Type of Submission: Workshop Proposal on Education

Title: LEGO Engineering: Using LEGOs and the LEGO RCX to teach engineering in K-12
Topic: Educational technology
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Background:

Engineering is a hands-on discipline that integrates math, science, and other topics. Children have many natural tendencies towards engineering as they build creations and take a part objects to understand how they work. The mission of The Center For Engineering Educational Outreach (CEEO) at Tufts University in Medford, Massachusetts is to help make engineering a part of K-12 education. Engineering in the classroom facilitates math and science learning in a manor that is appealing and engaging to students. Moreover, it exposes students to the discipline of engineering, giving them a better understanding of what engineers do and why they might want to become an engineer.

Many materials can be used to teach engineering through hands-on design projects from paper clips and tape to metal and wood. LEGO materials are another excellent option as many elements correspond directly to real world elements (gears, axles etc…). They are also accessible and engaging to students and a reusable classroom resource. Much can be learned from building and creating structures with even the simplest LEGO materials. Projects like building a sturdy wall or "A Chair for Mr. Bear" can help students address the topics ranging from stability and forces to construction techniques and design constraints.

Figure 1: "A Chair For Mr. Bear" challenges students to build a chair that will support a teddy bear and keep him upright

The LEGO RCX, a microprocessor embedded in a LEGO brick, adds amazing potential to LEGO creations and to the learning process. With the ability to control motors, lights, and other outputs and respond to input from a variety of sensors (light, temperature, touch, rotation, pH, humidity) the RCX can be embedded in LEGO constructions to allow for "smart" creations ranging from robots to greenhouses. The RCX can also be used to collect data for science investigations ranging from how many people pass through a doorway to measuring the temperature decay in a cup of hot chocolate as it is stirred or fanned.

Figure 2: The LEGO RCX can power up to 3 outputs and accept inputs from 3 sensors

Tufts' CEEO, in partnership with LEGO Educational Division and National Instruments, has developed ROBOLAB, a software application for programming the RCX. Powered by National Instruments' LabVIEW, the software allows for graphical programming of the RCX making it accessible to very young children and also allowing for quick coding and easy debugging for older students. As it is based on LabVIEW, an industry standard for measurement and automation, ROBOLAB users can easily transition to LabVIEW.

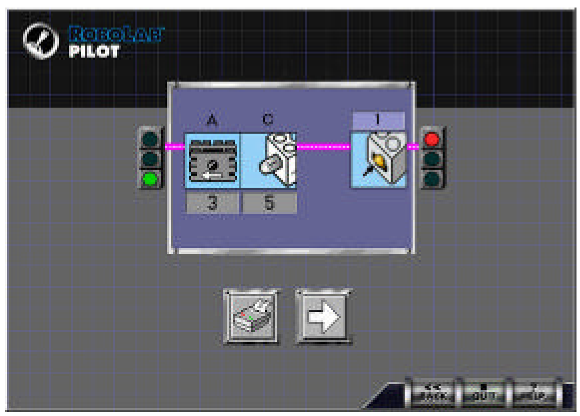

Figure 3: The Pilot Levels of ROBOLAB are graphical templates that can easily be manipulate by students as young as 5 or 6 to create simple programs

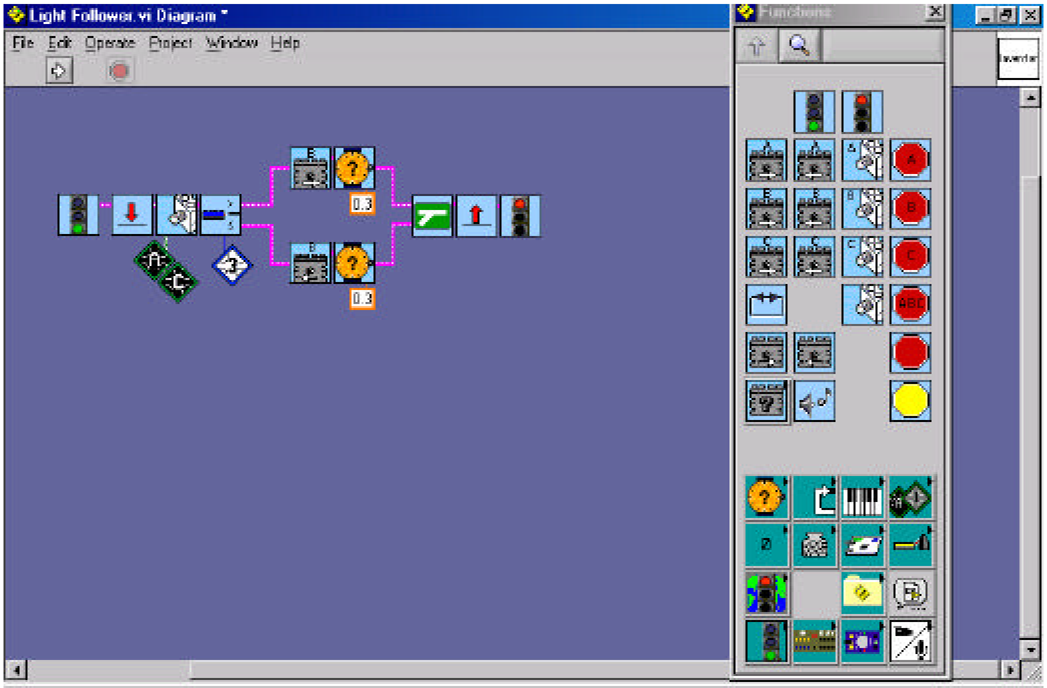

Figure 4: Inventor, the higher levels of ROBOLAB, provide users with a palette of options that can be connected together for infinite combinations.

The CEEO has been using ROBOLAB, the RCX, and other LEGO materials extensively in its efforts to bring engineering to the K-12 classroom. The combination of materials and software allow students to learn science, math, and engineering through hands-on design projects. These projects make concepts relevant and meaningful to children and give them greater ownership of the learning process. Curriculum, activities and resources are featured at www.ceeo.tufts.edu/curriculum for any interested educator.

Workshop Overview

The proposed workshop would give participants an introduction to teaching engineering using LEGO materials through hands-on projects that utilize the RCX and ROBOLAB. Participants would be given an brief presentation on engineering in education and the LEGO components. They would then engage in two activities that would involve design, construction, and programming. Each activity would be followed up with a discussion highlighting the key learning concepts, engineering principals, and classroom implementation issues.

Duration: 90 Minutes

Space: Any room that will accommodate all participants with some long tables and a few power outlets.

Materials: Tufts would bring 10 LEGO Kits (with RCXs) and up to 5 laptops with the ROBOLAB software loaded. Ideally an LCD or overhead projector would be needed.

# of Participants: 20 (ideal for teams of 2) up to 40 (teams of 4 with less hands-on opportunities)

Target Audience: K-12 Educators, Parents and/or College Professors and Students interested in K-12 Outreach

Structure:

Time (minutes)	Event(s)
0-5	Introduction to Engineering
5-15	Introduction to LEGO Components
15 – 35	HANDS-ON ACTIVITY #1 – “Going the Distance”
35-45	Share & Discuss ACTIVITY #1
45-70	HANDS-ON ACTIVITY #2 - “Cool it Down”
70-80	Share & Discuss ACTIVITY #1
80-90	Wrap-Up, Questions, Advanced Challenges

Activity #1 – Participants build LEGO RCX based vehicles. They program their cars to travel for different amounts of time (e.g. 1 second, 2 seconds, etc..) and then measure how far their car traveled (e.g. 11 cm, 23 cm etc…). They create a distance time plot of their data. Using only their graph, they must program their car to reach a random distance specified by the workshop instructor. They cannot test their vehicle once they have programmed it for the random distance. Therefore, how well they do (how close they get to the specified distance) is based on car design, accuracy of measurements, range of data, and precision of graph.

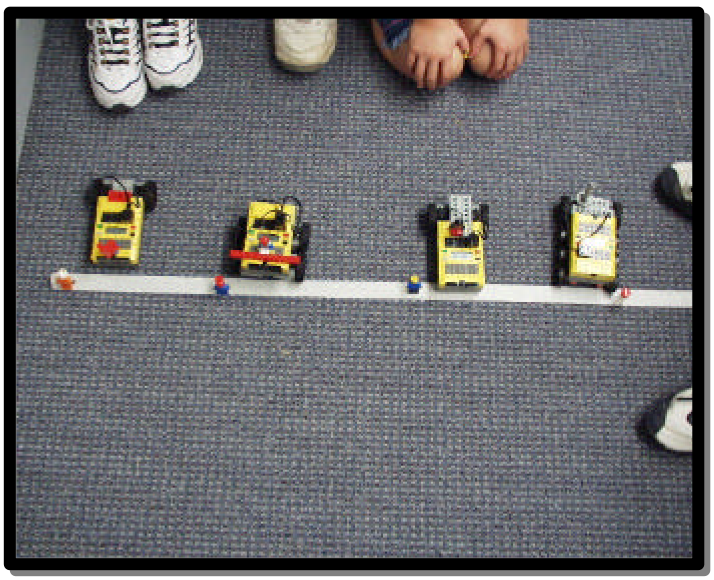

Figure 5: Going the Distance – Get as close to your LEGO person or the tape using only your graph as your guide

Activity #2 – Participants design a method of cooling a cup of hot water as quickly as possible using LEGOs and the RCX based on their ideas about heat transfer (stirring, blowing etc…). They write a program for the RCX that powers their creation and also collects temperature measurements. Participants present their creation and data to illustrate how well it performed.

Figure 6: Cool it Down - Fan or Stir or both ? What will cool down the water fastest?

About the Authors:

Merredith Portsmore is the Education and Technology Program Manager for the Center For Engineering Educational Outreach at Tufts University. She received a BA in English, a BS in Mechanical Engineering, and MA in Education from Tufts University. She is involved in the development of the ROBOLAB software and in the creation of dynamic curriculum that supports engineering in the class. In addition, she creates and implements professional development programs for teachers to help them bring engineering into their classroom. She also is involved in the development and creation of web resources that support educators ranging from curriculum (www.ceeo.tufts.edu/curriculum) to a new online virtual museum initiative for kids.

Dr. Christopher Rogers is a professor of Mechanical Engineering at Tufts University. He received his B.S.,M.A., and Ph.D in Mechanical Engineering from Stanford University. He is the original creator of ROBOLAB and the lead developer. As a software developer he is working to bring the concepts and ideas of robotics and image processing to younger audiences as another method for teaching science, math, and engineering. He spends at least one day a week in a K-12 classroom helping teachers implement engineering (and causing trouble a recess). His other research areas (www.ceeo.tufts.edu/tuftl) focus on particle turbulence, musical instruments, and chemical mechanical planarization.