Inside Engineering Lab Visit

Visitor Information

Visit #1
Group: Lower East Side Preparatory High School
Number of students: 30
Grade(s): 9-12 *ELL (English Language Learners) needs
Date: December 1, 2016
Time: 4pm-5pm
Length: 25-30 min
Lab: Teherani
Department: Electrical Engineering

Visit #2
Group: Scholars' Academy, Rockaway Park
Number of students: 30
Grade(s): 7
Date: December 8, 2016
Time: 11am-12pm *students may arrive slightly late, around 11:10.
Length: 25 min
Lab: Teherani
Department: Electrical Engineering

Lesson Objectives

LO 1: Students will be able to describe engineering and electrical engineering, in general terms.
LO 2: Students will understand that electricity can be generated in different ways and be able to list various ways to generate electricity.
LO 3: Students will participate in a live demonstration of electricity being generated.
LO 4: Students will discuss the importance of electricity and identify consequences of not having access to electricity.
LO 5: Students will understand the accessibility of science Ph.D. programs – students receive a stipend, etc.

Materials Needed

- Compasses
- Magnet
- Wire coil
- Electrical source
- Resistor
- LED light bulb with plug
- Crank generator
- Mini alcohol-burning generator/Stirling Engine with small LED light (https://www.amazon.com/Sunnytech%C2%AE-Stirling-Educational-Electricity-Generator/dp/B00LWWVNTW)

Lesson Outline

1. Introduction (5 min)
- Make introductions:
  - PI Name, title, department
  - Graduate students and researchers
- Contextualize:
  - Ask students questions to gauge their STEM knowledge.
  - Ask or describe: What is Engineering?
  - Ask or describe: Specifically, what is Electrical Engineering?
  - Ask or describe: What does an Electrical Engineer do?
- Research — Briefly cover any/all of the following * in lay terms, easily understood with only basic knowledge:
  - What is your research area?
  - What is the problem your research addresses?
  - What's been done so far?
  - What uses or solutions will (or could) your research bring about?

2. Lab Demos (10-15 min)
   - Highlight fundamental concepts and key equipment
   - Asking students to think where electricity comes from, conduct the compass, magnet, and wire electricity demo.
   - Do the hand-crank generator demo. If possible, use two light bulbs with different wattages. Encourage students to point out the difference between the two (should take more cranking to make the higher-watt light bulb illuminate). Discuss how electricity is wasted because it is cheap. Encourage a discussion on how electricity used to be a luxury and ask students to discuss how that might affect the outcome of people in poverty.
   - Show a mini generator with the alcohol-burning candle. Mention that generators can be powered with wind, gas, water, etc. Talk about the implications of alternative energy sources and why they are important.

3. Conclusion (5 min)
   - Discuss social context of electricity — how do we take it for granted now? What would it be like to live without it? Do you think people still do that? What do they use?
   - Tie this into the real world. How would this affect the children, e.g. not being able to do homework after sunset?
   - Emphasize intersectionality (collaboration) of different types of engineering and sciences.
   - Emphasize *accessibility* of science Ph.D. programs — students will get paid a stipend.

4. General Tips
   - Ask the audience a question early on to gauge their STEM knowledge
   - Ask questions throughout to encourage engagement
   - Ask for questions at the end
   - Avoid jargon as much as possible; students will be more likely to participate and ask questions
   - Emphasize big-picture ideas
   - When praising, praise the thought process, not intelligence (promote a growth mindset). More info on growth mindset: https://www.youtube.com/watch?v=NWv1VdDeoRY

Lesson Plan (Detailed)

Introduction:

1. Give a general intro to engineering. Ask: What is engineering? Give an answer that students will understand, e.g. *Engineering* is the application of scientific knowledge to solving problems in the real world. Ask students to give examples of engineering and what field it is (if they know), e.g. building bridges is civil engineering.
2. Give an intro to electrical engineering. Briefly discuss what your specific field of engineering is about. Give real-life examples of what you do that students could relate to. Sample definition: "In broad terms, *chemical engineers* conceive and design processes to produce, transform and transport materials — beginning with experimentation in the laboratory followed by implementation of the technology in full-scale production" (source: https://cheme.stanford.edu/admissions/undergraduate/what-chemical-engineering). Clarify difference between chemical engineering and chemistry.
3. Briefly share what your research is about. Ask students to think about why it is important throughout the demo as you will ask them at the end.

Demos

1. Ask: Where does electricity come from?
2. Show a line of compasses. Pass a magnet across them. The needles will point toward the magnet, reflecting the change in magnetic field.
3. Use a coil of wire that is un-magnetized and move it over the compasses — nothing happens.
4. See if you can generate a magnetic field through electricity — electrify the wire (including a resistor if necessary), then pass the coil over the compasses. This time they will move
5. Ask: But where did the electricity come from? Can electricity come from changing a magnetic field alone?
6. Detach the wire from the electrical source. Try dropping the magnet in the coil of wire — LED lights will not turn on. But, if you pull it out quickly, the light will flash. This demonstrates that the movement of the magnetic fields creates electricity.
7. Next, take out the hand crank generator. Explain that this is basically a similar mechanism that causes the movement of gears past each other that then generates electricity. Have one student volunteer hold the crank.
8. Plug in an LED light bulb. Ask the student holding the generator to crank it. The light bulb will turn on.
9. Plug in a regular light bulb (with resistor if necessary). Ask the student to crank the generator again. It should take a lot more effort this time to illuminate the bulb. Explain that it is because it is a higher-watt light bulb and therefore requires more electricity to turn on.
10. Real-world application: Ask students how much you could get paid to crank the generator for an hour. Some will say a dollar, $10, $100, etc. Share how much it is – 10cents for kWh. That means you can do 10 watts for 100 hrs. That costs nothing. Therefore, people just leave their lights on.
11. Discuss the implications of energy waste. Ask: what are some consequences of wasting electricity?
12. Optional: Briefly discuss history of electricity/light. In 1946, only about half of rural Americans had electricity. Electricity was a luxury – a rich thing. Even in parts of sub-Saharan Africa as of November 2015, only 14% is electrified (https://www.washingtonpost.com/graphics/world/world-without-power/). I.e. 7/10 people in sub-Saharan Africa live without electricity. How do you think it affects their ability to succeed academically? Their ability to rise out of poverty?
13. Say: So how do you keep the crank generator moving? We can't hire a person to crank the generator all the time. Could you get a horse? A giant machine to move the crank?
14. Now show a mini generator (Stirling engine) with an alcohol-burning candle. It heats up a tube, generating compression and expansion of air and thus causing the gear to move — this then cranks the generator and the small bulb will light up.
15. The generator can be powered with wind, gas, water, etc. Talk about the implications of alternative energy sources and why they are important.

Conclusion

1. Discuss the social context of electricity. How do we take it for granted now? Imagine — what would it be like to live without it? Do you think people still do that? What do they use? Candles?
2. Tie into the real world, and how it affects the kids, e.g. no homework or reading or anything after the sun goes down. Ask: How would it affect your education, technology, etc.? How do you think that would affect someone's ability to be successful if they were poor?

3. Emphasize that students *can* do this in the future. They can go to college, and they can pursue a Ph.D. Mention that if students decide to pursue a Ph.D. in one of these engineering fields, they will GET PAID a stipend. In other words, it is accessible — students just need to do well in undergrad. It takes perseverance and hard work, but it is an option. Also, many colleges (e.g. CU and other Ivy Leagues) offer need-based scholarships – depending on your money and situation (and they take everything into account), they can pay up to full tuition.
4. Collaboration of different sciences: Mention that these creations are not only by engineers – they are a fusion and collaboration of all sciences – e.g. mechanical engineering to make the parts used in EE, chemical engineering for refining the chemicals used, etc.