ROLE MODELS INSPIRE GIRLS IN ENGINEERING

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HOW HAIRDRYERS AND ROLE MODELS INSPIRE GIRLS IN ENGINEERING

INTRODUCTION
Arriving with a box of hairdryers, Lyn Gomes introduced a group of middle school girls to her passion—engineering. When invited to take a screwdriver and break open the hairdryer, one girl quietly asked Lyn, “Can I really take it apart?” The last time this girl wondered how something worked, she took apart her curling iron. Her mother wasn’t too pleased. This afternoon, it was not only all right to get inside the hairdryer, but mandatory.

Lyn is a mechanical engineer who has a commitment to support the next generation of engineers. She is especially interested in reaching out to girls because she remembers her experience in college as one of only a few females in her engineering classes. While there have been advances, the numbers are still very low. Just twelve percent of today’s engineers in the U.S. workforce are women (National Science Foundation, 2013). The percent of female college students receiving bachelor degrees in engineering is 18 percent (Yoder, 2011). In a study by Harris Interactive, twenty-one percent of girls reported that their parents encouraged them to become an actress, while just ten percent of girls said their parents encouraged them to think about an engineering career (Harris Interactive, 2009). Tomorrow’s challenges require the talents and participation of today’s youth. We need to collectively take action in order to ensure that girls are part of the solution and fully engaged in engineering and technology.

WHY REVERSE ENGINEERING?
When reflecting back on when they first discovered an interest in the field, engineers often describe the experience of taking something apart. By taking apart a clock or household appliance, they discovered how each part functions. The activity is likely to raise as many questions as it answers. Lyn recreates this curiosity in the students with whom she works. She purposefully introduces take-apart activities rather than design challenges. Lyn remembers back to her own experiences and how designing could be intimidating. A design project can fail, which can make some students feel like they’ve failed. Taking things apart is easier and less intimidating.

In addition, design projects are often focused on one engineering discipline—circuits and electrical engineers, for example. Taking apart a hair dryer gives the students an opportunity to see the many different kinds of engineering disciplines involved in making a hair dryer and that they work together. For instance, a mechanical engineer designs the fan and determines how hot the hair dryer needs to get, then works with the ...

- Electrical engineer, who designs the circuit and the resistive heating elements to determine the wattage of the hair dryer.
- Chemical engineer, who designs the plastic of the case to make sure it will not melt.
- Industrial engineer, who designs the case to fit all the electrical and mechanical engineers’ components inside.
And together, they all work with an environmental engineer to make sure there are no toxic chemicals involved in the manufacturing process and that the hairdryer can be recycled.

Techbridge has led reverse-engineering projects with Lyn and other role models many times. Here are some tips to make them a success.

**Preparation**

1. Select appliances that are easy to access and likely to interest your students. When girls break apart hairdryers, they are surprised to see how simple the design is and how they are able to figure out the inner workings. Next time they use a hairdryer, they are reminded of their experience and success in figuring out how it works.

2. Be sure to have more appliances on hand than the number of students expected. There may be some appliances that can’t be taken apart because of frozen screws or design features. You’ll welcome the extras for situations like this.

3. In advance, make sure that you have plenty of tools for the dissection. And, make certain that they are the right fit. It is also helpful to have wide rubber bands in your toolbox. Putting a wide rubber band between a stripped Philips head screw and the screwdriver can get a stripped screw out.

4. Share safety reminders before you get started and ask the students to share back on their understanding of these rules. For this dissection lesson, Lyn required girls to wear goggles in case of flying pieces of plastic as they take apart the hairdryers. She also cut off the power cord to eliminate the possibility of an electrical mishap. It is critical that role models and teachers model the same safety behavior they expect of the students. Role models can also talk about what kind of safety gear they use in their work.

5. Start off with a lesson about how to use the tools. Many girls do not have prior experience using tools; it is helpful for them to hear from the role model that practice builds skill and confidence. This lesson extends from this activity to challenges they’ll face in the future. Teachers may want to ask their role model to include a brief story about something they struggled with initially but became good at with practice. This can be an important lesson for girls who may believe that they must excel at a skill right away in order to aspire to a career in math and science (National Alliance for Partnerships in Equity Education Foundation, 2009).

6. Check out the HowStuffWorks website (http://home.howstuffworks.com/hair dryer.html) to study how the appliance works and help anticipate questions that students might ask. Or, plan to have resources available for girls so that they can look up answers to their questions.

7. Read up on different engineering disciplines in order to help anticipate which engineers might have designed which part of the appliance. Remember to think beyond the box—engineers are needed to develop the raw materials, to mitigate environmental effects of using the appliance, and to research more efficient appliances. The National Society for Professional Engineers (www.nspe.org/Media/Resources/glossary.html) is a good place to start. The Wikipedia page for engineering disciplines also provides more detail at http://en.wikipedia.org/wiki/List_of_engineering_branches.

**During the Activity**

8. Before handing out the hairdryers, start with a discussion. Ask open-ended questions to elicit what the group knows about the appliances and engineering. What do you think is inside? What kinds of things do engineers have to consider when designing an appliance like this? Questions like these help get the group thinking about product design and engineering. They also help engage the group so that the role model doesn’t have to do all the talking.

9. While the girls are taking apart the hairdryers, Lyn moves around the group asking and answering questions that come up about the hairdryers. This approach also makes her available to talk about personal interests and helps her get to know the girls. Many kids are shy about asking their questions before the group, but find Lyn approachable one-on-one. They can ask questions about more personal items she talked about in her presentation—like her learning disability or how she got through college.

10. Make sure there is a goal for the end of the lesson once the hairdryers are apart. You could:
INSPIRE GIRLS IN ENGINEERING

In her spare time, Lyn likes to tinker on projects like this one—her very own customized Barcalounger.

You can pick up hairdryers and other household appliances for dissection at thrift stores and garage sales. Let friends and colleagues know that you are looking for them so that they can pass along their old or broken ones. Call salons or beauty schools or colleges a few months in advance—they are often more than happy to contribute. Toasters, coffeemakers, blenders, and other small kitchen appliances work well for this type of activity. Be aware that some electronics with screens or flashes—like monitors, TVs, and cameras—can contain capacitors that carry a charge for a long time, even if they have been unused. Don’t attempt to dissect these types of items unless you are knowledgeable about how to discharge capacitors. Taking these items apart without discharging the capacitors will result in a dangerous shock, even a lethal one (in the case of monitors and TVs).

EXTENSIONS

This activity can be expanded across more than one session. You can invite students to prepare presentations in which they explain how their appliance works. Not only do they get into the mechanics of electrical engineering, but also propose a better design and highlight careers in various fields of engineering. This project works particularly well when the group has a variety of appliances. Not only does this exercise give kids a chance to polish their skills with PowerPoint or Prezi, but also to enhance their public-speaking skills. You can have them practice informational presentations, product “pitches” to a company CEO, or creative commercials for their new and improved product. Encourage the group to recognize that they are building skills in collaboration, creativity, organization, and public speaking that are essential to careers in all fields.

Take Apart, Put Together

You can put a twist on this activity by giving kids the challenge of putting their appliance back together. This works better with some appliances than with others. For a unit on cars and engines, Techbridge has gotten lawn mower engines through Craigslist. Girls were given the challenge of taking apart and reassembling the engines. This makes it easier to reuse these engines with other groups. The girls work with a partner and use digital cameras to document the dissection so that they can more easily reassemble them. Despite the challenge, girls have been successful in the reassembly.

Helping Make a Connection to Careers: Role Models are the Important Ingredient

Taking apart a hairdryer, putting together a lawn mower engine, or designing an app can be fun, but they won’t necessarily get girls on the path to becoming an engineer.

Extending the Lesson

11. Afterwards, lead a group discussion about how the hairdryers work and the advantages and disadvantages of the various designs. What makes the air flow? How do hairdryers blow hot air? What kinds of engineers design hairdryers?

12. Invite the group to share ideas for making a better product. Students will share novel ways to improve upon the design, like making a filter to keep out hair, using materials that are lighter, or fashioning a more ergonomic handle.

13. Be sure to save time to talk about careers in engineering and to offer ideas for follow-up. Discuss the path to the career. The California State University has a helpful poster as well as a planning website at www.csumentor.edu/planning/high_school/.
Role Models: The Recipe for Success

No one would disagree that role models can be impactful. But hosting successful role models doesn’t just happen. Even role models with the most interesting jobs may not know how to connect with kids. The skills for communicating with a group of fifth graders aren’t learned on the job or in college.

With input from girls, Techbridge developed its recipe for success for role models. Girls want to know more than just what someone does at work. They want to know about family, friends, and hobbies. They want to know that someone like them who may speak English as a second language and who will need college scholarships can be an electrical engineer or computer scientist.

Be Personal

Kids are eager to hear about personal hobbies, family, friends, and pets as well as work. Role models can dispel stereotypes and break down the generation and racial divide by making a personal connection with these topics. In advance of a visit, it’s helpful to send bios so that the group can find out interesting information about a role model including that he/she played soccer in middle school, enjoys Mexican food, and liked taking things apart when he or she was little. It is always helpful to show photos on a recent vacation, with family, or participating in a hobby. If role models play a sport or musical instrument, they can share how practice and perseverance in these pursuits have helped in school and on the job. Girls can share bios of themselves, so role models have an idea of their hobbies and interests and make their presentation relevant and interesting.

Personal stories at the start of a visit help role models engage with the group and make them more approachable. By connecting with a role model, it is easier for kids to connect with their work. Lyn shares her background and includes information like the fact that she loved to play dress-up and sew as a child. She also shares how sewing is related to engineering, even though it is not traditionally viewed as an engineering-gateway hobby. Role models can talk about how knowing a second language is an asset on travels and in work. This will inspire students who may feel uncomfortable that English isn’t their first language.

Share the Passion

While it might not be how the role model presents herself in a college course or on the job, it’s communicating one’s passion for engineering that will be most effective in turning kids on. Engineers, in their careers, are taught that seriousness conveys credibility. As the teacher, you must convey to the role model that, just by coming into the classroom, he or she has credibility the moment they walk in the door. Therefore, they can leave the seriousness behind and be enthusiastic. Lyn loves her work and gushes about the projects she’s supported. When role models get excited about their work, kids do, too. In fact, at the end of a visit with Lyn, girls often comment how they want to grow up and do what Lyn does. Lyn shares that, while this kind of interaction—sharing the passion—isn’t common in the workplace, it is essential when she’s a role model to youth.

Communicate How Engineers Make the World a Better Place

Many kids, and girls especially, want to know that they can make a difference and alleviate problems through the career path they take. Whether they make that difference through their day job or volunteer efforts with Engineers Without Borders or Habitat for Humanity, kids are eager to understand how work matters and that they can make the world a better place as an engineer.

Lyn has worked on HVAC projects, and on a recent visit shared that she had helped redesign the heating system for the school. Your role models’ connections might not be as direct, but Lyn was able to convey that she takes pride in her work that makes people more comfortable, helps save the school money, and saves the environment by saving energy.

Make it Hands-on

Lyn brings up the idea of competitive benchmarking during the hairdryer dissection. She explains that while she doesn’t take
apart small appliances during her job, engineers often investigate competitors’ products as part of their development process.

Role models are most successful by engaging kids in a hands-on activity that offers a snapshot of their field of study or work. It may not be exactly what they do on the job, but the activity can draw kids in and offer a way for them to experience elements of what they do. For example, a chemical engineer may not make bouncy balls—the activity she leads with students—but she does design and test formulas and carefully record results. Role models can draw on ideas like collaboration and the engineering design process that carry over from the activity to the role model’s work.

**Offer Resources and Academic Guidance**

A good role model provides ideas and resources to follow up on. While some kids are fortunate to receive guidance at home and school to help them chart their academic path, many are not. Role models can fill a critical void by sharing the resources that helped them become the success they are today. For example, they can share the value of a study group that helped them get through algebra in eighth grade. They can encourage kids to make the most of summer and seek out classes and internships to help them find their passion and explore new talents.

Lyn tells girls how she started at a junior college and there decided on mechanical engineering. When she transferred to a four-year university, she was already prepared to take upper-level classes. The smaller classes from her junior college helped her feel more prepared and connected. Her choice of junior college and four-year university were also critical—both provided for a strong interaction with instructors, which helped her feel connected. Her four-year university experience was hands-on, which made the abstract principles come to life. Lastly, when she transferred, she participated in a week-long orientation program. This gave her a social network at the start.

**Keep it Short and Sweet**

Students enjoy hearing about a role model’s path to engineering, their hobbies and resources, but the message must be succinct. Keep the introduction to 10-15 minutes or less. Too much information and too many technical terms will only turn off students and leave less time for the hands-on activity, which is likely to be what turns them on.

**Where to Find Role Models**

Whether you live in an urban area in the middle of high-tech industry or in a rural community, there are people around who can, and want to, serve as role models. Don’t be shy about asking. Once you get started, it becomes easier to ask.

- They are waiting to be asked. Role models can be friends, colleagues, or relatives of your students.
• College and university students who are one step ahead of girls can be especially inspiring role models. While you may not think they’re qualified to be role models because they don’t have a degree, the students definitely see them as experts. These students are the best ones to provide academic advice because they have experienced it more recently than older role models. Check into local student chapters of professional engineering groups such as Society of Women Engineers, Society of Hispanic Professional Engineers, and National Society of Black Engineers. University websites will have links to these college clubs. Many professional societies will have liaisons as well.

• Professional societies are a great way to network. In addition to the professional equivalents listed above, Rotary International and the American Association of University Women can also be good sources of role models.

• Local businesses and corporations know that their long-term success depends on the next generation. Begin by checking to see if they have a women’s group, diversity program, or special outreach program. The economy has made outreach more challenging at corporations, so start asking two months in advance.

• Your local government agencies and utilities have engineers with interesting careers to share.

• FabFems.org is a growing database of role model profiles. You can search by location, career field, and other keyword interests. You may be able to find a role model to lead an activity for National Engineers Week, an after-school program, or summer camp.

You may at first feel uncomfortable asking someone to visit your classroom or after-school program, but remember that role models also benefit from the experience. Role models feel that they get more out of their visits than students. One role model shared that the experience reminded her why she got into engineering in the first place, and reinvigorated her passion for her career.

Don’t Put Career Exploration on Hold
Career exploration doesn’t have to wait for when role models visit. There are lots of ways to introduce interactive activities and invite girls to imagine their future in technology and engineering. Designing a career card about a future career, drawing a life map with academic and career interests, and modeling in clay an object that represents a career dream are examples of career activities that invite girls to think about STEM careers. They also provide the space to have conversations about how girls think about their futures and engineering. Discussions about work-family balance, stereotypes around engineering, and strategies for taking on leadership roles in STEM can be introduced through these career exploration activities.

The Internet also offers a wealth of resources. Use these resources to talk about real-life engineers even if one isn’t available in person.

• Engineer Your Life has videos that show what life and work are like for engineers and descriptions of dream jobs.

• SciGirls show for kids ages 8-12 showcases bright, curious real tween girls putting science and engineering to work in their communities. How great to have girls as role models for girls.

• Imagine Engineering offers profiles of engineers and includes Hispanic, African-American, and Native-American role models.

You can also use YouTube to find videos that feature role models connected with the engineering projects. For example, you can introduce a session on making water filters with a video about a role model who created a playground water pump in Africa. This creative engineering design uses the energy of children at play to operate a water pump to access clean drinking water.
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WHAT’S THE IMPACT

At the end of its first year, Techbridge discovered that, while the girls had fun doing hands-on projects, their enjoyment did not translate into a career interest. They described technology and engineering as a hobby, not as a career option (Kekelis, Ancheta, & Heber, 2005).

With little or no guidance about careers at home or at school, girls shared that they were looking for advice and support for exploring careers. One girl explained that greater guidance than “just graduate” would be helpful. Some parents explained that they would like to do more but don’t know about technical careers or how to encourage their daughter in technology or engineering.

Hands-on activities paired with career exploration can help students explore and expand their career options. Even at elementary school, it is not too early to start helping kids think about their career options. Girls are getting messages from what they see (and don’t see) and hear. When it comes to the media, girls are likely to take away the message that they don’t belong in technical fields. For example, in family films the ratio of males to females across computer science and engineering is 14.25 to 1; in prime time it’s 5.4 to 1 (Smith, Choueiti, Prescott, & Pieper, 2012). While every girl won’t become an engineer or go into computer science, it’s important for girls to know about these options and to have a fair chance at finding a technical career that is fulfilling and challenging and makes the best use of their talents.

The following technological literacy standards (ITEA/ITEEA, 2000/2002/2007) are obtainable with the activities discussed in this article:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Grade Level</th>
<th>Benchmark</th>
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<tbody>
<tr>
<td><strong>STL 2</strong>: Students will develop an understanding of the core concepts of technology.</td>
<td>6-8</td>
<td>N: Systems thinking involves considering how every part relates to others. S: Trade-off is a decision process recognizing the need for careful compromises among competing factors.</td>
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<td></td>
<td>9-12</td>
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<tr>
<td><strong>STL 3</strong>: Students will develop an understanding of the relationships among technology and other fields of study.</td>
<td>6-8</td>
<td>F: Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.</td>
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<td><strong>STL 8</strong>: Students will develop an understanding of the attributes of design.</td>
<td>6-8</td>
<td>F: There is no perfect design.</td>
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<td></td>
<td>9-12</td>
<td>J: The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.</td>
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<tr>
<td><strong>STL 9</strong>: Students will develop an understanding of engineering design.</td>
<td>9-12</td>
<td>J: Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. L: The process of engineering design takes into account a number of factors.</td>
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<tr>
<td><strong>STL 10</strong>: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.</td>
<td>6-8</td>
<td>G: Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.</td>
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<tr>
<td></td>
<td>9-12</td>
<td>I: Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.</td>
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Each year, Techbridge evaluates its impact with surveys, focus groups, and observations. Results have been very positive. The hands-on approach of Techbridge increases girls' confidence, technical skills, and interest in technology, science, and engineering. For example, in 2012 surveys Techbridge girls reported the following benefits: 95% believe engineering is a good career for women, 90% agree they are good at using technology, 81% plan to take advanced math and science classes, and 87% are more interested in working in technology, science, or engineering as a result of field trips and role models (Ancheta, 2012). Techbridge girls return years later and reflect on how the role model they met in sixth grade or the field trip they took in high school turned them on to a new career path that they never would have found on their own.

TECHBRIDGE

Since its founding in Oakland, California in 2000, Techbridge has served over 4,000 girls through after-school programs in Grades 5-12, focused on underserved communities across San Francisco Bay Area school districts. It’s reached another 15,000 girls through a partnership with Girl Scout councils nationwide. Additionally, Techbridge trains role models, teachers, and families. By advancing effective practices and collaborating with partners, Techbridge has helped bring about a movement for promoting girls in STEM throughout the Bay Area and beyond. Techbridge introduces design-based activities that make engineering, technology, and science accessible and engaging for girls, and emphasizes career exploration through role models and career activities.

REFERENCES


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