

How Are We Changing the Conversation?

Attracting and retaining more girls and young women to STEM fields takes the support of parents, teachers, mentors, role models, and professional organizations, with each playing a significant role. From initiatives such as SWENext and *FIRST*[®] Robotics to grassroots virtual mentoring programs and revolutionizing the way math is taught, the conversation continues.

By Seabright McCabe, SWE Contributor

Just as every successful artist has a solid command of craft, so, too, does every good engineer. For example, a painter must understand perspective, and a sculptor needs working knowledge of measurement in three dimensions. Technical skill is not the core of an artist's need to create, or the reason anyone becomes an artist for a lifetime.

Similarly, to keep girls engaged in engineering, the discipline has to be presented as meaning more than being good at math and science. In this sense, math and science skills might be considered the craft, and engineering the art. That is why our choice of words and their underlying messages, and the types of conversations we have, are so important.

In 2008, The National Academy of Engineering (NAE)'s report "Changing the Conversation" rolled out new messaging for encouraging young people to pursue engineering as a rewarding career. Among many key findings, it noted that, unlike engineering, "the medical profession does not market itself to young people by pointing out that they will have to study organic chemistry or by emphasizing the long hard road to becoming a physician. The image of the physician is of a person who cures diseases and relieves human suffering. When promoting engineering, our appeal should tap into the

hopes and dreams of prospective students and the public. This approach would also have the virtue of placing math and science, correctly, as just two of a number of skills and dispositions, such as collaboration, communication and teamwork, necessary to a successful engineer."

When surveyed, girls found such messages as "Engineering makes a world of difference" and "Engineering is essential to our health, happiness, and safety" more appealing than "Engineers are creative problem-solvers" or "Engineers connect science to the real world." Eight years later, that messaging has become a natural part of how we talk about the profession.

"There's a whole line of research on what's called, in a broad sense, 'STEM identity,'" Randy Freedman, SWE's associate director of educational programming, said. "I think of it more specifically as 'engineering identity' and it fits this sense that a person has. If you're an artist, or a writer, you belong there and identify as an artist or writer. Part of the thing that we need to do as an organization is help girls identify as



Mamta Patel Nagaraja, Ph.D., creator and program leader of NASA G.I.R.L.S.

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engineers. It will insulate them against the cultural mindset about girls pursuing a career in engineering."

CHANGING "THE MATH MINDSET"

A growing body of data underscores the importance of mindset in learning math and science. In a "fixed" mindset, intelligence or talent are treated as traits that one either has or doesn't. This reinforces a belief that talent alone is needed for success, not hard work. Conversely, a "growth" mindset promotes the idea that all basic abilities, such as math skills, can be developed by anyone through dedication and hard work. Brains and talent are just the raw materials. This view inspires a love of learning; values growth from, not fear of, mistakes;

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Every child deserves a role model. Mamta Patel Nagaraja, Ph.D., shown at Mission Control during the STS-131 flight to the International Space Station.

and builds the resilience needed for high achievement.

“There’s a myth out there that you can do math or you can’t. You’re either born with a ‘math brain’ or you’re not. That idea is crushing for kids,” Jo Boaler, Ph.D., professor of mathematics education at Stanford University, said in a January 2016 podcast for KQED in northern California. “Many teachers, to help girls in their classes, will say, ‘Don’t worry about math; it’s not your thing. You can be good at arts or music.’ And it tends to be girls they say that to. Once kids are given that message, they start a downward trajectory with math. We know that when mothers tell their daughters ‘I wasn’t good in math,’ their daughters’ achievement immediately goes down.”

What Dr. Boaler refers to as “math trauma” often occurs in primary school, when math is taught by rote and timed tests — and where pressure to solve problems quickly and the fear of failure are high. Dr. Boaler also noted a recent study showing that a child’s achievement level in math could be predicted by the level of a parent’s “math anxiety” when helping with homework. These are powerfully negative messages that Dr. Boaler wants to replace with positive ones.

Dr. Boaler is the co-founder of YouCubed, a Stanford-based program and curriculum aimed at making math accessible, even inspirational. At its recent summer camp, the YouCubed team taught growth mindset and brain messages to local sixth- and seventh-grade boys and girls. After 18 days of exposure

to innovative math teaching techniques, their scores on standardized test questions jumped by an average of 50 percent.

VIRTUAL MENTORING IS ANYTHING BUT REMOTE

Engaging girls in the STEM conversation and providing them with mentors and role models can be as simple as having a fun problem to solve and an internet connection. “One day I was teaching my 1-and-a-half-year-old nephew his ABCs over Skype,” Mamta Patel Nagaraja, Ph.D., a NASA engineer, said. “It dawned on me that if I could do that with a toddler, why couldn’t I teach young girls in middle America to do a math problem the same way, and help them apply it to a real situation they can relate to at the same time?”



Hands-on, project-based learning — such as takes place at “Invent It. Build It.” at the WE conferences — encourages a growth mindset that keeps girls engaged.

That’s how NASA G.I.R.L.S., which stands for Giving Initiative and Relevance to Learning Science, was born. “I believe all children deserve mentors,” Dr. Nagaraja, who is the program’s leader, said. “I wanted to reach girls we can’t physically get to from our seven sites around the country, due to geographical and budgetary constraints. We have the technology to reach them anywhere, so why not do it?”

Dr. Nagaraja piloted the program in 2012, and along with a similar, though smaller program for boys, it is the only one-on-one mentoring program of its kind at NASA. From 3,000 applications, 18 fifth- to eighth-grade girls were chosen by lottery to participate in a five-week summer program. Each student was coached one-on-one, via Skype or Google Chat, by a NASA mentor recruited from the agency’s group, Women@NASA. Each week’s lesson involved a core aspect of STEM, with one week including hands-on engineering experiments, such as building a robotic hand using rubber bands and cardboard that can pick up a paper cup.

“Very often we’ve heard from parents who say, ‘I never thought my child would like to do this type of learning, and by the end, they loved it,’” Dr. Nagaraja said. “Sometimes parents sign up a child who isn’t interested in STEM at all, to expose them to the possibilities. Those are my favorites, because most of them end up loving the engineering week of the program.”

Dr. Nagaraja coordinates and guides this “grassroots effort,” which has no budget other than her time as a federal employee. Enrollment currently stands at about 150 students, plus mentors. NASA G.I.R.L.S. doesn’t actively solicit feedback, but often receives it. “The overwhelming majority of feedback we get is from parents, who say things like they’ll be sitting at dinner, and their kid says, ‘I’m going to be an engineer’ or ‘Now they ask questions about engineering and math that make me want to look it up and help them understand.’ The conversation keeps going once the program is over.” Dr. Nagaraja said. “Parents let us know how the virtual mentoring impacts their families. And mentors often tell me, ‘I



Hundreds of girls attended the hands-on, project-based “Invent It. Build It.” event at WE15.

ended the five weeks by telling the student they can always contact me.’ And two years later, they’re still in contact.”

As a woman engineer, Dr. Nagaraja realizes the difficulty in getting students to understand how an engineer makes life better as opposed to the direct impact doctors make on health, for example. “I think one of the things engineers at our NASA aeronautics group does well is emphasize the ‘safer’ aspect — ‘We’re doing research that makes the plane that your family flies in safer’ —

and those are the ways that someone in the general public can directly relate to what engineers do.”

Dr. Nagaraja, whose Ph.D. is in biomedical engineering, said, “Biomed was one of the sciences where the gender gap shot to zero in some areas, and one of the things engineers can learn from that is it’s easy to grasp how biomed impacts people. If you’re designing a catheter that helps a young patient who has cancer get better — or tissue engineering with blood vessels to improve someone’s

heart function — then your research has created a positive change that can be seen and felt directly. You know your job has impact.”

She hopes to eventually solicit and measure feedback on NASA G.I.R.L.S. as a way to gain further investment from NASA. “It would be nice to have a staff and budget — with the proper support to make it bigger and better so we can offer it to more students,” Dr. Nagaraja said.

HELPING GIRLS IDENTIFY AS ENGINEERS

Engineering societies and organizations are doing their part to keep the conversation going, and SWE, with its many initiatives and resources, is in a unique position to expand that positive messaging for girls. “We consistently align with Changing the Conversation’s positioning of engineers as creative problem-solvers who help shape the future, are essential to our health and happiness, and can change the world,” Freedman said. “Our scholarship program distributed 220 scholarships, totaling about \$660,000 in 2015. We also have a successful continuing partnership with *FIRST*® Robotics, and our flagship event — ‘Invent It. Build It.’ — is now in its seventh year.” This year’s “Invent It.

Emphasizing Depth of Learning, Not Speed

In her book, *Mathematical Mindsets*, Dr. Boaler explores teaching math using deep learning rather than drilled performance to help students think quantitatively to solve problems in their work and lives.

Dr. Boaler’s teaching techniques reinforce “growth mindset” in a number of different ways. Among them, her consistent messages to students are:

- The math gene doesn’t exist and she expects all students to achieve higher.
- Mistakes are valuable. Failure and struggles are the most important part of math and learning; they don’t mean students “can’t do math.”
- Emphasize depth of learning over speed.

Dr. Boaler believes that students achieve at a higher level when exposed to the kind of deep understanding that’s not readily available in math classrooms, and that this is “particularly true for girls, who, research has shown, tend to be put off by procedural math.”

Dr. Boaler suggests building deep learning with a project-based curriculum that relates to students’ lives, and providing ample opportunities for hands-on teamwork.

Keep the conversation going! Listen to Dr. Boaler’s KQED podcast at: <https://www2.kqed.org/forum/2016/01/25/we-need-to-revolutionize-how-we-teach-math-says-stanfords-jo-boaler/>. For more information on Dr. Nagaraja’s NASA G.I.R.L.S., go to: <http://women.nasa.gov/nasa-girls/>. To read NAE’s “Changing the Conversation,” visit: <https://www.asee.org/public/conferences/20/papers/6684/view>.

Build It.” is slated for 500 middle school girls, 100 high school girls, 300 parents and teachers, and 300 to 400 SWE volunteers to participate.

Another important initiative is SWENext, which currently involves

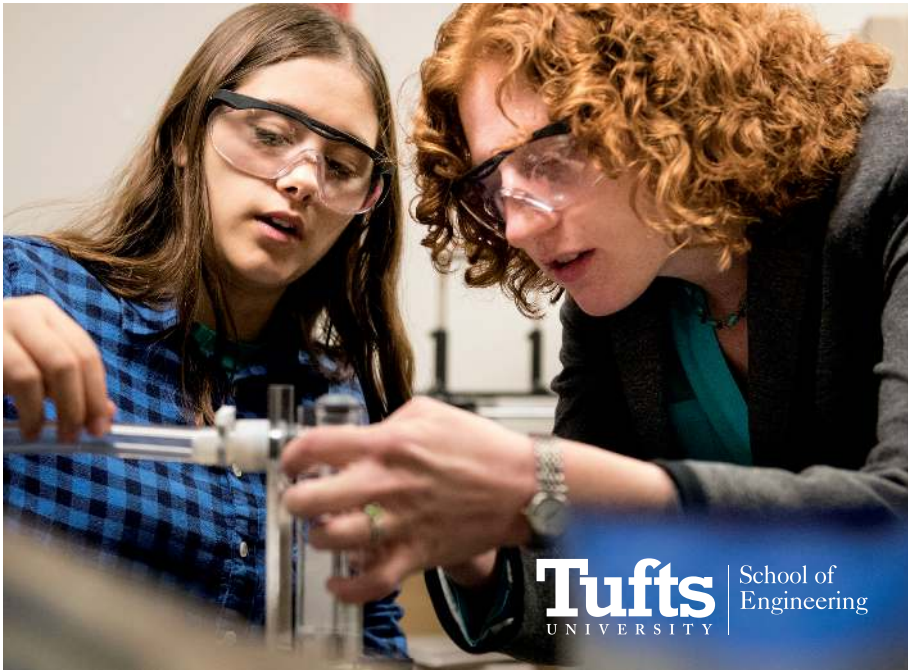
around 5,000 girls. “It’s a big focus for us, and we have a goal to get to 6,000 SWENexters this year,” Freedman said. “We want to continually keep the girls engaged with competitions and scholarship opportunities, and building out that

program is part of it. Right now we’re calling it a membership program, but it’s an affiliation of girls 18 and younger that gives them a path to SWE membership at no cost. Another key advantage is communicating about SWE scholarships to all of these girls. This is also the first year of an awards program for SWENexters who are rising juniors and seniors. Five were awarded and will fly with a parent or guardian to the conference, where they will attend programming, shadow engineers, and be recognized at the awards ceremony.

“The really bright lights for me are the five SWENext award nominees,” Freedman reflected. “These girls are an amazing group of kids. It’s so rewarding to meet them, learn their stories, recognize them, and bring them to SWE.”

In 2017, SWE will introduce outreach events similar to “Invent It. Build It.” at WE Local conferences in Pittsburgh and San Jose, California. “We want to have hundreds of girls coming to local SWE events and being exposed to women who are in college or who are professional engineers,” Freedman said. “Programs like these have an amazing power, and no other organization can do it because they don’t have the type of gatherings that we do.”

Finally, SWE is building an initiative around K-12 educator members, a class of membership open to teachers to become part of SWE. “Teachers are having that conversation with girls about careers in engineering,” Freedman said. “We want them to know how to communicate about it and know the opportunities. We have a goal of 600 educator members, and we’re building a suite of training, a ‘toolkit’ for them. Through that, we’re promoting SWENext clubs, where each club has a SWE member or educator as an advisor. What better way to help girls establish an engineering identity than by making them feel part of the SWE community?” ✨



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