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# Using Robotics as an Educational Tool in 4-H

**Abstract**
Although America is the world leader in science and technology innovation, the educational system is not preparing enough science and technology workers to maintain leadership. In an effort to prepare youth for the 21st century, Nebraska 4-H conducted a 2-day workshop using robotics to teach science, technology, engineering, and math (STEM) concepts. A subsequent competition was held at the State Fair to debut robots to the community. The competition was popular with fair-goers and let youth experiment with their robot designs and programming. To engage more youth, Nebraska will pilot the 4-H CCS curriculum and expand the State Fair competition.

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## Introduction

Nebraska 4-H is working to prepare youth with 21st century skills and training. The cornerstone of that effort is to disseminate a hands-on, minds-on program that utilizes robotics to teach science, technology, engineering, and math (STEM) concepts. To debut robotics in Nebraska, the authors held a 2-day workshop with members of the state's Technology Team. A competition was held at the Nebraska State Fair to showcase the team's efforts and present robotics to the community.

## Background

American students' low proficiency in math and science is a major concern in building a competitive 21st century workplace. America's economy is highly dependent on advanced technology, but research indicates that the United States is producing fewer science and technology workers (Porter & van Opstal, 2001). International test scores show that American students are relatively poor performers in math and science (Lemke et al., 2004).

The use of hands-on, minds-on educational tools like robots may reverse the downward trend in STEM fields. The research literature regarding robotics in education suggests that robotics can be used to:

- Engage students (Barnes, 1999; Mauch, 2001; Nourbakhsh et al., 2005; Robinson, 2005; Rogers & Portsmore, 2004; Miller & Stein, 2000);
- Teach scientific and mathematic principles through experimentation (Rogers & Portsmore, 2004);
- Promote math and science careers (Barnes, 1999; Rogers & Portsmore, 2004; Miller & Stein, 2000);
- Develop problem solving skills (Barnes, 1999; Mauch, 2001; Nourbakhsh et al., 2005;

Robinson, 2005; Rogers & Portsmore, 2004); and

- Promote cooperative learning (Nourbakhsh et al., 2005; Beer, Chiel, & Drushel, 1999).

In addition:

- Female students are more likely to appreciate learning with robots than with traditional STEM teaching techniques (Rogers & Portsmore, 2004; Nourbakhsh et al., 2005); and
- Robotics may be effective for at-risk or under-served student populations (Robinson, 2005; Rogers & Portsmore, 2004; Miller, Church, & Trexler, 2000).

## Description

In the spring of 2005, the Nebraska 4-H department held a 2-day workshop for members of the Technology Team. The team is comprised of 10 youth ages 15 to 19 with an interest in technology. The workshop covered topics including:

- Computer programming (variables, loops, conditions, counters);
- Engineering concepts (gear ratios, vehicle design);
- Data collection techniques to use with sensors; and
- Math concepts (threshold values, ratios, measurement).

Problem solving and computer program debugging procedures were emphasized throughout the workshop. For example, to debug a program, team members were taught to use musical notes to indicate what function within the Robolab program was executing at that precise moment. By listening to the notes, the team members could determine if the robot's behavior was working the way they had planned.

Although there are a number of different commercially available robotic kits available, Nebraska 4-H elected to use the LEGO Mindstorm for Schools kits. Because most youth have experience using LEGOs, they can easily transfer these skills to building robots. The LEGO Mindstorm kits are comprised of 828 parts, including axles, gears, motors, and sensors. The kits come with a programmable microcomputer with three output and three input ports for controlling sensors and motors. In addition, the robots are programmed using a specialized programming language called ROBOLAB.

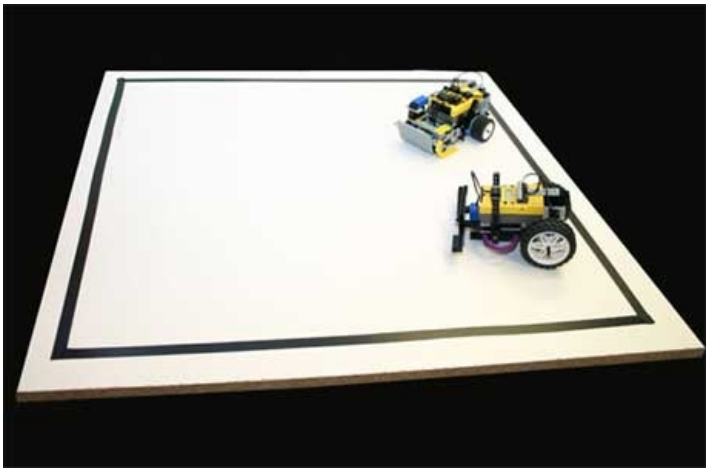
At the end of the workshop, students were sent home with the laptops and Mindstorm kits to prepare for the State Fair competition. A bulletin board type Web site was developed to foster communication. The site permitted members to exchange ideas and to post images and video clips of the robots in development. The rules and arena layout were also shared via the Web site.

## The State Fair Competition

The competition was designed to allow students to showcase what they had learned about engineering and programming. The arena was a 3 by 3 foot white melamine surface with a 1/2-inch black electrical tape border (Figure 1). The objective of the competition was to locate and push their competitor's robot out of the arena. The black border permitted the use of the light sensor to keep the robots inside the arena.

Each contestant's robot competed in a round-robin tournament. The competition was broken-down into rounds; each round consisted of three bouts lasting 1 minute each. The winner of two bouts would win the round and gain three points. A draw would give each member one point.

**Figure 1.**
The Competition Arena with Two LEGO Mindstorm Robots



Each contestant in the contest used a different strategy to try to win. One used a tracked, tank-like robot, while another focused on using large wheels and gears designed to provide maximum torque. Another contestant focused on maximizing the use of sensors. An alternative approach was a robot that walked around the arena on legs. The competition drew a large enough crowd to convince the Technology Team members to return to the fair several other days to put on exhibition matches for fair-goers.

Technology Team members comments indicated that they enjoyed the experience. Unfortunately, the beginning of the tournament was a little uncertain because the first robot flew off the arena and shattered on the floor while the other robot did not move. The non-moving robot won the bout, and it took a few minutes to repair the second robot.

The team members were allowed to make modifications to their robots and their programs between rounds. It was encouraging to see the team members experiment with their robots designs and programming, and make essential modifications. Ultimately, the winner of the tournament was the only female participant.

Here are some suggestions for running your own competition.

- Purchase LEGO Mindstorm for Schools Robotics kits (http://www.legoeducation.com) and become familiar with how to build and program robots.
- Organize a hands-on robotics training workshop for interested participants. At a minimum, the workshop should cover the following topics:
    - Basic robot building.
    - Basic robot programming.
    - Basic sensor programming and building.
    - Line tracking.
- Establish rules and scoring for the competition.
- Build your arena.
- Run your competition.

## Conclusion and Future Directions

Based on the success of these efforts, Nebraska 4-H will be helping to pilot a new set of 4-H CCS robotics curriculum. The curriculum will lead students through a set of increasingly challenging robot building and programming activities. By the time students are done with the program, they should be able to design and build impressive robots to compete in the next State Fair competition. Technology Team members expect next year's competition to be much larger and more competitive.

Robotics may be a valuable tool for integrating science and technology into 4-H. More research is needed to determine the effectiveness of using robotics to teach STEM concepts.

## References


Barnes, D. J. (2002, February-March). *Teaching introductory Java through Lego Mindstorms models*. Paper presented at SIGCSE 2002 Technical Symposium on Computer Science Education, Covington, Kentucky.

Beer, R. D., Chiel, H. J., & Drushel, R. F. (1999). Using robotics to teach science and engineering. *Communications of the ACM*, 42(6), 85-92.

Lemke, M., Sen, A., Pahlke, E., Partelow, L., Miller, D., Williams, T., Kastberg, D., & Jocelyn, L. (2004). *International outcomes of learning in mathematics literacy and problem solving: PISA 2003 results from the U.S. perspective*. Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Mauch, E. (2001). Using technological innovation to improve the problem solving skills of middle school students. *The Clearing House*, 75(4), 211-213.

Miller, D. P., & Stein, C., (2000). "So that's what Pi is for" and other educational epiphanies from hands-on robotics. In Druin, A. & Hendler, J. (Eds.) *Robots for kids: Exploring new technologies for learning experiences*. San Francisco, CA: Morgan Kaufmann.

Miller, G., Church, R., & Trexler, M. (2000). Teaching diverse learners using robotics. In Druin, A. Hendler, J. (Eds.). *Robots for kids exploring new technologies for learning*. San Diego: Academic Press.

Nourbakhsh, I., Crowley, K., Bhave, A., Hamner, E., Hsium, T., Perez-Bergquist, A., Richards, S., & Wilkinson, K. (2005). The robotic autonomy mobile robots course: Robot design, curriculum design, and educational assessment. *Autonomous Robots*, 18(1), 103-127.

Porter, M., & van Opstal, D. (2001). *U.S. competitiveness 2001: Strengths vulnerabilities and long-term priorities*. Washington, DC: Council on Competitiveness.

Robinson, M. (2005). Robotics-driven activities: Can they improve middle school science learning?

*Bulletin of Science, Technology & Society*, 25(1), 73-84.

Rogers, C., & Portsmore, M. (2004). Bringing engineering to elementary school. *Journal of STEM Education*, 5(3&4), 17-28.