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Robotics Competitions: An Overview of FIRST® Events and VEX® Competitions

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Abstract: *Robotics competitions generate excitement and raise the profile of a robotics program. This article provides an overview of robotics competitions, concentrating on those sponsored by FIRST (For Inspiration and Recognition of Science and Technology) and RECF (Robotics Education and Competition Foundation). FIRST® LEGO® League and VEX® robotics competitions are the most well-known robotics competitions that these organizations sponsor. Equipment, costs, timelines, and funding are presented.*

4-H and Robotics

4-H National Headquarters promotes robotics nation-wide as a way to engage youth in Science, which is one of their current mission mandates. A new 4-H robotics curriculum has been recently released, grants are offered for youth to participate in FIRST® (For Inspiration and Recognition of Science and Technology) competitions, and in 2009 a robotics challenge was added to the National 4-H Engineering Challenge <<http://www.four-h.purdue.edu/naengr/naengr.html>>.

Choosing to Compete

Costs and competition-specific equipment can dictate whether or not youth participate in a competition. For competitions sponsored by FIRST®, participation costs are considerable, and some equipment changes yearly. Details of costs presented later in this article are correct at time of preparation.

Skills enhanced through participating in competitions include teamwork and learning to problem solve under stressful conditions. Some youth thrive in a competitive environment, while others prefer the more relaxed atmosphere of informal robotics classes. Studies on the origin of science self-efficacy in middle school youth found that mastery experience had the most significant correlation with the four sources of self-efficacy identified by Bandura (1994) and was a strong predictor of achievement (Britner & Pajares, 2006; Usher & Pajares, 2005; Zimmerman, Bandura, & Martinez-Pons, 1992). Successes such as tournament achievements develop belief in one's own efficacy, while failures corrode it.

Robotics competitions are exciting and newsworthy, and raise the profile of robotics programs. University scholarships are available to students who compete. Competitions validate student learning, and competition scores can serve as "external evaluation" of a robotics program's strength.

Choosing a Robotics Platform for Competitions

Habib (2012) provides an overview of LEGO® Mindstorms® Education NXT and VEX® Robotics Design System, which are the two most widely used robotics platforms (or robot kits). LEGO® provides different robotics sets for elementary through middle school youth, while the VEX® Robotics Design System caters to youth in elementary school through college. (The starter bundle has additions that make it increasingly sophisticated.) These robotics platforms are used by two separate organizations that hold robotics competitions nationally and internationally. (1) FIRST® organizes four robotics events for youth from elementary school through high school and uses LEGO® Education platforms for three of the four. (2) Innovation First, Inc., which produces the VEX® Robotics Design System, commissioned RECF (Robotics Education and Competition Foundation) to run VEX® robotics competitions.

FIRST® Competitions

FIRST® organizes the following four events:

1. Junior FIRST® LEGO® League (Jr. FLL), a non-competition-based robotics event for youth 6-9 years old
2. FIRST® LEGO® League (FLL), a competition-based robotics event for youth 9-14 years old
3. FIRST® Tech Challenge (FTC), a competition-based robotics event for youth 14-18 years old
4. FIRST® Robotics Competition (FRC), a competition-based robotics event for youth 14-18 years old

At Jr. FLL, youth celebrate and share what they learned during the robotics season. Youth in Jr. FLL choose either of the following platforms:

- WeDo robotics set
- Jr. FLL base kit (List of components: <<http://www.usfirst.org/roboticsprograms/jfill/content.aspx?id=13142>>)

The WeDo set allows users to build 12 models around four themes (Amazing Mechanisms, Wild Animals, Play Soccer, and Adventure Stories). Figure 1 presents the models that can be built using the instructions in WeDo kits. The kit has a motor, a tilt sensor, and a motion sensor. Models are programmable using an icon-based drag and drop program (a simplified version of NXT-G software used to program the LEGO® Mindstorms® Education NXT). Models must be connected to the computer to execute the program, however, and both the models and the program have limited versatility.

Figure 1.
The Models Built Using Instructions in WeDo Kits



The FLL competition is based on the yearly Challenge, which addresses current world issues. Under the guidance of a team coach and mentors, youth spend 8 weeks researching and solving a problem based on the Challenge theme. They present their research and solutions at regional tournaments. They also build an autonomous robot and program it to solve missions that are part of the robot game component of the Challenge. For example, one mission of the 2008 Climate Connection Challenge required the robot to construct a levee with blocks. Figure 2 shows a FLL team during technical judging. FLL teams that qualify in regional tournaments move on to compete at the State level. There are also National and International level tournaments. The FLL timeline follows in Table 1.

Figure 2.
A FLL Team during Technical Judging



Table 1.
The FLL Timeline¹

Month	Activity
May - September	Team registration on FLL website
August – Mid-September	FLL kits begin shipping
Early-September	Challenge announced
September – November	FLL season
Mid-October	Regional tournament registration
November - December	Regional and State tournaments

¹Adapted from the USFIRST website <http://www.usfirst.org/>

FTC was introduced as a less intensive and less expensive alternative to FRC for high school students. While the robot's microcontroller is the NXT intelligent brick (i.e., the same as in the LEGO® Mindstorms® Education NXT set), the robot elements are *TETRIX™ parts*. Thus, an FLL team can supplement their LEGO® Education kit with *TETRIX™* elements to participate in FTC.

FRC is the most expensive and intensive robotics event. One participant described its intensity as the "hardest fun you will ever have." FRC teams fabricate their own robots; therefore, access to a machine shop is necessary. VEX®, FTC, and FRC competitions are game-based rather than mission or project-based; robots are built and programmed to perform a task against competitors.

Only FRC requires teams to buy an expensive kit of parts every year. All the others, including VEX®, re-use the same robot kit and only issue a new playing field every year.

Table 2 summarizes all FIRST events.

Table 2.
Summary of Robotics Events Sponsored by FIRST®, With Approximate Costs

		LEGO® Education/FIRST®				
		Kit Name	Kit Cost in US \$		Event name and team size	Minimum Competition Cost (approx.)
			LEGO® Education online Store	Through registration with FIRST®		
	WeDo robotics construction set+ WeDo activity	\$184.9 ¹	\$169.90 ²	Jr. FLL,	Registration with FIRST®=\$25 Tri-fold poster	

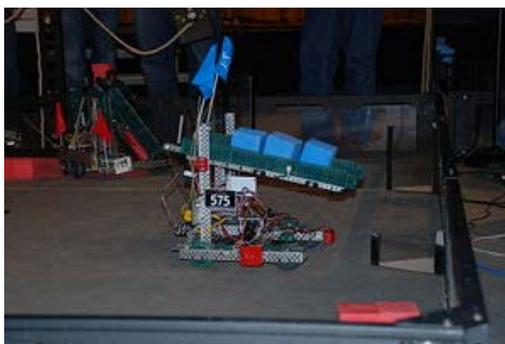
Age	6-9 years	pack+soft ware			teams of 2-6 youth	board = \$10
		Jr. FLL base kit ³	Not available from LEGO Education store in a single pack	\$139.95		Event fees=\$25-50
	9-14 years	LEGO® Mindstorms Education NXT base set+ resource kit+software	\$439.85 ¹	\$395.00 ²	FLL, teams of 2-10 youth	Registration with FIRST®=\$200 Field set up kit=\$65 Regional tournament registration ⁴ =\$80
		Official FTC kit ⁴	Kit = \$897.95 RobotC software = \$79.95 ¹	\$749.00 ⁵	FTC, teams of 2-10 youth	Program registration=\$275 Event registration fee=\$0-\$300 Travel costs=\$0-\$500
	14-18 years	Official FRC kit ⁵	Not available from LEGO® Education store	\$6500 for rookie teams, \$5000 for veteran teams ⁶	FRC, 15-25+ youth (there is no maximum team size)	Team registration = \$5000-\$6500 Arena/Practice Field=\$500-\$1000 ⁷ Travel costs=\$500 Additional parts & shop materials \$1500 Robot cart & shipping crate = \$300
	18+ (College)	None available	N/A		None available	

1 Software does not come with site licence
 2 Price includes team site licence for software.
 3 Includes LEGO® Technology set, motors etc. Complete list of components at <http://www.usfirst.org/roboticsprograms/jfll/content.aspx?id=13142>
 4 LEGO® Mindstorm Education NXT base set with TETRIX®
 5 Includes LabView software not avialble from LEGO® Education store
 6 Kit of parts not available separate from team registraion
 7 Varies. Teams have to build their own duplicate of the arena

VEX® Competitions

VEX® robotics competitions are open to both middle school youth and high school youth. Its platform is ideal for high school youth who wish to continue robotics upon entering a university. Participants may hold competitions either in the classroom or at multi-team events. Age divisions vary by region; thus, local entry rules account for different programming needs. VEX® competitions are *vastly* cheaper to participate in (for exact cost comparisons see Tables 2 and 3), and they have the flexibility to be held at any time of the year. Youth can participate in multiple regional competitions, building on experience to improve their skills. Figure 3 shows a VEX® robot manipulating game elements.

Figure 3.
 A VEX® Robot Manipulating Game Elements During a Competition



The VEX® robotics platform is the chosen platform at the National 4-H Robotics Challenge. It is more sophisticated than LEGO® Mindstorms Education NXT, thus necessitating engineers and/or physicists to serve as mentors. Table 3 presents a summary of VEX® robotics design system kits and associated competitions. PIC microcontroller prices are quoted as opposed to the more powerful (and higher priced) Cortex microcontroller.

Table 3.
Summary of Robotics Events Sponsored by RECF (Robotics Education and Competition Foundation) - VEX® Robotics Competitions, with Approximate Costs

		VEX® Robotics Design System			
		Kit Name	Kit Cost in US \$ from VEX online Store	Event name and team size	Minimum Competition Cost (approx.)
Age	6-10 years	As below	As below	None available	Not applicable
	11-18 years	VEX protobot starter kit	with radio control = \$299.99	VEX Robotics Competition (Middle/High Schools)	Registration with RECF=\$75 + \$25 for each additional team from the same organization
			with autonomous control = \$319.99 (without programming hardware & software) ¹		
			with dual control = \$419.99 (without programming hardware & software) ¹		
		VEX booster kit (contains mechanical elements) ²	\$179.99		Crystal Upgrade kit=\$49.99
		VEX Sensor bundle ²	\$99.99		VEX programming hardware kit = \$49.99
18+ (College)	As above	As above	VEX Robotics Competition (College)	Registration with Innovation First=\$75 + \$25 for each additional team from the same college	
<p>¹ Choice of programming software available, for different prices. Programming hardware is \$49.99. Software options begin at \$74 (Easy C 2.0)</p> <p>²To be used in addition to one of the protobot starter kits above</p> <p>³ Varies from year to year, depending on game elements</p>					

Funding

Given the costs involved, corporate sponsorship may be necessary. Teams spend some of their off-season participating in fundraising drives. Innovation First® offers teams 50% of the profit when they sell HEXBUG Micro Robotic creatures. FIRST® offers teams participation in the FIRST Camp program that promotes FIRST® events

locally while raising funds to support existing teams and start new ones. NASA Robotics Alliance Project funds robotics teams entering all the major robotics competitions <<http://robotics.nasa.gov/>>.

Conclusion

Platform choice is an important decision because of the costs involved. The VEX® platform is more economical because the same kit can be used by youth from elementary school to college. The facts that regional competitions can be modified to meet local needs and can be held at any time of the year are also attractive. In fact, VEX® competitions are becoming increasingly more widespread. On the other hand, FIRST® competitions are well established with a long history (FRC started in 1992, with the other competitions added on later), are highly structured, and are high profile. The costs for competing in FIRST® competitions are high and necessitate aggressive fundraising and/or corporate sponsorship. A survey of local resources will need to inform the decision of platform choice.

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