Tufts University | Center for Engineering Education and Outreach

Design and Engineering Workshops
Annual Report 2013-2014
Executive Summary

Design and Engineering Workshops (DEW) comprise one important part of the CEEO’s outreach efforts. Each of our workshops is designed around open-ended engineering challenges that allow students to demonstrate their knowledge and creativity. This year, we hosted over 20 workshops and reached almost 400 students and 40 teachers.

Our workshops help our research and tool development efforts, and they enable us to engage a wide variety of students in the engineering design process. We also host teacher workshops- allowing us to leverage our ideas and think about how we disseminate our work.

This year, we added two Educators in Residence to our outreach staff- Daniel Wise, a middle and high school educator, a Lija Yang, an elementary educator and long-time CEEO collaborator. These additions allowed us to reach more students than ever before. They also pushed our thinking, with us incorporating new workshop themes and additional grades. For example, with the help of CEEO collaborator Bill Church, hosted our first workshop for high school-aged students. We also incorporated new technologies, like Arduino, into some of our workshops.

This coming year, we will hold workshops in our new, larger space at 200 Boston Avenue. Our larger space will allow us to schedule more workshops and have a greater diversity of activities within them. We also plan to write case studies on our workshops so that we can highlight the work that we do. Additionally, we will continue to experiment with new ideas, to support the CEEOs research efforts, and to look for new ways to engage populations that are under-represented in STEM fields.
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DEW Team

Elissa Milto- Director of Outreach

Elissa began working with the CEEO in 1999 while she was a classroom teacher at a local school. The following year she entered Tufts as a graduate student at the Center, taking classes in engineering and education, and received a M.Ed in 2002. Elissa has been working as CEEO staff since graduation. Elissa is particularly interested in bringing engineering to elementary students and does this through her work at the CEEO and her children's classrooms.

Daniel Wise- CEEO Educator in Residence

Dan is an Educator in Residence at the CEEO. He comes to us from San Diego, California, where he taught 10th Grade Humanities at High Tech High- a project-based charter school. He previously taught grades 6-9 in public schools in New York City and was the Program Director at Urban Action Academy- a small public high school in Brooklyn. His work with students has been featured in Phi Delta Kappan, on the New York Times website, and in the Harvard Graduate School of Education's Center for Student Work.

Lynne Ramsey- Office Assistant

Lynne received a Bachelor's Degree in Psychology from Dickinson College. She went on to earn a Master's Degree from University of Nevada, Reno, in Experimental Psychology. There, she worked on Project Washoe, a research study conducted by Drs. Allen and Beatrix Gardner during which they cross-fostered chimpanzees and taught them American Sign Language. Lynne began working at the CEEO in the summer of 2010.

Liya Yang- CEEO Educator in Residence

Liya comes to the CEEO from Somerville Public Schools where she has taught since 2006. She has taught dual-aged 3rd & 4th grade, and 1st grade at the Healy School and The Benjamin G. Brown School respectively. Liya has collaborated with the CEEO on various initiatives and research projects since 2007. She was one of the first teachers to open her classroom to REESE for research using LEGOS and engineering. She continued her relationship with the CEEO in W-STOMP, leading teacher
professional development and with a stand-alone unit integrating life sciences and engineering. She and her students incubated chicken eggs and used LEGO to model a chicken coop and feeders for the baby chicks.

**Barbara Bratzel - Partner Educator**

Barbara is a science teacher at the Shady Hill School, a preK-8 independent school in Cambridge, Massachusetts. In addition, she is a consulting teacher at the CEEO. Her most recent book, STEM by Design, is a collection of classroom activities using the LEGO EV3.

**Bill Church - Partner Educator**

Bill received his BS in Physics from Binghamton University in 1992. He received his MAT in Curriculum and Instruction from Cornell in 1997. He received his MS in Mechanical Engineering from Tufts University in 2014. Bill is a former public school physics teacher who has used engineering design challenges and technology toolsets in his science classes for over fifteen years. Currently, Bill is the executive director of White Mountain Science, Inc (WMSI). WMSI’s mission is to support STEM education in northern New England through development efforts, consultant work, and instruction in both formal and informal education settings.
Mission

Our design and engineering workshops are intended to engage students and teachers in creative engineering activities. To attract as wide an audience as possible, including populations that might not otherwise be interested in engineering, we have a variety of themes and materials.

Our workshops for students allow us to engage young people and excite them about engineering. Each workshop consists of open-ended design challenges and ends with an exhibition for families and guests. Some themes this year were “Animal Rescue,” “Mars Rovers,” and “The 21st Century Workshop Room.” Many of these workshops are revenue-generating, with each workshop allocating some room for scholarships. Revenue from workshops has been used towards staffing costs, such as Lynne Ramsey’s time and materials costs such as the CEEO’s new laser cutter.

Other workshops are explicitly designed so that we can test new products and ideas. For example, we held a workshop to see how students with high-functioning autism-spectrum disorders respond to robotics. We also, in collaboration with LEGO, hosted a workshop to test ideas for their new StoryStarter product. All of our workshops with students inform our approach to engineering education, including how we reach out to groups that are traditionally underrepresented in STEM fields.

We also offer workshops for teachers. Like our workshops for students, these allow us to reach a wide audience, test new ideas, generate revenue, and disseminate best practices. Workshops this year included trainings with the EV3, LEGO’s latest robotics platform, and Novel Engineering- based on our Integrating Engineering and Literacy grant.
2013-2014

Highlights:

- This year, we ran more after-school workshops than ever before. These workshops, led by Educator in Residence Dan Wise reached 177 students and generated $25,000 dollars in revenue.
- We added our first workshop for high school students. Robotics Design Studio took place this August. It was led by CEEO collaborator Bill Church and Educator in Residence Dan Wise. During this workshop, students explored a range of topics such as sensors, algorithms, rapid prototyping, actuators, and mechanisms. They used the LabVIEW program environment with a quiver of robot controllers, including LEGO EV3 and Arduino. The final projects included a LEGO mechanized arm that picks up and puts down a ball, a lip reading program, a 3D printer that uses a glue gun, balancing bots, a rubber band firing bot that detects its target, a sound altering program, a guitar playing robot, and a teleoperated hand.
- On Saturday, March 8th, 51 girls in grades five through eight came to Tufts University for a free, day-long workshop entitled G-TEC: Girls at Tufts Engineering for the Community. Throughout the day, the girls took part in engineering design challenges all focused on helping the community.
DEW Statistics From the Past School Year (September 2013- August 2014)

- **Students Reached**: 401
  - Scholarships: 15

- **Student Workshops that We Coordinated and Ran: Tufts**: 20 (329 students)
  - After-School: 10 (168 students)
  - Summer: 9 (161 students)

- **Student Workshops that We Coordinated but Did Not Run**: 4 (82 students)

- **Teachers Workshops**: 1 (18 teachers)
Publicity

We created the following promotional postcard that visitors to the CEEO can bring home with them and share with interested parties such as parents, teachers, and schools.

The Tufts Center for Engineering Education and Outreach (CEEO) is a leading innovator in K-12 engineering education. We believe all students are budding innovators who will excel by learning through failure, working in teams and solving problems. The CEEO knows Kids Can . . . Think. Solve. Discover. Invent. Change the World.

We offer workshops in which boys and girls in grades K-12 participate in hands-on and open-ended design projects.

"My 4th grade daughter loves the CEEO workshops. Under the supportive and inspirational guidance of the CEEO staff and graduate students, she has explored and expanded her problem-solving skills in novel ways. I've observed her confidence in her creativity and pragmatism grow as a result."

Past workshops have included:

- Robotic Zoo
- LEGO Mindstorms
- Engineering and Literacy
- Toy Design
- Early Elementary Robotics
- Engineering for Girls

We also created the following poster that we display in the Center and reference during tours for guests:
We believe all students are budding innovators who excel by learning through failure, working in teams and solving problems. Teachers are integral partners in this process.

We offer workshops during which educators and students alike participate in hands on and open-ended design projects that foster understanding of engineering design and related principles.

We also partner with schools to design and support curricula and tools that encourage creativity and innovation.
Workshops from the Past School Year (September 2013- August 2014)

(for workshops from the past fiscal year- July 2013-June 2014, please see Appendix A)

Each workshop consisted of approximately 20 students and was staffed by at least one professional teacher and two undergraduate assistants.

Workshops Run by the DEW Team:

**Under The Sea** (Grades K-2): Students built and programmed a variety of animals and man-made objects that could be found under the sea.

**Animal Rescue** (Grades K-2): Students designed and programmed robotic animal parents or objects that would help and comfort baby animals that have been rescued by the local zoo and aquarium.

**Beginner Robotics** (Grades 3-8): This program was for students who wanted an introduction to the LEGO NXT platform. Students started with activities focusing on stability in design and moved on to challenges that incorporated gearing, weight distribution, and momentum. They also learned how to program using motors and sensors.

**Intermediate Robotics** (Grades 3-8): This program was for students who have some experience with the LEGO NXT platform. Through several open-ended challenges, students gained experience with the Engineering Design Process. They learned how to incorporate programming tools such as Loops, Data Wires, and Logic Blocks.

**Co-Ed Robotics** (Grades 3-8): During this session, students designed, built, and programmed robots using the engineering design process. Several open-ended challenges were posed to the students throughout. They used standard LEGO bricks, programmable LEGO bricks (including the LEGO EV3), and other materials. The session started with activities focusing on stability in design and moved to other topics such as gearing, weight distribution, and momentum as the students incorporated programming, sensors, and motors into their designs.

**Mars Rovers** (Grades 3-8): We built Mars Rovers that interacted with and responded to their environment. Through several challenges, students gained experience with use of sensors and increasingly complex NXT programming.

**Toy Design** (Grades 3-8): Students had three weeks to invent and refine interactive toys for people their age or younger.
**The 21st Century Workshop Room** (Grades 3-8): Students redesigned the CEEO’s workshop room to meet the needs of the diverse people who use it, including college students, Tufts staff, and themselves.

**Novel Engineering** (Grades 3-5): Novel Engineering is an integrated approach to teach engineering and literacy. As part of Novel Engineering, students used literature as a basis for engineering design challenges, drawing from the texts to identify engineering problems in books, considering characters as clients, and using details from the story to impose constraints.

**Women's Design and Engineering (W-STOMP)** (Grades 6-9): Engineering Camp for Girls consisted of open-ended mini-challenges using different materials and new technologies culminating in a larger user-centered design project. Students explored the topics of simple electronics, human factors, 3D printing, programming, robotics, and user-centered design. Students designed and built using LEGO materials, found materials, and simple electronics.

**Robotics Design Studio** (Grades 9-12): During the workshop, we explored a range of topics such as sensors, algorithms, rapid prototyping, actuators, and mechanisms. We used the LabVIEW program environment with a quiver of robot controllers which included LEGO EV3, Arduino, and Raspberry pi via Brick Pi. The workshop was project-based, striking a balance between exploring many topics with short projects and diving deeply into a few topics with longer duration design challenges.

Workshops Coordinated by the DEW Team:

**LEGO Story Starter** (Grades 3-8): Students were presented with a creative challenge to make up their own story, which they will then build the scenes of using LEGO’s new Story Starter Set. The students then presented their stories and ideas using LEGO's StoryVisualizer software.

**Robotic Toy Design**: Young women from Japan came to the CEEO for the second consecutive year. They worked on basic building and programming, using the LEGO NXT platform. Their final project was a robotic toy that they presented to young students.

**Engineering Solutions with the Help of a NAO Robot** (Grades 2-6): The purpose of the workshop was to explore the usefulness of using a robot to help students, ages 7-12 who have been diagnosed with high-functioning Autism-Spectrum Disorders.
Financial Breakdown for Workshops from the Past School Year (September 2013-August 2014)

For information on the Fiscal Year (July 2013-June 2014, please see the following page)

Revenue:

After-School Workshops: $25,665

Summer Workshops: $70.350

Costs:

Full-Time Staff: $57,140

Part-Time Staff: $19,677

Total Staff: $75,067

Materials: Approximate Cost (Based on previous fiscal year): $6,774

Net:

Net for School Year: $12,424
Financial Breakdown for the Fiscal Year (July 2013-June 2014):

Revenue:

Workshop Fees: $87,932

Costs:

Total Staff: $75,067

Miscellaneous Materials: $3,792
Food for Workshops: $1,215
T-Shirts: $599
CORI Forms: $1,625
Promotional Materials: $3,560

Total Materials: $10,791

Net

Net for Fiscal Year: -$2,065
Featured Workshop: The 21st Century Workshop Room

This spring, we hosted a project-based workshop with the mission to redesign the CEEO’s workshop room. The workshop took place over nine two-hour sessions and included 18 boys and girls between the ages of 8 and 14.

We chose the theme for the workshop because we wanted our students to work with real clients, engineer based on open-ended design challenges, and create items that would “live on” in an authentic space. We also wanted to give them multiple opportunities to cycle through the design process. Each individual project took as much time as was needed- with the result being that almost all of the students had a chance to work on multiple projects.

The workshop was structured so that the first three weeks consisted of exploration of materials and rapid prototyping, followed by three weeks of individual (or group) project work. The final three weeks were dedicated towards product testing and refinement.

We held our final exhibition in May, with attendance from families, CEEO staff, and guest such as professor Dan Hanon. Final products included an alarm for the IEL iPad cabinet, a stand for our LCD projector a robotic floor sweeper, cupholders for the workshop room podium, a mechanical “Welcome” sign, and others.
Featured Workshop: W-STOMP- Women in Engineering

This was the third year in a row of our W-STOMP (Women in Engineering) workshop, which is free for students and funded by the DEW budget. W-STOMP allows us to explore materials and challenges that may help attract young women to engineering.

This year, we had 16 girls, between the grades of 6-9, from Medford and Somerville. Many of these young women have been with us for all three years of the program.

Participants began the week by creating personalized name tags using Tinkercad.com, a free, web-based 3D design program. Their nametags were then 3D printed through a partnership with the mechanical engineering department.

Students then designed and created automatic plant-watering robots, learning the basics of programming with LabVIEW and the in-development software called Botspeak (botspeak.org) and LabVIEW for LEGO Mindstorms to program the Arduino microcontroller and the LEGO EV3.

Students also engaged in a Novel Engineering project based on the book “Long Walk to Water.” The girls read a chapter from the story aloud, practiced carrying large amount of water to empathize with the main character, and then designed and created products to make her life easier. For documentation of the learning process, students tested a new, web-based version of SAM Animation (in development at the CCEO).

The last project for the week was solving a problem for the staff and residents of Wolf Hollow, a wolf sanctuary just north of Tufts University. Problems were proposed by the staff of the facility, such as keeping the wolves’ water cool, giving them a way to exercise while getting food, and helping the staff throw many pounds of food over a tall and bulky fence. This project is in line with our findings that young women respond well to animal-based challenges. We are pursuing a partnership with Tufts Veterinary School to see what other authentic needs we may be able to address.

Featured Workshop: G-TEC: Weekend Engineering for Girls
On Saturday, March 8th, 51 girls in grades five through eight came to Tufts University for a free, day-long workshop entitled G-TEC: Girls at Tufts Engineering for the Community. This workshop was made possible by Jessica Scolnic and Jessica Swenson, who secured a grant from the Society of Women Engineers and planned and ran the workshop.

Throughout the day, the girls took part in engineering design challenges all focused on helping the community. Research on girls’ attitudes toward STEM indicate they are more attracted to professions through which they help people or give back to their community—all of our activities focused on designing for a user or client.

All girls participating in STOMP were invited to attend G-TEC, with special focus placed on inviting girls from the immediate Tufts communities such as Somerville, Medford, and Boston. 14 girls from Somerville, 16 from Medford, and 5 from Boston attended, as well as 19 girls from other surrounding towns such as Revere, Cambridge, and Malden. Twenty-four women in STEM volunteered to staff the event throughout the day. The volunteers were mostly graduate and undergraduate engineering students from Tufts, but also included one working engineer and one full-time teacher.

The morning included a rotation of three activities: designing an ergonomic sled for a LEGO minifigure, using EV3 Robotics to develop wearable assistive devices, and creating a device to help the main character from the book “Island of the Blue Dolphins.” In the afternoon, the girls tackled three sustainability problems that included a way of conserving water while showering, a device to help manage compost, and a way of detecting if an item could be recycled or not.

There was an overwhelming interest from the community to participate in this event. We received over 100 applications for the 50 spots in our workshop. It was also clear that the girls thrived in this environment. Before the formal design challenges were introduced, the girls spontaneously began to design LEGO doorstops to keep the door to their room open. When we entered the classroom to meet as a group, the girls had drawn diagrams of their working prototypes on the chalkboard, and there was a crowd of girls around the door testing out new designs. This unprompted display of enthusiasm was an amazing representation of the day: girls working together and being excited about engineering.