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Idaho Robotics Opportunities for K-12 Students: A K-12 Pipeline of Activities Promoting Careers in Science, Engineering, and Technology

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Abstract: 4-H youth development programs nationwide are responding to the 4-H National Science, Engineering, and Technology (4-H SET) Initiative to involve more youth in Science, Engineering, and Technology activities. The goal is to increase the numbers of youth choosing to pursue SET careers. This article describes a program that is having great success engaging many more youth through robotics programs that meet the National 4-H SET program criteria. In addition, the article argues that in order to keep youth focused on SET careers, we need to build programs that provide contiguous, K-12 support to nurture the development and encouragement in SET.

Introduction: The National 4-H SET Initiative

In 2007, National 4-H Council established the 4-H Science, Engineering, and Technology (SET) initiative with the goal of engaging an additional 1 million youth in high-quality 4-H SET activities by the year 2013 (National 4-H Council, 2007a). To reach this goal, each state is tasked with developing programs and strategies to increase the numbers of youth in 4-H SET.

Recent research has emphasized that robotics activities are effective in promoting systems understanding (Sullivan, 2008), problem-solving among middle school youth (Norton, McRobbie, & Ginns, 2007), and in motivating youth toward SET fields (Brand, Collver, & Kasarda, 2008). Barker & Ansorge (2007) provide an excellent review of the literature reporting the effectiveness of robotics in SET education. Moreover, they and others report the effectiveness of robotics in promoting SET education through informal education (Barker & Ansorge, 2006; Barker, Nugent, & Grandgenett, 2008).

The lack of adequate numbers of youth entering SET fields has been described as the "Pipeline" problem, and there has been a great emphasis recently to get more youth into the science and engineering pipeline (Russell & Siley, 2005). The ultimate goal of the 4-H SET Initiative is to increase the numbers of scientists, engineers, and technologists in the United States. The use of robotics appears to be an excellent mechanism to engage and motivate many youth in educationally beneficial SET activities and to channel them into and through the SET pipeline.

Program Description: A SET Program in Idaho

In Idaho, we have taken an engineering approach toward the "pipeline" problem. We started by specifying the ways to increase the effective output from a pipeline, which include the following.

1. **Make sure the pipe reaches its destination** by engaging youth in inter-related science and engineering programs continuously over the long-term through grades K-12 and into higher education.

2. **Build a bigger pipe to accommodate greater flow** by reaching out to engage more youth and by helping children realize that they too can be scientists and/or engineers. We need to support the dreams and aspirations of children who early on see themselves as scientists/engineers, and we need to reach out to and engage others who do not envision themselves in these roles.

3. **Fix the pipe along the way to minimize turbulent flow and to reduce loss due to leaks** by requiring more focus and dedication to study amid the distractions of youth. SET projects must help children develop motivation from within, which will be the reason they choose to work toward a SET career.

The Idaho Robotics Opportunities for K-12 Students (Idaho ROKS™) exemplifies our approach. Idaho ROKS™ is a collaboration among the University of Idaho Colleges of Engineering, Agriculture & Life Sciences, 4-H, and the Idaho Space Grant Consortium. Idaho ROKS™ consists of seven interconnected K-12 programs with a bridge to higher education. Three of the programs were developed by Idaho ROKS™ and are specific to Idaho. The other four programs are developed by *FIRST*. *FIRST* stands for: For Inspiration and Recognition in Science and Technology. *FIRST* is an international non-profit education foundation that develops and supports four major robotics programs for K-12 youth <<http://www.usfirst.org>>. Idaho ROKS™ is the Affiliate Partner with *FIRST* and responsible for managing the *FIRST* LEGO League (FLL) and *FIRST* Tech Challenge (FTC) programs in Idaho. A brief description of the seven programs is provided in Table 1.

Table 1.
The Seven Programs of the Idaho ROKS™ System

Program	Grade Levels	Program Objectives
Junior <i>FIRST</i> LEGO League	K-3	Introduce youth to authentic science and engineering activities; Engage youth in research to learn about real-world topics; Design and build a model of idea the youth develop as a team; Develop Life Skills (especially communication, teamwork, problem-solving); Develop basic science and engineering skills
4-H Robotics	2-8	Outreach through 4-H network and after-school programs to reach new audiences;

		Develop Engineering Critical Analysis skills of robot designs and function
Idaho TECH*	5-6	Design and build a LEGO Mars-Rover Research and work on real-world issues NASA scientists encounter; Develop basic mechanical engineering principles of design
FIRST LEGO League	5-8	Research the real-world issue presented in the annual challenge; Design, build, and program an autonomous robot; Develop mechanical and software engineering principles
FIRST Tech(nology) Challenge	9-12	Design, implement, and program a robot to compete in a robotic game. Develop engineering skills and knowledge
FIRST Robotics Competition	9-12	Design, build, and program a remote controlled robot to solve a common real-world problem; Develop engineering skills and knowledge
Vandal** Robotics Challenge	9-12	Bridge to SET in higher education; Build and foster educational relationships between high school youth and university science and engineering faculty and students.
* Idaho Teaching Engineering to Children (TECH). ** The University of Idaho mascot is the Vandal.		

The term "pipeline" is used within Idaho ROKS™ to connote the inter-connected and progressive nature of programs that encourage youth to engage in SET activities and develop an eye toward higher education, especially in SET fields. Our "pipeline" provides continuity of programs incorporating lessons from the former programs, adding new and expanded information, and moving expectations incrementally higher.

The Idaho ROKS™ "pipeline" is purposefully engineered to direct youth at an early age toward higher education. For young children in early elementary grades, the pipeline provides a path on which youth can see themselves traveling and introduces them to critical life skills and basic engineering activities. In the middle school years, the program introduces youth to more sophisticated robotics design, including mechanical engineering concepts, basic science methods, the use of electronics, and computer programming. And, at the latter end of the pipeline, the programs create a bridge between high school and college, introducing youth to college courses, facilities, and people. Throughout the series of programs, Idaho ROKS™ helps develop and nurture the perception among youth that they can go to college and that they may like science and engineering.

In Idaho ROKS™, programs progress sequentially based on reasonable expectations for youth. At an early age, youth begin working on fundamental skills that are essential for developing more sophisticated and demanding skills and knowledge. Moreover, they learn to appreciate the importance of those skills. Robotics provides the motivation; the programs provide the structure necessary for channeling that motivation toward quality and effective youth development. To enhance the chance of youth continuing in the sciences and engineering, a sustained, long-term set of programs is necessary.

The Idaho ROKS™ program meets the 4-H SET Outcomes and Criteria recommended by the National 4-H Council (National 4-H Council, 2007b), and the robotics programs are growing. Table 2 below shows the increasing participation levels in each of the programs.

Table 2.
Current and Expected Numbers of Youth Participating in Idaho ROKS™ Programming

Program	2006-07 Participants	2007-08 Participants	2008-09 Participation Goals
Idaho Jr.FLL	0	0	180
Idaho TECH	280	300	330
Idaho 4-H Robotics	73	324	600
Idaho FLL	80	444	800
Vandal Robotics	0	300	300
Idaho FTC	0	0	120
Idaho FRC	100	153	250
Total	533	1,521	2,580

Future plans for Idaho ROKS™ include developing dual credit courses for high school youth to help them jump-start their college careers and developing college scholarships for youth who participate in robotics programs.

Conclusion

We believe, with Idaho ROKS™ that we have developed a correct "formula" for increasing the numbers of youth pursuing careers in science, engineering, and technology. Robotics is appealing to many youth. It sparks their imaginations. It also provides a medium in which children can engage in authentic engineering tasks that are integrated with real-world significance. In addition, a key feature of the pipeline of robotics activities is that the activities are contiguous over the full K-12 grades. The programs build on each other. And, by involving college faculty and students in the programs and by hosting events on the college campuses, the pipeline leads youth directly into higher education. The Idaho ROKS™ program intends to help develop and foster children's interest and pursuit toward SET careers.

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