

Students are to select a STEM-based company and write to request to learn more about the work these companies perform and what specifically they look for in new hires. What skills are most important to them? How do they factor in the creative element of new hires and the value of part-time jobs the students might have had while going to school? How much do school grades matter in being selected for an interview? How about communication skills?

Panel Discussion

Design a panel discussion event about the importance of good communications on the job, and invite a variety of people from different professions to look for commonalities. Some typical professions might include, but not be limited to:

- Engineering
- Journalism
- Teaching
- Politics
- Science
- Lawyer
- Doctor
- Writer
- Artist

A Children's Book

Assemble teams of students to develop plans for a children's book, say 3-4 grade levels below their own, and create a draft for review. The book can be on currently popular topics like robots, electric vehicles, environment, etc. It may introduce

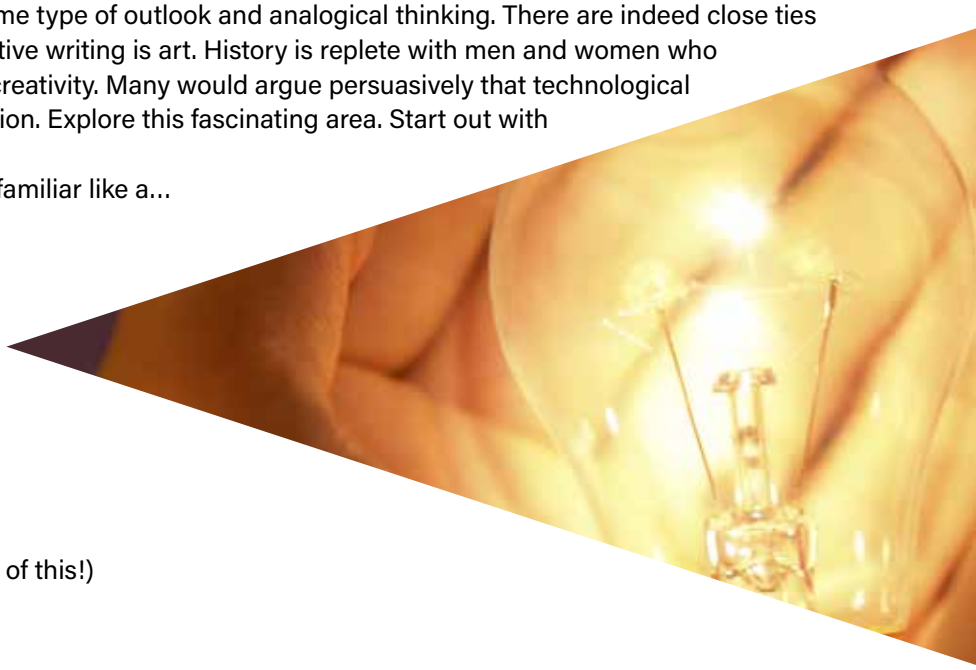
characters, a story line, or bring students up to speed on a new area. Clarity and organization of topic are key areas of concern. The book may be humorous and light in style and tone. A sampling of young students may be asked to read and review the book for feedback.

School to Work

Every school now takes some time to immerse their students in school-to-work activities and career choices. Do you think it is possible to have your students contact people in a variety of technically oriented professions and interview them? Of course this should all start with you and the students developing a set of common questions that can be asked. With these questions, it will then be possible to compare the different technical professions on a common basis.

Creative Writing

I happen to believe very strongly in a huge tie between creative writing and creativity as displayed in invention and technology. Both activities essentially require the same type of outlook and analogical thinking. There are indeed close ties between art and science. Never forget that creative writing is art. History is replete with men and women who displayed both great artistic and technological creativity. Many would argue persuasively that technological creativity is just another form of artistic formulation. Explore this fascinating area. Start out with some simple things like having your students:



- Write a poem to something technologically familiar like a...
  - Lightbulb
  - Mobile phone
  - Train
  - Electric vehicle

- A short story about a new technology to...
  - Allow people to live to be 120
  - Make someone or something invisible
  - Produce copies of anything
  - Capture human intelligence

(Humor is not only okay, but very welcome in all of this!)

Before and After

Here is one that I think might be quite revealing. As your new tech ed/STEM classes start in the fall, have each student write a page about what they think tech ed/STEM is and what they hope to gain in the specific class they are taking with you. Collect the pages and file them.

As the term is nearing completion, once again have the students discuss on a page or two:

- What memorable things they have learned in your class.
- Their understanding of tech ed/STEM.
- How might they improve tech ed/STEM classes?

Now show them their original single page submitted at the beginning of the term and have them discuss the differences!

The Job Description

Have your class write a job description for a new tech ed/STEM teacher for your school. What should be the qualifications and skills the new teacher would need to function effectively in your school district? Students may talk to other teachers and research the topic on the internet—and should be encouraged to become familiar with the relevant standards that should govern what is being taught during the school term.

Let's Put on a Show!

Engage the whole class in developing and putting on a short play or show based on some aspect of tech ed or STEM. Various teams of students could be involved in such tasks as:

- Scenery
- Story line
- Casting
- Dialogue
- Filming of it

The play should be performed to similar age groups and parents, and later critiqued.

Good Oral Presentations

The class should be broken into teams, with each team focused on developing a simple tri-fold document that provides readers with the elements of giving a good oral presentation—the steps to success presented in a concise, one-page format.

Writing Technical Reports

Writing a technical report is a common activity in the work-a-day world. Getting early practice and feeling comfortable with such reports is important. Survey fellow students about a topic of interest like the value and ease of use of a certain phone or tablet app. Compile a summary of the various comments received from the survey and write a technical report of your findings, including:

- A summary of the comments received.
- Statistics about the comments.
- The spread of the data if any.
- Comparison against published materials in the popular press.

Writing Another Technical Report

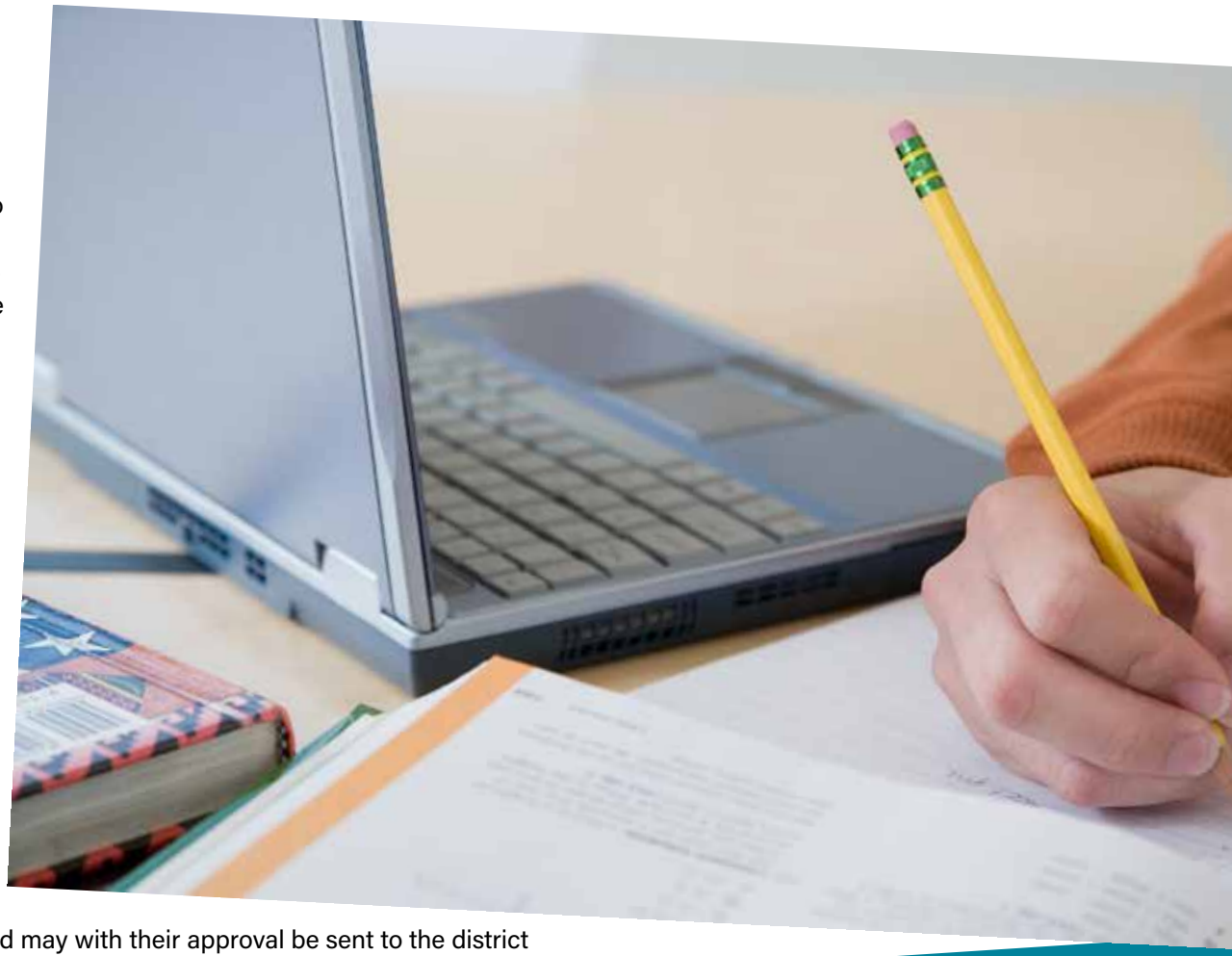
Conduct a series of experiments or STEM activities and use the data collected from these activities to write a technical report. It can be structured as described below:

- Discuss the activities and how they were conducted.
- Identify the data as collected.
- Present an analysis of the data.
- Discuss the analysis of the data.
- Draw conclusions from the analysis.

Clear Communications are Important

Throughout the business world, clear communications are very important, from issuing simple instructions to employees to complex procedures for operating expensive equipment. Here is a chance to develop some comfort with writing an operating procedure. In this case, design an instructional document that would help senior citizens use some form of social media or perhaps operate a mobile phone or tablet. In developing such an instructional document, make sure students talk to the intended target for this—senior citizens.

Write an Article



Professionals in the business world often publish articles and professional papers to appear in magazines, journals, and newsletters. They may also be presented at conferences and symposia. Outline first and then write an article about the value of STEM education in your school. This article should be targeted for your school newspaper or online blog. It should reference recent articles and research published in the STEM literature. A copy of the article should be reviewed by your teachers and assistant principal; and may with their approval be sent to the district administration, and perhaps even the PTA/PTO.

Suggested Reading

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

The Big Book of STEM Classroom Activities: 125+ Challenges and Team Designs. International Technology and Engineering Educators Association (ITEEA e-book), 2019. Free with donation of any size to ITEEA's Foundation: www.iteea.org/File.aspx?id=162611

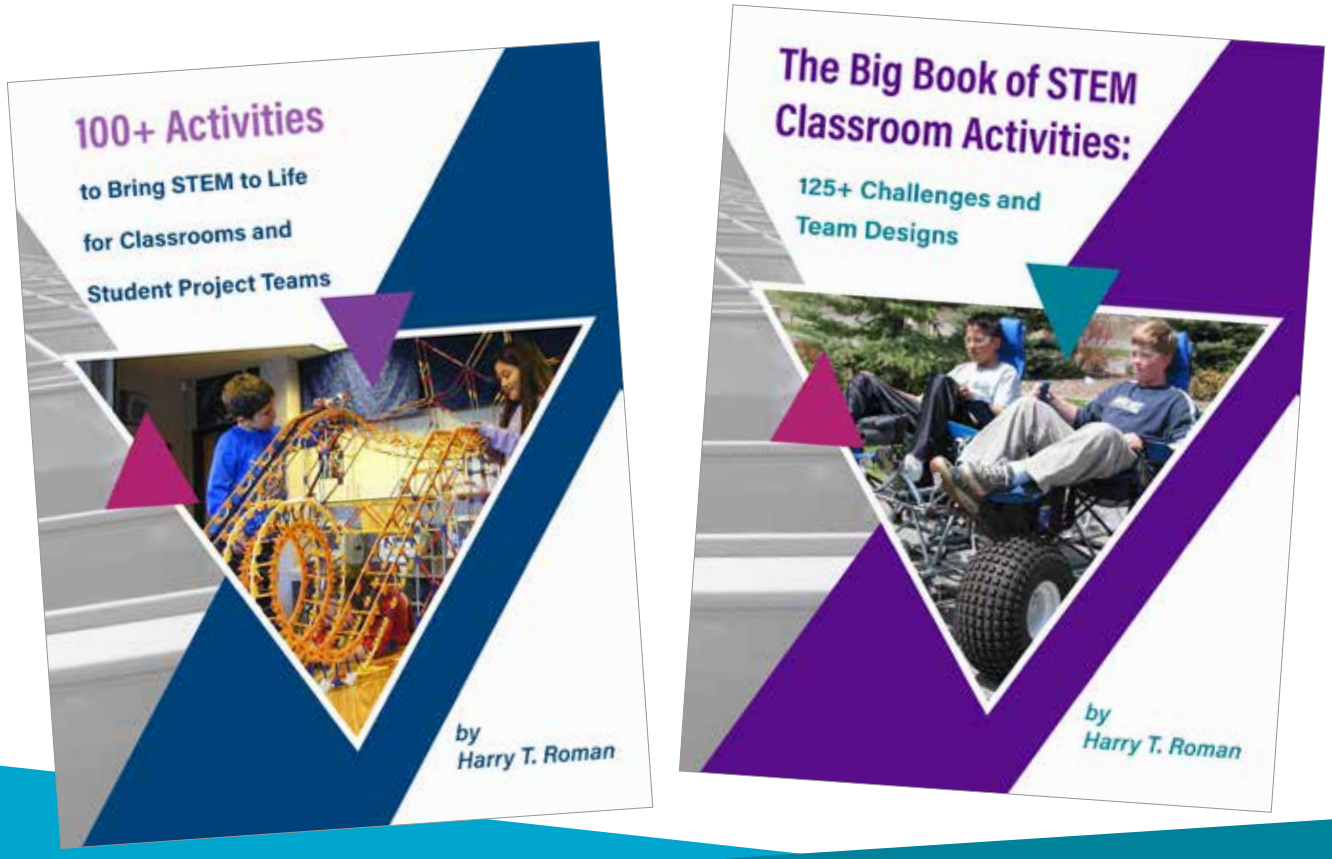
100+ Activities to Bring STEM to Life for Classrooms and Student Project Teams. International Technology and Engineering Educators Association (ITEEA e-book), 2019. Free with donation of any size to ITEEA's Foundation: www.iteea.org/File.aspx?id=156460

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 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 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!

MAKE A DONATION TODAY AT: www.iteea.org/capital_campaign.aspx

ITEEA

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