

Bringing Engineering Education to Your School

In this brief overview, we shall present:

The motivation for teaching engineering in elementary education;

The tools used in the classroom;

Resources available for teachers and students to become comfortable with engineering and technology curriculum;

Sample challenges will be presented for elementary grades, and ideas for higher grades as well.

"But what is engineering and how does it help?"

Engineering is the application of science and math to real world issues and objects. Engineers are involved with nearly every object you come in contact with on a daily basis - pots, pans, radios, stereos, cars, trucks, roads, computers, power lines, and even shampoo and lipstick. Their jobs require them to not only be able to perform calculations and understand theories but to gather information, synthesize data, and generate coherent reports and communications. Adding engineering and its elements to education offers students a new way to learn that encourages inter-disciplinary work.

"How can I teach this to small kids?"

Tufts University's Center for Engineering Education Outreach (CEEEO) brings together teachers, engineers, professors, and other educators to develop curriculum and lesson plans that will create a dynamic, inter-disciplinary learning environment in K-12 classrooms. The skills and projects presented by this facility allow students of all ages to learn technology and engineering skills, as designed by the collaborative efforts of educators and engineers. The website presents useful tools for classroom use, including example and startup challenges to get a classroom going, and background information to enable teachers to feel comfortable with more technical concepts. The curriculum offered by the CEEEO is appended by other Tufts sites, containing information and projects done by college students involving LEGOs and the RCX, a wireless programmable LEGO brick.

"What do I need to bring to class?"

The RCX is a small battery powered microcomputer [see figure 1]. The RCX helps to overcome the logistical nightmare of too few computers and too many students by making it possible for several groups of students to embed "smarts" into their designs at one time. After downloading a ROBOLAB program into the RCX, the desktop computer is not needed to run the LEGO design. The programs are downloaded via an infrared transmitter that is connected to the serial port of a desktop computer. Without wires, there is a wider range of projects that a classroom of students can design.

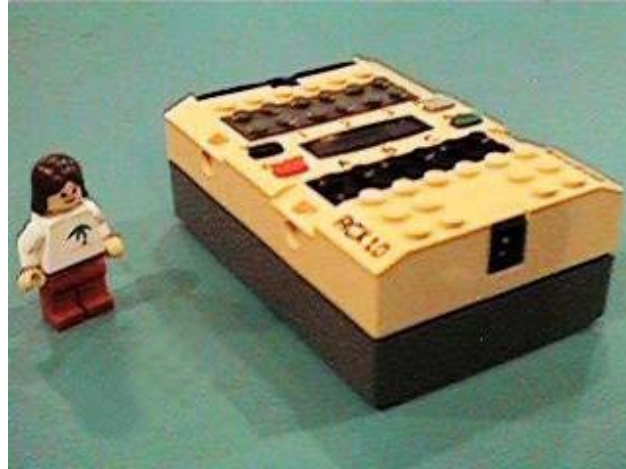


Figure 1: RCX showing inputs labeled 1,2, and 3
Outputs labeled A, B, and C.

ROBOLAB™, the software package used to control the RCX, runs on a modified version of LabVIEW 5 a visual programming language. ROBOLAB™ has two phases of programming. The first phase, Pilot, is a way to introduce programming to students. In Pilot there are limited choices of elements to modify in a pre-existing program. Figure 2 shows an example of this interface.

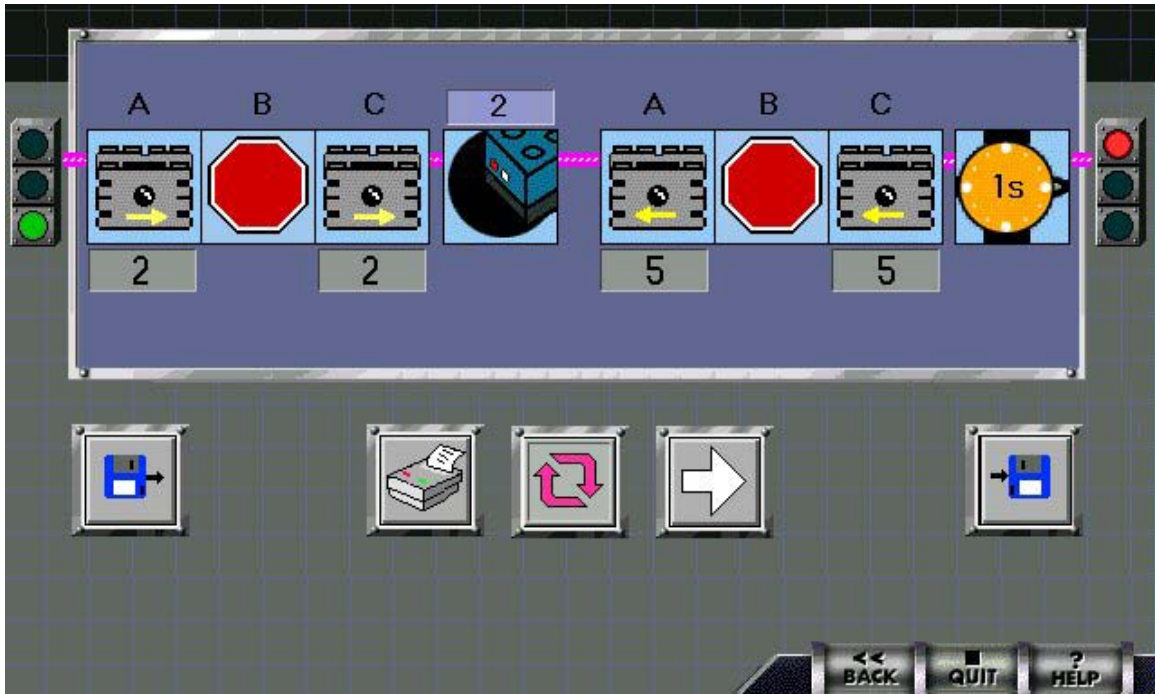


Figure 2: Pilot program. The components are pre-arranged. Students can alter the program slightly and note effects.

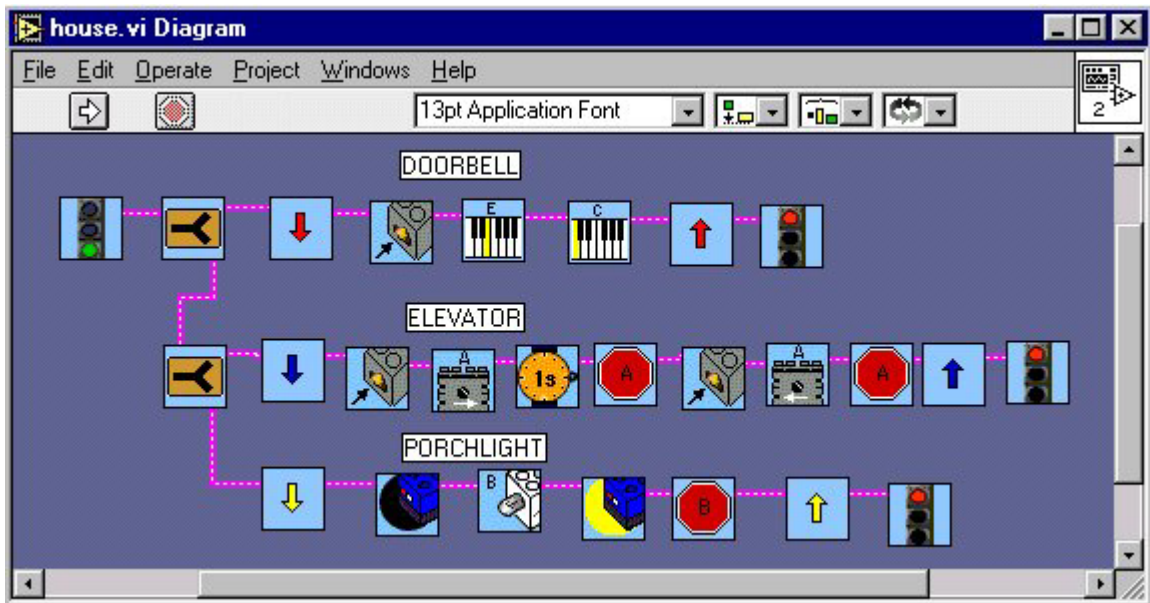


Figure 3: Inventor Program. The icons are pulled from a toolbox, and the user creates and entirely new program.

The second phase, called Inventor, allow students to construct more complex programs exclusively in the diagram window involving variables, loops, multitasking, and case structures. Figure 3 shows the inventor diagram, exhibiting the new freedoms of multitasking and looping while using several different sensors and motors.

Check out <http://www.ceeo.tufts.edu/Robolab/default.asp> for more information on this.

"How do I start?"

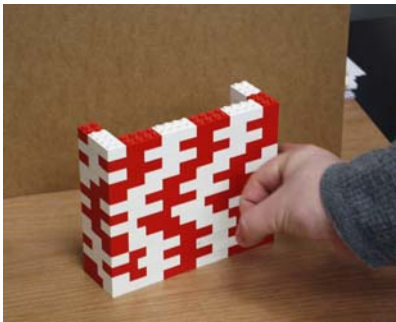
The CEEO website lists information on all of the following challenges, as submitted by CEEO educators, teachers at the Lincoln School and others. Teachers can also find a glossary of technology and engineering terms, outlining these concepts. Classroom observations concerning gender differences are also discussed, and suggestions made to level the playing field for girls and boys.

Challenges listed on the site contain information on materials needed, description of assignment, procedure, and lessons learned, in terms of traditional curriculum (ex. math, geography) and personal development (ex. communication, confidence in original ideas)

Kindergarten project

The "Flick" Test

Students will build a wall that is to withstand the "flick test" (you trying to knock over the wall by flicking it with your finger). Children learn basics of construction, what makes a wall stable, and that everyone can design their own individual solution to a problem. Kids realize that asking questions and making observations helps to figure out how things work. Also coincides well with "The Three Little Pigs".



Second Grade

"Cross-Country Adventure"

A large floor map of the US is placed on the floor, and students pick their destination and starting point. After building a simple car, students write a program to traverse their chosen path. Geography, conversion of miles to feet, and simple programming and problem solving skills are used to accomplish this task.



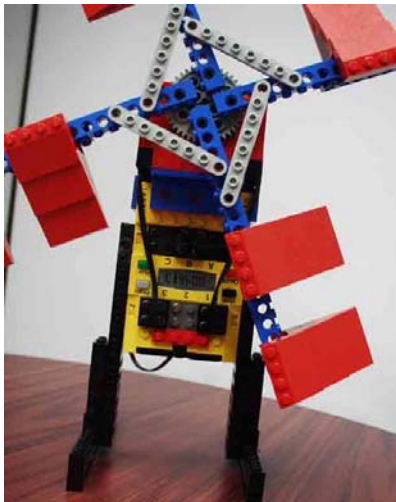
Fourth Grade
"Scavenger Hunt"

A light sensor connected to an RCX is used to collect readings from around the room. This information is uploaded from the RCX back to the desktop computer, and analyzed graphically. Students learn to collect data using observations, surveys, and experiments, as well as how to best represent their data.



Sixth Grade
"Fan-tastic"

Student design a working fan and a program to control it. Their design can be simple or complex, and include features they deem important, such as an on/off switch or variable speed control. Students learn that design is a creative planning process that leads to useful products and systems, also that any design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.



Systems Engineering Project: The House

These results are from a 5th grade project at the Lincoln School in Lincoln, Massachusetts. A systems engineering project requires intra- and inter-group communication to succeed. While individually each student will learn to deal with programmatic, mechanical, electrical, and architectural issues in their designs quite successfully, they will not individually run into the kinds of issues that arise when real engineers work together on complex projects. Normally, engineers with an expertise in a given field must communicate with other engineers in different fields to produce a system that has many interconnected elements. This process creates new design issues that don't arise when working alone or even in a small group.

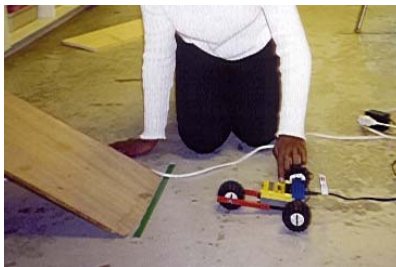
First, a design challenge was posed to the students to design a "smart" building. During a brainstorming session, everyone talked together about what kinds of features the building might have: a porch light, a moving garage door, a doorbell, a ceiling fan, a security system, an elevator, etc. They had to make tradeoffs as to which components to include based on the limited number of sensors. Next, the students decided which was to be their area of expertise: programming, structures/electronics, or architecture/landscaping.

From the first day of working on the house the students started running into design issues that come up in any project involving many elements. The biggest issue was communication. The first thing that was decided by the students collectively was that the building would have two floors, and the structures/electronics expert set off on building an elevator independently. The architecture experts, however, needed to coordinate the placement of the walls and ceiling so as to allow room for the elevator to be placed inside. In this way, problem solving and communication skills are developed.

High School:

"Peak Performance"

Students are asked to build the fastest car they can by using LEGO pieces. The cars are then raced over a set distance, and going up a hill. Applicable traditional curriculum includes physics principles such as friction and center of mass. Students get more building, planning, and design experience while learning to use gearing to maximize available power. Additions to this experiment include asking students to design a more robust car to handle a variable surface with peaks and valleys.



College:

ME-94 : Distributive Intelligence with Robots

"Younger Brother"

This class used inter-RCX communication to gather data and relay commands. In this project, two RCX's are used. The first is controlled manually, but is running a program that sends its position information to a second RCX. This second unit then copies the movement of the first unit. Many other examples of RCX communication can be found at: <http://www.ceeo.tufts.edu/me94/>, the homepage for this class. Other classes taught at Tufts University using LEGOs, ROBOLAB™ and the RCX can be found at <http://www.ceeo.tufts.edu/College/default.asp> .

Go to <http://www.ceeo.tufts.edu/> for more information. Questions about information presented in this paper should be directed towards Sande MacMaster, or Rebecca MacMaster at <mailto:rmacmast@tufts.edu> .

Information found here was compiled and edited by Rebecca MacMaster from:

The Center for Engineering Education Outreach at Tufts University website

"Middle School Engineering with LEGO and LabVIEW" by Ben Erwin, Martha Cyr, John Osborne, Chris Rogers. Presented at the MIT LabVIEW in Education days and National Instruments Week, August 1998, in Austin, Texas.