LEGOS, ROBOLAB, and LabVIEW: Designing, Programming, and Collecting Data

at the

University of Wisconsin-Madison

prepared for

The Institute on Learning Technology

part of the

A Project of the Wisconsin Center for Education Research
National Institute for Science Education
Funded by the National Science Foundation

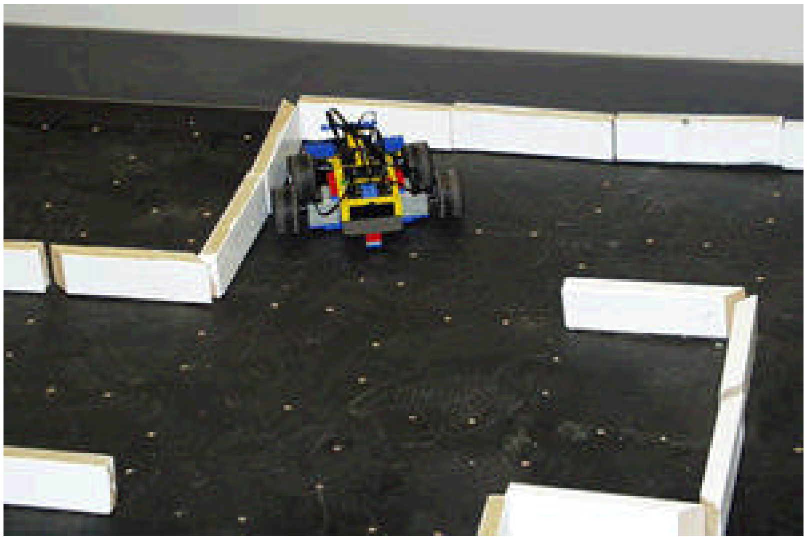
Spring 2001

This quicklook also is available from the
Learning Through Technology web site,
http://www.wcer.wisc.edu/nise/ilt/

LEGOS®, ROBOLAB, and LabVIEW: Designing, Programming, and Collecting Data

Chris Rogers
Associate Professor
Department of Mechanical Engineering
Tufts University-Medford/Somerville Campus
Medford, Massachusetts
crogers@tufts.edu

Why use technology?
Because it's fun. I run a mechanical engineering class that teaches students how to do data acquisition—how to design and build an experiment. We do it all with LEGOs®, the colorful children's construction pieces, and LabVIEW, the software that guided and collected the data from NASA's Sojourner Rover robot on the Mars Pathfinder Mission.



LEGO® car in a maze

If students have to make projects in the machine shop, they can't make very complicated parts. With LEGO® bricks, they can prototype far more quickly, and the complexity of the part correspondingly increases. The same is true with the software; LabVIEW allows rapid software prototyping and students can develop much more complicated software without many of the difficulties associated with a syntactical language (like C). Then you have a pretty powerful combination. By letting students create the experiment themselves, rather than giving them a canned experiment, you can get them more excited about and more involved in what they're learning.

The courses
I've used the LEGOs® in a class called Introduction to Mechanical Engineering, which is a required class for sophomores, with between 40 and 60 students every year. I also teach a freshman Robotics course with about 30 students and a senior Robotics course with high-level

algorithm development and distributed intelligence, which usually has only about five or six students. I use the LEGOs® and the LabVIEW software in both of these as well. You can look up my class work at my Website: http://mike.me.tufts.edu. This site has many examples of the students' work. I would recommend going to EN 10 at this URL and looking at the figures for the robotic zoo. I've also provided LT^2 with other figures, shown here: 1) Teaching about pressure drop in pipes; 2) Measuring topography of a surface (flipcar); 3) A scanner; 4) A LEGO® load stand for a wind tunnel; and 5) Maze navigation.

The strategy

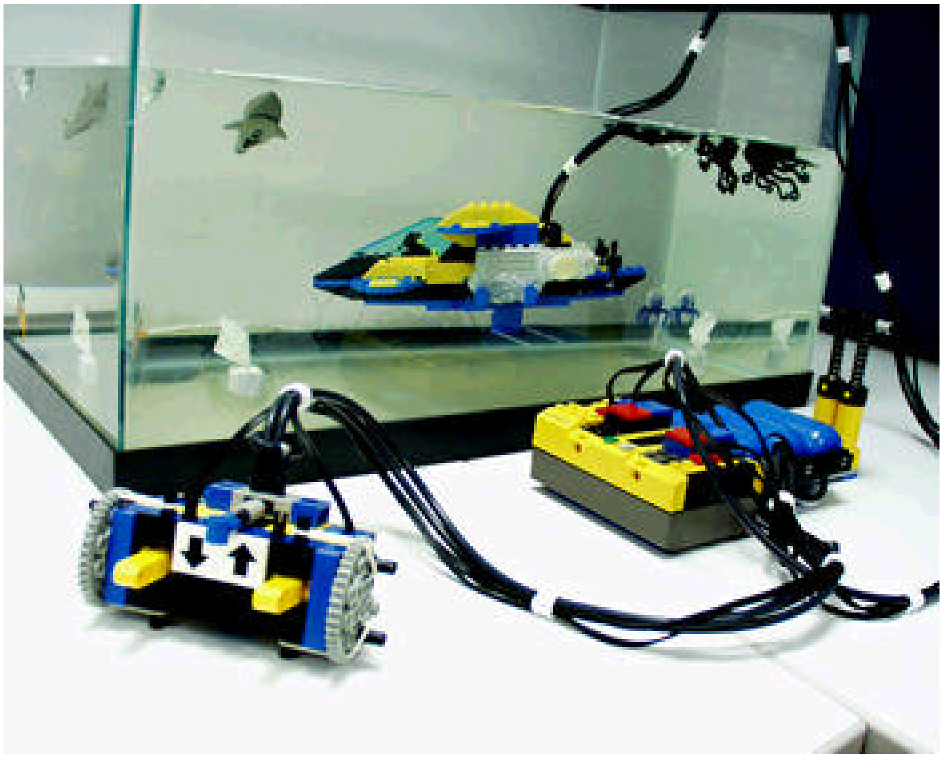
Some time ago, I was looking for a cheap way to do experimentation that a lot of students could do as homework assignments. LEGO® had an older version of their robotics system that I figured out how to control. After I contacted LEGO® and showed them what I had done, we decided to develop educational software for their new piece, the MINDSTORM Brick, here at Tufts. LEGO® has two versions of the software; the one that they developed is for the general public, available at Toys R Us. The one we developed is for schools, primarily focusing on teaching kids how to learn math, science, and engineering—when I say "we," I mean my colleagues and I at the Center for Engineering Educational Outreach (CEEO) at Tufts; engineers at National Instruments; and the research and development team at LEGO Dacta. You can find out more about the CEEO and its projects at: http://www.ceeo.tufts.edu. The first audience for this was K-12, but as I've said, I use this successfully in my undergraduate classes. I've used the technology with kids as young as 3 years old; the oldest student I've had was 50 years old.

The learning technology

The MINDSTORM RCX: The RCX is a programmable LEGO® brick, a plastic, rectangular LEGO® that contains a microprocessor and is powered by batteries. You can download a code or program into the microprocessor, and then the microprocessor goes off and acts on its own; it can control motors, lamps, and gather data (temperature, light, touch, rotation, etc) from sensors. This allows the robot to interact with its environment. You communicate with the RCX to give it instructions using an infrared transmitter.

LEGO® Flipcar

Basically, the students use the RCX as the core of their design; they can modify the brick with LEGO® attachments or add-ons from the RCX Building Sets to make it look like anything they want: a submarine, a boat, an animal, a moon robot. In an experiment we created for the boat, students can send it to the middle of a lake, drop a gauge sensor to measure the pH of the lake water, pull the sensor back up, turn the boat around, and bring it back to give them the pH measurements.

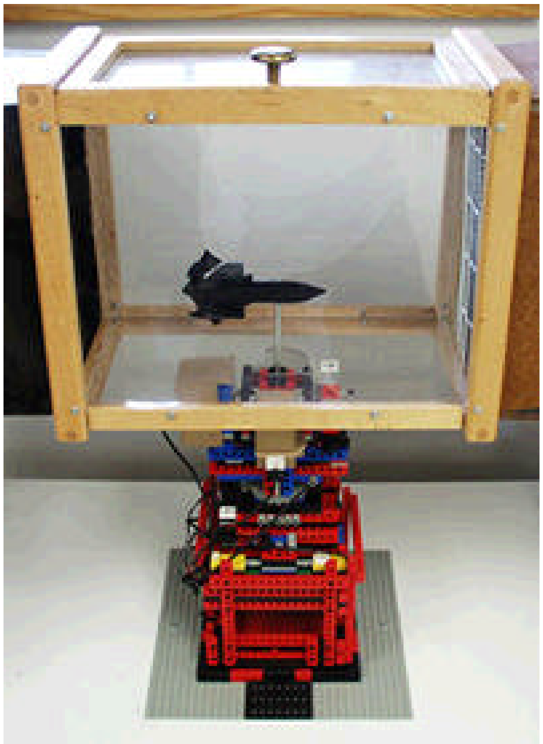


LEGO® submarine

In another experiment using just the RCX, you can put accelerometers on it and throw it across the room. As it flies across the room, it measures acceleration, and you can back up what the drag coefficients are. We also have a moon robot that the students drive around on a moonscape that we've built here and use it to measure things. People can get on the Web and control it. They submit a mission plan and come back the next day after the "mission" to download what happened. The moon robot can have a video camera attached to record the mission.

ROBOLAB: The LEGO® ROBOLAB programming software runs the RCX; students use this software to create a program for the robot they've created around the RCX. Then they download the program to the RCX via infrared, and the RCX robot starts acting autonomously. You can check out the RCX system, the educational tools and software, and other commercial versions at the LEGO® website: http://www.lego.com. The educational versions of the LEGO® systems are accessed at: http://www.lego.com/dacta.

LabVIEW: The ROBOLAB software is based on powerful programming software, LabVIEW, which was designed by National Instruments Corporation for scientists and engineers, and is the leading programming software for measurement and control. NASA used LabVIEW to monitor and control the Sojourner Rover robot on the Mars Pathfinder Mission. LabVIEW provides a powerful programming environment used in many applications: energy research, biomedical, and aerospace, among others. The NI Website: http://www.ni.com.



I use the educational version of LabVIEW in my classes; the students write their own software to move the LEGOs®, drive them forward, to measure the light, measure the pH or the temperature, whatever they want to measure.

The project support

Much of this work was funded by LEGO®, because it's developing products that they can sell to schools. The National Science Foundation, Division of Undergraduate Education (DUE)/Course, Curriculum, and Laboratory Improvement (CCLI) Program also contributed funding. NASA originally funded the whole project at the very beginning to get engineering into the elementary schools.

The results

This has definitely made the students more enthusiastic about the course material. They spend a lot more time analyzing results and a lot less time trying to screw things together. The freshman course is one of about 20 that caused the Tufts engineering program go from a net loss of freshmen entering the engineering program to a net gain—I believe it's one of the few engineering colleges in the nation that has more sophomores than freshmen. Of course the robotics are only a part of that picture. But the success of the class is definitely based on the use of LEGOs® robots and LabVIEW. At my Website, you can check out some of the work the students have done—the animals they've created are pretty humorous; but many of the experimental things we do are as real world as possible. They work just as accurately with the LEGOs as they would with a regular computer and standard methods.

It's basically just a method of prototyping ideas—they work a lot on the prototype and test out various design ideas they have. It has strengthened their design abilities because they've actually been able to build their paper designs and see that they actually work or fall apart. They see what the limitations are on their designs. And it allows them to come up with a simple prototype in an afternoon as opposed to a month.

If you have any questions, you can contact me at: crogers@tufts.edu.

LINKS
Center for Engineering Educational Outreach: http://www.ceeo.tufts.edu/
Course website: http://mike.me.tufts.edu/
LEGO®:

http://www.lego.com/
LEGO® Dacta: http://www.lego.com/dacta
MINDSTORM: http://mindstorms.lego.com/
National Instruments: http://www.ni.com/