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Creating Engineers For the Future

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Abstract

As the demand for engineers continues to grow it is necessary to educate young students in technology and science related careers. This challenges educators to make engineering exciting and interesting. The following briefly details the implementation of a youth-development program that is committed to preparing the engineers of tomorrow. The non-profit organization For Inspiration and Recognition of Science and Technology (FIRST™) has created FIRST™ LEGO® League to encourage and equip students ages nine to fourteen to pursue careers in engineering and technology fields. Through this program, FIRST™ hopes to develop the qualities of teamwork, cooperation, creativity, problem solving, sportsmanship, confidence, communication, and leadership in middle-school youth across the nation. The only roadblock in the proliferation of the program is the apprehension of schools and civic organizations to commit to the activity considering their involvements in a variety of other activities.

Since the start of this program at Ames Middle School, each of the seventeen participants has been successful in building the skills they need to become the engineers of the future. Participating on the FIRST™ LEGO League teams has helped these students develop problem solving skills, critical thinking skills, interpersonal skills, personal responsibility, time management, and creativity. Individuals have also gained a better understanding of engineering, as well as achieving new confidence levels, interests, and involvement in science and math. Many of these skills will be invaluable to the students regardless of what career path they take; however, the activities and experiences are enticing their appetites for engineering and technology, creating engineers for the future.

Introduction

As youth grow up in a technologically advanced society *something* happens in their development to steer them either toward or away from science and technology. Their exposure to and confidence with engineering and technology is that *something* that funnels students either into or out of this career path. The limited exposure to engineering and technology related content early on in education is limiting the number of students seeking out higher education in engineering fields.

According to the American Society of Mechanical Engineers, the United States is facing a predicament of increasing concern:

> There has never been more of a demand for engineers. With such problems as a growing world population and limited resources as well as an increasing need for energy and the threats of pollution, there is no shortage of problems for engineers to solve.
> But where will these engineers come from? As the number of challenges the world faces increases at a tremendous rate, the number of people educated to solve these problems must also increase at a tremendous rate. Unfortunately, we know that is not happening. Simply put, the engineering profession is not supplying the number of professionals that the world is calling for…If we want to solve the looming problems facing us, our nation must shift its reward structure from its entertainment focus to a technology focus. Students at the earliest age must see engineering, science and technology as opportunities that are fun, rewarding and achievable. They must be inspired to learn.[1]

In order to inspire students to become interested in technology related fields, For Inspiration and Recognition of Science and Technology (FIRST™) created FIRST™ LEGO® League (FLL). FLL allows students ages nine to fourteen to become system engineers, computer engineers, mechanical engineers, manufacturing engineers, industrial engineers, electrical engineers, and automotive engineers.

This describes the implementation of the FLL program--a youth-development program that is committed to preparing the engineers of tomorrow. The non-profit organization FIRST™ has created FIRST™ LEGO® League to encourage and equip students to pursue careers in engineering and technology fields. As Dean Kamen, the founder of FIRST™, encourages, "We need to show kids that it's more fun to design and create a video game than to play one."[2]

Overview of FIRST™ LEGO® League

FIRST™ is committed to designing "innovative programs to build self-confidence, knowledge and life skills while motivating young people to pursue opportunities in science, technology and engineering."[3] FIRST™ encourages collaboration between schools and industry to build partnerships between existing and future engineers.[4]

FLL was created by FIRST™ as a nation-wide program to encourage middle school aged students to focus on team building, problem solving, creativity, and analytical thinking.[5] Teams of approximately ten students have about eight weeks to research, plan, create, test, and program an autonomous robot that is able to conquer a series of missions. These missions are based on real world events or problems and are known to the student participants as *The Challenge*.

Through creating these challenges for the student participants, the FLL program is able to fulfill its mission:

> The mission of the FLL program is to provide an inspirational learning experience for children celebrating science and technology, by combining educational context with hands-on challenges that empower children to discover their own theories and solutions. FLL believes that children's natural curiosity, imagination,

and creativity are critical qualities to envisioning possibilities and solutions. By encouraging children to explore and develop these qualities in a progressive and positive activity - such as the FLL program - children learn, at their individual level and pace, and achieve a positive perception of science and technology for their future.[5]

Objectives

The primary goal during the FLL season was for the students to have fun while learning about engineering. Developing a FLL team helped those who participated develop problem solving skills, critical thinking skills, interpersonal skills, personal responsibility, time management, and participants also gained a better understanding of engineering. Participants also gained new confidence, interests, and involvement in science and math. One of the other most important goals for the team was not to win but to succeed as a team.

One considerable goal of this program was to set an example to other middle schools across the state of Iowa. Prior to the 2001 FLL season Iowa was not involved in FIRST™ LEGO® League; last year forty-four out of the fifty states were involved in the FIRST™ LEGO® League.[3]

The Process

Prior to Developing the Teams

Before creating FLL teams, Iowa State University College of Engineering (ISU) developed a partnership with the Ames Middle School (AMS). Creating this partnership allowed ISU to help AMS develop teams using ISU resources such as funds, student mentors, and facilities. ISU agreed to provide the necessary equipment to participate in FLL as well as the in-service teacher's coaching salary (see Table 1).

Table 1. Program Costs using 2001 amounts.

Items	Cost	
Coach's Salary	$800-1500	Yearly
FLL Registration	$150	Yearly
Challenge Kit	$100	Yearly
Tournament Costs	$30-100	Yearly
LEGO Robotics Kit	$280	Startup
Challenge Practice Table	$75	Startup
First Year Total	*$1435-2205*	
Additional Year Total	*$1080-1850*	

Once a partnership was developed, ISU students were asked to mentor the two AMS teams. Two mechanical engineering students, a family and consumer sciences student, and a computer engineering student volunteered to mentor the AMS teams. By providing the teams with

mentors the middle school students were introduced to the engineering principles necessary to create a robot. The students needed to learn concepts such as gear ratios, friction, slippage, pressure, strength of materials, multitasking in a computer program, and sensor control. The mentors could provide real world examples in order to help the students understand why it was necessary to learn the information for the FLL challenge.

Preparing the Teams

Throughout the FLL season the students learned a lot of basic principles prior to designing their robots. During the students' regular practices they began to learn the mechanical and computer engineering skills necessary to build a successful robot. Once the students felt they had mastered the necessary concepts they set out to work on creating a robot for the Arctic Impact Challenge.

The Arctic Impact Challenge required that the students build an autonomous robot completing as many of the nine mini challenges inside the challenge arena in two minutes (Figure 1). The students needed to decide how their robots would solve the challenge. The students were allowed to complete the mini challenges in any order. They mini challenges were in numerical order as follows: save the scientists from the polar bears without harming the polar bears, deliver the new instrument to the target in the arena, transport ten fuel barrels to the storage hut, trigger each field instrument, retrieve the ice core for scientific research, save the medical supplies from falling into the ocean, complete the construction of the weather tower, release the weather balloon, and move the storage hut of the crack in the ice.

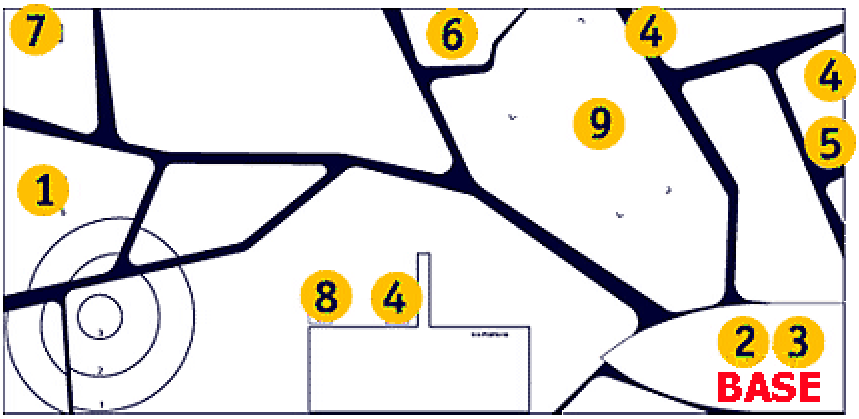

Figure 1. Arctic Impact Challenge Arena

In order to decide how the students would build the robots, students worked as a team and discussed what advantage each idea would bring to the robot. As the two teams discussed how their robot would be built, participants took into consideration many of the basic principles that they had learned. During the actual building process the students brainstormed, designed, and tested many prototypes before achieving a successful design. They would often seek help from the engineering mentors when they came upon a problem they had trouble solving. One specific problem that the students had was gearing up a train of gears, but not loosing too much torque in

the process. The gears were needed to lift an arm on the robot; however, the arm was too heavy. The engineers helped the students understand why this was happening, so that the students could create a more successful design.

In addition to designing a robot and strategy to accomplish the Arctic Impact Challenge, each team also created a hypothesis presentation that complemented the theme of the challenge. The teams researched global warming, pollution, and the greenhouse effect to ascertain the cause. Each team sought out evidence to support one of two theories of cause—human intervention or nature's natural cycle—and presented this evidence before a panel of evaluators. The teams also focused on how their hypothesis was related to the Arctic Impact Challenge and real world events.

Not all of the activities embedded in the FLL program related directly to succeeding in the challenges. To ensure that the students were learning about technological principles outside of robotics, the mentors created Fun Research in Engineering Education (FREE) Fridays. On FREE Fridays the students would visit the ISU campus and participate in engineering outreach activities. The students participated in the following engineering activities: Virtual Reality Lab, spaghetti and gumdrop towers, Toying With Technology℠ (robotic egg drop), DNA extracting, Rebops (creating an animal using parent DNA), LEGO® Hotel, and Cybot and Oscar (real robots built by the Computer and Mechanical Engineering Senior Design students). These experiences allowed the students to understand and simulate the work of electrical engineers, computer engineers, mechanical engineers, civil engineers, construction engineers, and biomedical engineers.

Challenges in Program Development

The three most difficult aspects of developing a FLL team were recruiting volunteers, finding a dedicated teacher, and soliciting corporate sponsors. Volunteers and corporate sponsors were difficult to find due to time commitments, prior obligations, and the lack of program notoriety. Recruiting a qualified teacher was a challenge because teachers are often already involved in numerous extracurricular activities. Overcoming these obstacles took confidence, persistence, and a strong belief in the FLL program.

Discussion

Since the start of this program at Ames Middle School, each of the seventeen participants has been successful in building the skills they need to become the engineers of the future. Participating on the FIRST™ LEGO® League teams has helped these students develop problem solving skills, critical thinking skills, interpersonal skills, personal responsibility, time management, and creativity. They have also gained a better understanding of engineering, as well as new confidence, interests, and involvement in science and math. Simply put, the student participants learn what engineers do. And according to the American Society for Engineering Education, Engineers "[apply] scientific and mathematical principles, experience, judgment, and common sense to make things that benefit people."[6]

Many of these skills will be invaluable to these students regardless of what career path they take, but the activities and experiences are whetting their appetites for engineering and technology, creating engineers for the future. A survey of past participants involved with FIRST™ revealed that "96% of the student respondents have a better idea of what engineering is and how it is used, 87% think math and science can be exciting, and 91% saw how skills learned in class can be applied to a real-world setting."[7] This is the very purpose for infusing K-12 curriculum with engineering and technology principles. Not only are the students involved with the program more likely to pursue engineering studies, but also "84% of school personnel reported they would incorporate new activities into their curriculum following their participation in FIRST."[7]

FLL makes the study and profession of engineering a reality for adolescents. In many ways the participants were able to see what engineering is like in the real world. Dean Kamen, the founder of FIRST™, applauds FLL for imitating the engineering industry. He states that "In every business I have ever seen, you start out with a problem, not enough time, not enough resources, you don't know what the competition is doing and you have to invent, design, develop, prototype, rebuild and deliver a working solution. The FLL process is, in every way, a microcosm of a real business."[8]

Conclusion

The FLL program promotes engineering technology because it instills in youth both abilities and appreciations in youth that will lead toward careers in engineering. Studies show that the crucial period for career and interest development is during ages nine through fourteen—during the transition from concrete to abstract thinking—because "[the students] are developing lasting attitudes about learning, work, and other adult values."[9] Exploratory activities, theme-centered learning, and cooperative learning are three of the effective youth development strategies[9] that FLL incorporates in the program. These strategies enable FIRST™ LEGO® League to create engineers for the future.

Recommendations

To ensure the integrity and consistency of the FLL program it is recommended that it is promoted and governed by a partnership between team schools and a university student organization such as American Society for Engineering Education, Society for Women in Engineering, or National Society of Professional Engineers. These organizations allow for engineering students of all disciplines to collaborate in order to mentor the teams, promote engineering, and manage the competitions. Because of this partnership, team members gain insights into engineering while the university students gain interpersonal skills, more practical views of engineering principles, and greater appreciation for the youth's potential. Most importantly, it is the personal relationships that develop between the mentors and the team members that impact both the university students and the future engineers they are creating.

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Biographical Information

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is an undergraduate student in Computer Engineering at Iowa State University. She has been working with Toying with Technology℠ since September of 1999. She recently mentored two FIRST™ LEGO® League teams at Ames Middle School. She also helped to bring the Iowa FIRST™ LEGO® League teams together for a competition at Iowa State University.

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is an honors graduate of Family and Consumer Science Studies at Iowa State University. She began working with the Toying With Technology℠ program in 1996 and recently undertook a mentoring role for two FIRST™ LEGO® League teams at Ames Middle School. She is continuing her education toward a medical degree at the University of Iowa.