Robo Expo – A Soft Approach to Robotics Teaching and Learning

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ABSTRACT

Robo Expo is a robotics exposition that has been held annually in New York City since 2005. It emerged from the Logo Summer Institute[1], a professional development workshop focusing on Logo-based technologies and their use in schools and other educational environments. Participants wanted to create a robotics event for their students that was more relaxed than competitive robotics contests.

What emerged was Robo Expo, which offers an alternative avenue for students to share their Robotics creations in a friendly and supportive environment. The one-day event is divided into two parts:

1. The Challenges, where robots complete a specified task, such as following a line on the floor, or moving around on a table top without falling off. Groups do not compete against each other, but rather seek to achieve the goal.

2. The Exhibition, where students display their robotics creations – along with an accompanying poster explaining the project and displaying code used to program it – for all participants, parents, and teachers to see. This part of Robo Expo is open ended, with no restrictions on what may be displayed.

Participants have mostly been middle school age, with occasional elementary and high students participating as well. The Challenges are posted on the Robo Expo Web site several months before the event so participants may prepare for them as part of their course work or in an afterschool program. For some teachers, Robo Expo serves as a focal point around which a robotics curriculum is structured.

In this paper we report on the activities and projects in Robo Expo, and the modifications that have occurred over the years along with changes in available hardware and software.

BACKGROUND

Beginning in the mid-1980s robotics systems were under development at the MIT Media Lab using Logo software and LEGO building materials[2]. In the 1990s work at MIT extended to the Programmable Brick[3], which allowed for autonomous robots.

These research projects became the basis for a series of LEGO products – LEGO TC Logo, Control Lab, Mindstorms with RCX and later NXT[4]. Although LEGO shifted away from Logo software to applications based on Labview[5], Logo software that worked with these packages continued to be developed at MIT and used in The Logo Foundation workshops. Additional products became available including Handy[6] and PICO[7] Crickets.

The popularity of LEGO robotics products spawned a series of competitions for students, including the FIRST LEGO League[8]. These events emphasized engineering and tended to neglect the artistic possibilities of the materials. Participation was disproportionally by boys, and was focused on the competition. Robo Expo was designed to appeal to a broader range of students with differing learning styles and interests. In addition to preset challenges we sought to provide an open-ended venue for students to express their creativity, and share their knowledge in a non-competitive environment.

The goal of Robo Expo to cast a wider net in creating opportunities for learning about robotics is shared by other programs, a few of which have been written about in scholarly publications. *Crickets and Crafts*, sponsored by MIT[9], elementary and middle school constructionist school robotics programs[10], and the *Robot Diaries* program[11] all intend to capitalize on a general interest in creative self-expression, meaningful uses of technology, and social contexts for using technology. A dominant concern in these programs is to investigate how these characteristics can attract more girls to experiences with technological innovation and leave them with increased positive self-efficacy in working with technology. These programs typically follow a non-competitive format, emphasize creativity and use of art and craft materials alongside typical building materials like LEGO, allow for multiple-gendered interpretations of robotics creations, and prevent overly competitive practices or attitudes from putting too much pressure on participants. In addition, when engineering challenges are introduced, the more supportive events do so in a way that emphasizes cooperative problem solving and a low-risk environment that allows learners to try things they may otherwise feel they couldn't do.

It should be noted that half of the organizers of the first Robo-Expo in 2005 were teachers at girls' schools, and participation by such schools has been consistently high over the years. Teachers' experiences working with girls and robotics influenced the design of Robo Expo toward non-competitive, open-ended and creative projects and activities. Each year, five to six girls' schools participate in Robo-Expo, shifting the overall gender balance towards girls.

PLANNING AND ORGANIZING ROBO EXPO
Each year a volunteer group of six to eight teachers plans and runs Robo Expo. The event is held on a Saturday when school space is available. A gymnasium is ideal, with large open space for the challenges and bleachers for parents and other guests. Tables with exhibitions of students' projects are arranged on the periphery.

The Robo Expo Web site[12] has all of the information about the Expo. This includes the location, date, time, directions to the venue, challenges, exhibition guidelines, printable PDF fliers, and registration and fee information along with photos of previous Robo Expos. The registration fee of USD$100 covers the cost of materials and, if needed, building maintenance fees.

In the months and weeks leading up to the event the group of teachers meet to decide on the challenges for that year and to prepare the materials needed for them.

On the day of Robo Expo participants are invited to arrive an hour before the actual event begins in order to set up their exhibits at their school's table as well as test their robots. As the Expo opens participants and visitors are invited to walk around to view exhibits by the students who tell about their creations and demonstrate how they work.

After an hour of viewing the exhibits visitors are asked to sit on the bleachers for the challenge portion of the event. At each challenge station, there is a judge who determines if the challenge has been met, and awards robot stickers to those students who complete it successfully. If the students are unsuccessful on the first attempt, they are encouraged to try again.

During the week after the event, an email is sent to the faculty member/chaperone who accompanied the students to the Expo. The email asks for feedback on the event and whether there are any suggestions for the next year. A few weeks after the event, the organizers gather to debrief and take notes for the following year's event.

THE CHALLENGES
We designed tasks that required attention to both construction and programming. One group of challenges requires that a vehicle follow a black line drawn on a white background. The simplest such challenge is an oval about 1 m by 1.5 m. To meet the challenge the vehicle has to follow the line and return to its starting point within two minutes.

A common approach for this challenge is to build a vehicle that has two driving wheels, with a separate motor powering each. Turning on both motors in the same direction causes the vehicle to move forward or backwards. With one motor on and the other off, or with the motors spinning in opposite directions, the vehicle turns. In principle this gives one complete control over where the vehicle goes. To detect the line one may use a light sensor pointed down at the mat. Since the white background reflects more light than the black line, the sensor values will be different.

If one places the vehicle pointed to move clockwise around the oval, the strategy to program would generally be:

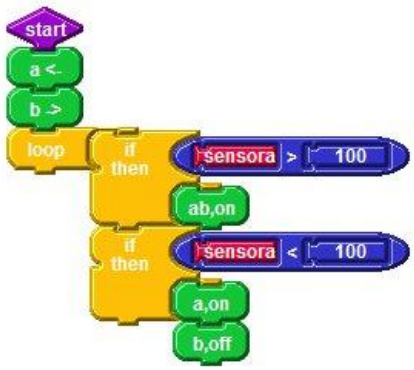
If black is detected, move forward.
If white is detected turn right.

For a counterclockwise running of the course, the turn would be left.

A Cricket Logo program might look like this (text following the semicolons are comments and not part of the code):

```
to follow                ;follow is the name of the procedure
a, thisway               ;sets the rotation direction of motor a
b, thatway               ;sets the rotation direction of motor b[13]
loop [ if sensora > 100         ;higher sensor value
                                ;indicates less light, i.e. on
                                ;black
            [ab, on]            ;both motors on, vehicle
                                ;moves forward
        if sensora < 100        ;now on white
            [a, on b, off]      ;one motor on, the other off,
                                ;causing a turn
                       ]
end
```

Using Logo Blocks as the programming language, the procedure would look like this:



A somewhat more difficult challenge is a path in the shape of the letter S. Since the curvature could be either way, always turning one way to recapture the line will fail. The most common approach is to use two sensors, one on the right side and one on the left side of the front of the vehicle, spaced widely enough so that the path is between them. A typical program would do this:

If both sensors detect white, move forward
If the left sensor detects black, turn left
If the right sensor detects black, turn right

Although this may seem straightforward, the details are critical. For example, if the turn is too great, both sensors may be over the white background on the same side of the black line. The vehicle will then wander off into the distance.

Another challenge is getting out of a box – a structure about 60 cm * 90 cm with walls about 10 cm high and an opening on one side of about 20 cm. The robot is placed inside facing one of the short walls and has two minutes to escape.

The table top challenge required that a robot move around on a table for two minutes without falling off. The first year this challenge was tried the common strategy was to place the robot in the middle of the table and have it move back and forth a few centimeters until time was up, never getting close to the edge. This was not our intention. The next year we specified that at least part of the robot be over the edge at some time. We also did not specify the size or shape of the table ahead of time. The results were more interesting with light, touch, or distance sensors used to detect the edge of the table and trigger backing up and turning away behavior.

The specifications of the Challenges are posted on the Robo Expo Web site ahead of time so participants may build and program to meet them, and practice before the event. Still, things don't always go as planned. The lighting on the day of the event may be different from the way it was in the practice environment. This can require changes in the values specified for the light sensors. Participants bring laptops so they may reprogram on the spot as needed. Sometimes altering the construction can help. For example, in the line-following challenges, if the light sensor is closer to the floor, less ambient light reaches the sensor and it is more reliably reported reflected light.

Participants may make adjustments to their robots and programs and try a challenge again.

THE EXHIBITION

The instructions and requirements for projects in the Exhibition are very open-ended. Students are allowed to exhibit any robot that they have created. Each project must be accompanied by a poster with student's or students' name(s) and grade(s), the name of the school, a description of the robot and what it does, and a print out of the programming code.

Student Exhibition projects have been very diverse over the years, including

- an automated, motor driven LEGO town
- a spin art machine
- a skyscraper with a working elevator
- a robot-controlled game that rewards visitors with candy for hitting a target with a ball
- a drum playing robot
- various animal robots, including many that walk
- a venus flytrap robot
- a long, winding dragon robot
- an elevated tramway
- a robot that doodles with markers
- and many more creative and artfully executed projects.

IMPACT

There is anecdotal evidence of benefits of participation in Robo Expo. Feedback from teachers, students and parents has been very positive.

Another indicator of success is that people return multiple times. There have been eight Robo Expos so far. Each year between nine and 12 schools take part with a total of 25 schools having participated since 2008. Attendance ranges from 100 to 150 people. More than half the schools have attended three or more times.

Participation in Robo Expo has been stable over the years. The events are a good size, with enough participation for rich interactions, but not so large as to be overwhelming or create logistical problems. Expansion would not involve increasing the size of Robo Expo. Rather, cloning would be more appropriate, with other clusters of schools drawing on our experience to start Robo Expo events of their own. In fact, this has started to happen. Teachers from one of the schools attending Robo Expo began ROBONanza in 2010[14]. Also in 2010, Brimmer and May School hosted 21 Century Expo for seven Boston-area schools.

This cloning process could form the basis for a network of similar events, with organizers and participants sharing experiences.

[1] http://el.media.mit.edu/logo-foundation/workshops/summer.html

[2] Resnick, M. and Ocko, S. (1991). LEGO/Logo: Learning Through and About Design. *Constructionism*, edited by I. Harel & S. Papert. Norwood, NJ: Ablex Publishing.

[3] Resnick, M., Martin, F., Sargent, R. and Silverman, B. (1996). Programmable Bricks: Toys to Think With. IBM Systems Journal, vol. 35, no. 3-4, pp. 443-452.
Sargent, Randy, Resnick, Mitchel, Martin, Fred, and Silverman, Brian (1995) Building and Learning With Programmable Bricks. *Logo Update Vol. 3 No. 3* http://el.media.mit.edu/logo-foundation/pubs/logoupdate/v3n3.html#brick

[4] http://mindstorms.lego.com/

[5] http://www.ni.com/labview/

[6] http://handyboard.com/cricket/

[7] http://www.picocricket.com/

[8] http://www.firstlegoleague.org/

[9] Rusk, N., Resnick, M., Berg, R., Pezalla-Granlund, M. (2008). New pathways into robotics: Strategies for broadening participation. *Journal of Science Education and Technology*, 17(1), 59.

[10] Beisser, S. R. (2005). An examination of gender differences in elementary constructionist classrooms using Lego/Logo instruction. *Computers in the Schools*, 22(3/4), 7-19.
Hartmann, S., Wiesner, H., & Wiesner-Steiner, A. (2007). Robotics and gender: The use of robotics for the empowerment of girls in the classroom. *Gender Designs IT: Construction and Deconstruction of Information Society Technology*, 175.

[11] Bernstein, D. L. (2010). Developing technological fluency through creative robotics (unpublished dissertation).
Hamner, E., Lauwers, T., Bernstein, D., Nourbakhsh, I., & DiSalvo, C. (2008). Robot diaries: Broadening participation in the computer science pipeline through social technical exploration. *AAAI Spring Symposium on using AI to Motivate Greater Participation in Computer Science*

[12] www.robo-expo.org

[13] It may appear that the two motors are being set to turn in opposite directions, and that this would cause the vehicle to rotate in place when the motors are turned on. In fact, since the motors are positioned on opposite sides of the vehicle, as mirror images of each other, the rotation is being set so as to cause them both to turn in the direction that will move the vehicle forward, or backward.

[14] http://www.greenwichacademy.org/podium/default.aspx?t=131404&tn=ROBOnanza