Family Style ENGINEERING

Learning alongside students creates a win–win situation for all

By Lara K. Smetana, Joan Chadde Schumaker, Wendy Severin Goldfien, and Cheryl Nelson

What do engineers do, anyway? This is a question that you may hear from your students. While there are similarities between the fields of science and engineering, it is important to understand the differences. Although science seeks to understand the natural world, engineers seek to solve problems or design (and redesign) objects and systems in response to societal needs and desires. Stated simply, "Engineers design, create, imagine, innovate, and invent" (Jackson et al. 2011). Cunningham and Lachapelle (2011) found that most students have a naïve understanding of the field of engineering, mistaking it for the work of technicians or artisans and neglecting to see the contributions engineers make to our daily lives. In general, public (and teacher) understanding is not much more refined. These misconceptions about engineering have led to negative stereotypes and disinterest in the field, consequently reducing the number and diversity of students entering the engineering pipeline (NRC 2009). For example, though engineers must rely on deep understanding of math and science, they also use imagination and creativity to design, create, and test unique solutions to challenges both large and small. By helping our students recognize examples of engineering at school, home, and in daily life, and by involving our students and their families in opportunities to apply the engineering design process in a variety of contexts, we can help change these negative misconceptions. Our experience indicates that teaming up with the larger school community and inviting families to learn alongside our students has benefits for all.

Getting Started

Think of the young students in your class who are already fascinated by constructing and deconstructing things, trying to investigate how things work, experimenting, and imagining. Indeed, they are naturally poised to become engineers. Many early elementary educators are already doing engineering in their classrooms and do not even realize it. When students design boats, create castles and roads on a sand table, or combine various ingredients to invent a new "goo"—they are engineering!

There are many ways that teachers can provide students with examples of engineering fields that exist, the everyday products that engineers design, and relevant challenges that engineers address. From common household appliances that we take for granted (e.g., electric toasters, clothes dryers) to toys that entertain us (e.g., Slinky, Silly Putty) to sophisticated equipment and techniques (i.e., prosthetics, water treatment processes), engineering has truly shaped our society, changed our world, and improved our quality of life. Using trade books such as Those Amazing Engineers (Forbes 2010) is an excellent way to introduce students to the work of different types of engineers and to the countless examples of engineering that they encounter daily. For a comprehensive approach to teaching engineering in the classroom, the Engineering Is Elementary project provides an entire research-based curriculum appropriate for elementary grade levels (see Internet Resources). These resources also contain materials for teachers that will help further their own understanding of engineering.

At Newington Forest Elementary School, fourth-grade teachers Wendy Goldfein and Cheryl Nelson get their students thinking about engineering through their self-designed "Get Caught Engineering" integrated curriculum program. "We decorate our school with a huge visual display of Engineering: The ABC's (Novak 2009) that we created from the book with the same title. We placed framed miniposters with messages such as, 'Do you like to ride roller coasters? An engineer designed it!'; 'Do you like to play video games? An engineer designed it!' We also ask students to contribute their own examples of engineering that they see in their home and on television, or as they travel to and from school. Students show photos or pictures of engineering in class and describe the problem that the engineering example was designed to solve." These assignments also provided a beneficial formative assessment of students' prior and developing knowledge of engineering. When students have had their interest piqued, invite them and their families to a family engineering event in which they will explore together not only what engineers do, but also how they go about their work.

Why Family Events?

Hosting a family engineering event offers the opportunity for schools to demonstrate their commitment to giving engineering a prominent place in the school curriculum and motivating students to acquire the scientific and technological literacy essential to becoming successful and competitive in the 21st-century workforce. *Family Engineering: An Activity & Event Planning Guide* (Jackson et al. 2011) is full of hands-on activities and event planning resources to effectively engage students in grades 1–6 and their families in exploring engineering (for more ideas, see Internet Resources). The activities incorporate a wide range of engineering skills, concepts, and fields, as well as explore the misconceptions that students, and even parents, may have about engineering. For example, in the "What Do Engineers Do?" activity, participants cast their votes for those activities they think engineers do, such as improve bandages; design ways to clean water; and invent better bubble gum. Participants withhold their votes from those activities that engineers *do not do*, such as repair cars and install electrical wiring. Offering families an opportunity to engage in informal learning events is a great way for the school community—teachers, students, and families—to learn together.

The overwhelmingly positive connection between family engagement and student academic success has been well documented (Henderson and Mapp 2002). Parents and caregivers play a critical role in supporting students' formal and informal science education. The efforts we begin in elementary school to introduce students to the world of engineering can only go so far without support from families. We have found that family engineering events, in particular, are a great way to involve families in working together to solve engineering challenges. As families are invited to ask, imagine, plan, create, and improve together, they not only work like a typical engineering team and engage in the engineering design process, they also increase their understanding of the designed world and the various fields of engineering. "Family" should be broadly defined to include parents, grandparents, caregivers, older siblings, mentors, neighbors, and anyone else who supports a student's learning. In our experience, multigenerational family units particularly enjoy working together at these events, sharing their varied perspectives on the world. For example, the creativity of a younger sibling combined with the worldly experience of a grandparent is an incredible combination for collaborative exploration not possible within the confines of a typical classroom.

Host a Family Engineering Event

Many schools already host "family events" like ice cream socials, open houses, and science fairs. A family engineering event is both social and educational, yet so much more. We've found that today's busy families welcome the opportunity to engage in educational activities with their children away from the glare of the television, and appreciate the convenience of attending an event where the work of deciding what to do and gathering all of the supplies is done for them.

A family engineering event also presents an opportunity to highlight the diversity of people who practice engineering. Nothing makes it more real for students than meeting engineer role models from their community. For your event,

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be sure to include a female engineer or an engineer that represents an underrepresented minority to show children that anyone can become a successful engineer. You can prepare your students ahead of time by brainstorming questions to ask, such as: "What type of engineering do they do?" "What kinds of problems do they solve?" "What do they like most about their job?" Excellent resources for these introductions are the National Engineers Week Foundation and *Engineer Your Life* (see Internet Resources). Displaying posters from *Engineering, Go for It* in your classroom or the school library is also a great way to visually depict the variety of people who are engineers and the many things they do (see Internet Resources).

As part of their "Get Caught Engineering" program, Goldfein and Nelson host a Family Engineering Night for K–6 students and parents twice each school year. They consider it a "systems engineering challenge!" They tap their principal, fellow teachers, parents, high school students, and college students to help them conduct events that attract more than 400 students and parents. You can find additional suggestions for organizing and conducting your own family events in the *Science and Children* online archives.

As families arrive at Newington Forest Elementary School for Family Engineering Night, they are greeted by the principal and several teachers who are staffing the "welcome table." Each family receives a color-coded schedule that shows them where to go at which time. For the last event, "We planned three activities that everyone would cycle through, spending 40 minutes at each," explains Wendy Goldfein. "We offered two engineering challenge activities in the classrooms taught by fellow teachers, and a dozen short, self-directed tabletop activities set up in the cafeteria. At any one time, one-third of the participants engage in one of these three opportunities. Three classrooms were designated for each of the challenge activities with approximately 40 students and parents in each room. Simultaneously, approximatley 150 families circulated through the cafeteria. We set up multiple stations of some short activities to allow more people to do each one."

Example activities include Artistic Robots (Jackson et al 2011), which challenges families to tap into their creativity while working like mechanical engineers to design and build an innovative robot that draws designs on its own, without human assistance. Families shared not only their final products and the art that their robots created, but also the problems they worked through during the engineering design process.

Save the Penguins (Schnittka, Bell, and Richards 2010) challenges families to design an enclosure that will keep ice cube model penguins from melting in the hot Virginia summer sun.

The Get a Grip engineering challenge (Olds, Harrell, and Valente 2012) asks families to imagine what it would be like having no arms. Families become biomedical engineering teams whose task is to design a prosthetic arm that can be used to carry out normal daily activities, like carrying school books, opening doors, and giving hugs.

The short tabletop activities are monitored by volunteers (parents, area university and high school students, teachers, and parents who are engineers) who refill supplies and answer questions. High-school students were the gofers, helpers, and photographers. Cheryl Nelson recalls the excitement over the first event that resulted in Family Engineering Nights becoming a regular event at their school. "We received rave reviews and lots of great feedback, along with many requests to do it again."

The Fun and Learning Continues

A family engineering event represents just part of a larger aim to deepen students' understanding of engineering. "The impact of informal learning is not only the result of what happens during a particular experience, but also the product of events happening before and after an experience" (Fenichel and Schweingruber 2010, p. 161). Thus, efforts to link students' engineering night experiences back to both their formal learning in the classroom and to their own lives will be important.

Students who participated in the event can be encouraged to share with the class which engineering challenges their families were presented with, the design process they followed, and the results. Other classroom extensions might include setting up some of the tabletop activities as part of a classroom "Engineering Center" in which students are invited to continue exploring with their classmates. Goldfein and Nelson even paired up their fourth-grade classes with second-grade classes to allow for peer teaching.

At Newington Forest, excitement over family engineering night events led to the development of a schoolwide engineering program. Goldfein explains, "Last spring, we visited classes at every grade level to introduce the field of engineering to fellow teachers and their students, as well as demonstrate and model lessons that integrate engineering into all aspects of the curriculum." This year, engineering education and a focus on problem-solving skills are part of the school plan. A Science and Engineering Committee with representation from each grade level was convened to further encourage and support the integration of engineering schoolwide and an Engineering Room now stores materials for all to use.

Whether you are embarking on a single family engineering night, or a schoolwide integration program, family partnerships are integral to success. Suggest resources and activities that families can use or do together to further

their exploration of engineering. Families will likely appreciate suggestions for how to continue to encourage their children's interest in engineering and science outside of school. Just as you do in class, families should model good questioning and problem-solving strategies that they used during the family engineering event to solve problems they encounter on a daily basis. A reproducible and well-articulated set of tips for parents can be found in Family Engineering: An Activity & Event Planning Guide (Jackson et al. 2011). Sending home copies of the *Engineering Go for It* magazine will give students a great visual and engaging reading about young people who are engineers (see Internet Resources). The National Engineers Week Foundation also has a suggested reading list where teachers can find books to recommend to families (see Internet Resources). Encourage your families to "Get Caught Engineering" like they do at Newington Forest Elementary School! ■

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Internet Resources

Engineering: Go for It
www.egfi-k12.org

Engineering Is Elementary
www.mos.org/eie

Engineer Your Life
www.engineeryourlife.org

Family Engineering
www.familyengineering.org

Family Math
www.lawrencehallofscience.org/equals

Family Science
www.familyscience.org

National Engineers Week Foundation
www.eweek.org

Those Amazing Engineers Teacher Guide
www.trilogypublications.com/pdfs/TAE_TeachersGuide_lo.pdf

Connecting to the Standards

This article relates to the following National Science Education Standards (NRC 1996):

Teaching Standards

Standard A

Teachers of science plan an inquiry-based science program for their students.

Standard B

Teachers of science guide and facilitate learning.

Standard D

Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.

NSTA Connection

For a copy of the student instructions and materials list, visit *www.nsta.org/SC1212*.