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Starting a Robotics Program in Your County

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Abstract: This article provides information on how to begin, locate resources for, and recruit volunteers to support a robotics program targeted at middle school youth. It also presents options for program delivery (volunteer-driven and staff-supported, or staff-driven) and evaluation.

Introduction

The current mission mandates of the National 4-H Headquarters are Citizenship, Healthy Living, and Science. Robotics programs are excellent in fulfilling the Science mandate. Robotics engages students in STEM (Science, Engineering, Technology, and Mathematics) fields by providing interactive, hands-on, minds-on, cross-disciplinary learning opportunities (Barker, 2006 and the references therein). Easily modified curriculum accounts for varying needs and available resources. Research shows that informal science experiences have a strong influence on whether a youth will follow a STEM career (Schwartz & Noam, 2007), thus robotics programs can influence career choices of participants.

Middle and high school students in the United States consistently perform poorly in internationally-administered STEM tests, e.g., U.S. 15-year-olds ranked 27th out of 39 countries that participated in a 2003 administration of the Program for International Student Assessment (PISA) examination, which assessed students' ability to apply mathematical concepts to real-world problems (National Center for Education Statistics, 2005). It makes sense, then, to address this problem early by gearing robotics towards elementary or middle school youth. This article focuses on programs appropriate for middle school youth.

Program Organization

With myriads of robot vendors and four national robotic competition organizations, venturing into the robotics arena can be confusing to a 4-H educator. A robotics program can be expensive; it requires significant staff support and technology-minded volunteers. Thus, program planning and organization are very important. Staff-driven programs may function as an after-school program or a special emphasis club. For programs held at external sites, the 4-H educator and site will want to agree upon how responsibilities and resources will be shared. Volunteer-driven programs, with staff-support, may flourish within traditional 4-H clubs. Existing 4-H volunteers, passionate about engineering or science, make excellent robotics leaders. Engineers and scientists may join 4-H in order to teach robotics.

Choosing a Robotics Platform

The two most widely used robotics platforms (kits) are LEGO® Mindstorms® Education NXT and VEX® Robotics Design System. Two factors affect the choice of a robotics platform: age range of the target audience and resources available (time, funding, technology-minded volunteers, computer labs, etc.). LEGO® Mindstorms® Education NXT provides robotics sets for elementary and middle school youth. The VEX® Robotics Design System, used for the National 4-H Engineering Challenge, offers additions to the starter bundle, making it useful for elementary through college-age youth.

LEGO® Mindstorms® Education NXT Platform. Introduced in 2006, features of this platform include the following:

- LEGO® name is universally recognized and associated with play
- Easily built and taken apart, thus amenable to quick alteration
- No toolkit required
- Programmed by a graphic (icon-based) language; does not require learning a programming language
- Used for one of the four FIRST (For Inspiration and Recognition of Science and Technology) robotic events

At a minimum, one must purchase the LEGO® Mindstorms® Education NXT set, supporting software, and site license. If additional funds are available, the Resource set is an excellent investment and enables youth to build a variety of robots (clawed, tank, etc.). Figure 1 shows the robot built using the instructions in the set.

Figure 1.
Robot Built from the LEGO® Mindstorms Education NXT Set Using Instructions Included in Set

For non-competition programs, two to four youth can share a robot. More may result in some members of the group not contributing significantly. Each group must have a dedicated computer for programming. Storing sets in multiple fishing tackle boxes (each with itemized inventory) simplifies inventory and expedites building. These can be stacked in milk crates for transportation. The online LEGO® Education store sells LEGO® Mindstorms® Education NXT base sets <http://www.legoeducation.us/store/>.

Table 1 gives a summary of recommended LEGO® Mindstorms® Education NXT inventory for starting a robotics program. Computer system requirements for NXT-G programming software for LEGO Education robotics kits are presented in Table 2. Note that WeDo kits are significantly less versatile than NXTs.

Table 1.
Recommended LEGO® Mindstorms Education NXT Inventory With Approximate Costs

LEGO® Education		
Age	**Item Description**	**Unit Cost in $**
6-9 years	WeDo robotics set+soft ware	179.95
	WeDo construction set	129.95
	WeDo Robotics software+Site Licence	279.95
9-14 years	LEGO Mindstorms Education NXT base set	279.95
	LEGO Mindstorms Education NXT -G software + site licence	279.95
	Education Resource Set	79.95

Table 2.

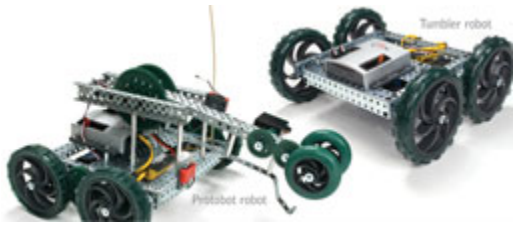
System Requirements for NXT-G Software[1]

Microsoft Windows	Apple Macintosh
For Windows XP OS: Minimum Windows XP Professional or Home Edition with Service Pack 2 or newer. Intel© Pentium© processor or compatible, 800 MHz minimum (1.5 GHz or better recommended)	For Apple Mac OS X: Apple Mac OS X v10.3.9, v10.4 or v10.5, Intel processor
For Windows Vista OS: Windows Vista Service Pack 1 or newer. Intel© Pentium© processor or compatible, 1 GHz minimum, (1.5 GHz or better recommended)	For Power PC©: PowerPC© G3, G4, G5 processor, 600 MHz minimum (1.3 GHz or better recommended)
512 MB of RAM minimum	512 MB of RAM minimum
Up to 700 MB of available hard-disk space	Up to 700 MB of available hard-disk space
XGA display (1024 x 768)	XGA display (1024 x 768)
One available USB port	One available USB port
CD-ROM Drive	DVD-Drive
Compatible Bluetooth adapter (optional)[2]	Compatible Bluetooth adapter (optional)[2]
[1]Adapted from LEGO® Education store website. http://www.legoeducation.us/store/detail.aspx?ID=1670 [2] Supported Bluetooth software are Widcomm© Bluetooth for Windows newer than v. 1.4.2.10 SP5 and the Bluetooth stacks included in Microsoft Windows XP with Service Pack 2 or Service Pack 3, Windows Vista or Vista Service Pack 1, Apple Mac OS X 10.3.9, 10.4 and 10.5.	

VEX® Robotics Design Platform. Unlike the NXT platform, which has only autonomous (programmed) robots, the VEX® platform can produce both autonomous (programmable) and remote-controlled robots. Dual control bundles are also available. The remote controlled robot requires no programming. Elements forming a system (e.g., sensors) are purchased in "bundles." The basic starter bundle includes a fully programmable remote control. Figure 2 shows the robots built using the starter bundle.

Figure 2.

Examples of Robots Built Using VEX® Starter Bundles



Characteristics of the VEX® system are as follows:

- Starter bundle can be augmented by bundles dedicated to a single operation (e.g. tank tread, advanced gears, bumper switch)
- Hardware and software purchased separately for autonomous control
- Autonomous and dual control robot kits require learning programming language: C or ROBOTC
- Easy-C, however, is drag and drop programming to the VEX Cortex microcontroller

The VEX system can use a variety of software spanning several price ranges. The greater the number of systems one controls with the software, the higher the price, but the computer system requirements are similar to those for the NXT. All equipment is available online from the VEX® website <http://www.vexrobotics.com/vex-products.shtml>. Table 3 offers a summary of recommended VEX® robotics inventory for a beginning robotics program.

Table 3.
A Summary of Recommended VEX® Robotics Inventory for Starting a Robotics Program With Approximate Costs

VEX®			
Age	**Item Description**		**Unit Cost in $**
11-18 years	VEX protobot starter kit	with radio control	299.99
		with autonomous control (without programming hardware & software)[1]	319.99
		with dual control (without programming hardware & software)[1]	419.99
	VEX booster kit (contains mechanical elements)[2]		179.99

	VEX Advanced Sensor Kit[2]	99.99

[1] Choice of programming software available, for different prices. Programming hardware is $49.99. Software options begin at $74 (Easy C 2.0)
[2] To be used in addition to one of the protobot starter kits above

Locating Resources

Because costs can be an issue, possible sources of funding are summarized in Table 4.

Table 4.
Potential Sources of Funding

Potential Sources of Funding	Notes
Local tech based businesses usually give small grants or are willing to sponsor a club	Best to contact a 4-H volunteer employed at the company
Utility companies provide educational grants	Best to contact a 4-H volunteer employed at the company
Local School districts provide grants	Partner with school or school district for funding, premises and perhaps teachers
4-H Leader's Associations have funds for project-start up	Need to sell the idea to them. A demonstration helps tremendously
NASA Robotics Alliance Project funds robotics programs	http://robotics.nasa.gov/

Available curriculum/resources for all LEGO® NXT based robotics projects:

- LEGO® Mindstorms® NXT website with technical support, community and general information www.mindstorms.lego.com
- Carnegie Mellon Robotics Academy's *Robotics Engineering*, volume 1 & 2 http://www.education.rec.ri.cmu.edu/
- Tufts University and LEGO® Education provide online resources at: www.legoengineering.com
- University of Nebraska robotics program curriculum: GEAR-Tech-21 (GEOspatial And Robotics Technologies for the 21st Century) http://4hset.unl.edu/itest/index.php

- LEGO® Education Mayan Adventure curriculum http://www.legoeducation.com/store/
- *The Unofficial LEGO Mindstorms NXT Inventor's Guide* by David Purdue and companion website: http://nxtguide.davidjperdue.com/
- NXTprograms.com, a free web resource for building and programming http://www.nxtprograms.com/
- Free online tutorials for programming by Dale Yocum http://www.ortop.org/NXT_Tutorial/index.html
- Maine Robotics Tutorials http://www.mainerobotics.org/tutorials.html
- Educate NXT, robotics resource for teachers and students, from LEGO® Education

The VEX® Robotics Design System website <http://www.vexrobotics.com/ >, maintained by Innovation First International, Inc., has extensive support resources for all educational needs from a classroom setting to a home-school network. The Carnegie Mellon Robotics Academy website <http://www.education.rec.ri.cmu.edu> has educational resources for several robotics platforms, including NXT and VEX®.

Evaluation

The evaluation plan depends on the program delivery and the educational goals of stakeholders. Possible evaluation outcomes are teamwork skills, problem-solving skills, STEM knowledge, programming skills, creativity, and interest in following STEM careers. Youth and mentor surveys and interviews, observation, and competition scores are options for data collection. A retrospective post-then-pre-test is highly recommended. Young people can more effectively assess their skill-level increase when asked to compare their current skill levels with those at the beginning of the program.

Summary

Once the decision has been made to start a robotics program, it is judicious to review available recourses and explore avenues for partnerships. An advertisement campaign can attract both tech-savvy volunteers and corporate sponsorship. The choice of the robot platform can depend on the partnerships forged or the availability of locally held competitions. Given that this program requires a heavy investment of resources, the report back to stakeholders is crucial. Therefore, the evaluation plan must be carefully developed around the priorities of the various stakeholders. The benefits of a county robotics program include greater visibility, greater importance given to the program by politicians, and the chance to supplement and enhance formal STEM education.

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