ISEK: Iowa State Engineering Kids
Enticing Future Generations of Engineers

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Introduction

Iowa State University College of Engineering is working to provide engineering opportunities for students in kindergarten through eighth grade that are fun, hands-on, and educational. These activities make up a program called Iowa State Engineering Kids, simply referred to as ISEK. ISEK is a program designed to address the ever-increasing demand for engineering and technologically literate students to enter the pipeline of higher education and ultimately, the workforce. Based on a study done by IEEE-USA, employment of engineers has risen by 12 percent, and the number of graduated engineers has declined by 17 percent over the same period[1]. Through these activities, we hope to simulate real world experiences that allow children to see beyond their own environments, to what the future holds for them, utilizing innovation and technology to find solutions for their future.

The middle grades are a critical time for students, especially for young girls and underrepresented minorities, to continue their interest and studies in science and math. In order for this group to maintain interest in these areas throughout high school and college, they must develop related skills, and retain positive feelings about them[2]. Data on science attitudes shows that girls in the middle grades had consistently less exposure to science opportunities than their male counterparts. The Department of Education relates that access to an equitable education can be an effective means for girls to escape the limitations of discrimination and reach their full potential[3]. With engineering being the most male dominated of all professions, and expectations of serious shortages of engineers projected over the next several decades, women and minorities must be recruited into engineering if we are to meet the demand for the future[4].

It is important for young people to understand the wider possibilities of education and career choices. Through these activities, it is our goal to offer additional opportunities to increase engineering exposure for these students to enhance their science, math, and engineering interests and engage them in learner-driven activities that can entice them to consider a career in engineering. One such activity is FIRST LEGO League (FLL).

First LEGO League

FLL is a LEGO robotics competition for children ages 9-14 created by a partnership between the LEGO Company and non-profit organization FIRST (For Inspiration and Recognition of Technology). FIRST has a mission of providing a means for young people to pursue opportunities in engineering and technology. There are currently over 60,000 children involved in FLL across with the world in twenty countries. FLL challenges students to problem solve,

research, invent, and imagine, all in a team setting. Teams of up to ten children plus a coach and engineer mentor work to design, build, and test a fully autonomous LEGO robot through utilization of the LEGO® MINDSTORMS™ Robotics Invention System™ technology as well as compile research information on a specified theme. The challenge theme changes annually, allowing teams to continue working together year after year while discovering new information and improving their engineering design concepts and knowledge together. The challenge is released each September to teams across the world. Teams then spend several weeks applying science and math concepts learned in the classroom, as well as engineering concepts related by their coach and mentors to solve real-world problems that engineers face everyday. The team's efforts culminate in a one-day tournament held on the Iowa State University campus where teams show off their knowledge and compete in a high energy, sports-like event. Teams are presented awards on robot design and performance, research and presentation, teamwork, team spirit, overcoming adversity, and creativity.

Teams learn not only about programming and design, but about critical life skills such as working with others, being a gracious professional, being a leader, interacting with others, and public speaking. Many of these skills fall within the ABET Criteria a-k. At a very early age, these students are preparing themselves for a future career by having these types of engineering and social experiences. These experiences qualify them to lead the next generation as outstanding engineers. In particular, it is very difficult to teach young college students the skills necessary to speak effectively (criterion g) or how to work on a team (criterion d) when they are heavily involved in their basic program of study. The participants of FLL are already experiencing and learning many of these "soft" skills prior to enrolling in higher education, making them an enhanced group of potential students.

FLL also allows both males and females to feel that they are treated with equal esteem and importance. As the teams begin to focus on the commonalities of both genders as capable team members, rather than identifying with stereotypes that divide the genders, they can reach success and high self-esteem. Students are well informed that no child will be kept from participating in programming or design activities based on something they cannot change, such as gender or skin color. This equity gives children the freedom to explore, and protects them from ridicule or exclusion[5]. Many female college students do not feel high levels of technical self-confidence, and feel that their opportunities to have mechanical experiences in childhood were lacking[4]. In fact, many women do not get the "tinkering" experiences that males do in childhood, due to socialization. FLL allows for young women to gain experience in building, designing, and manipulating motors, gears, sensors, and parts to create a robotic invention[4].

Another benefit of FLL is that it allows young students to learn what engineering is. It has been researched that by the time many students, especially females, arrive at college, they still know little about engineering. In fact, almost 90 percent of women interviewed in a study done by Judith McIlwee and J. Gregg Robinson had no clear idea of what engineers did before they entered the field[4]. They understand it exists and can provide a good income, but it is often perceived as a male profession. Women are more likely to mention other people as the reason they chose engineering, such as teachers, mentors, counselors, and friends. FLL gives these young people those contacts, such as coaches and engineer mentors, to entice them to consider engineering, as well as educate them on what engineers really do.

Summer Camps

Another program of ISEK that continues to develop is summer day camps. The summer of 2004 was the inception of the summer day camps for students grades 3-8. Twenty-seven young people took part in a two-day camp filled with hands-on science and engineering activities. Participants studied underground water flow models and contamination issues with faculty in environmental engineering, as well as running a simulated chocolate factory with faculty from industrial and manufacturing engineering. They also worked with graphing calculators and sensors to determine collision forces with toy cars, and launched balsa planes to study lift, drag, pitch, yaw, roll, and other concepts related to aerospace engineering. The students were all intrigued with programming and robotics components of the camp led by Human Computer Interaction graduate students, as well as demonstrations and hands-on experimentation with interesting inventions and engineering design such as the Segway Human Transporter. Students were involved in team-building activities, as well as getting a taste of campus life through tours of the college and eating in the residence dining services new market café facilities. Through their hands-on, experiential learning, participants began to feel more knowledgeable about what engineering actually is, and how every product and most every aspect of their lives is affected in some way by the various curriculums of engineering. It is also evidenced in college admissions that students are more likely to attend a university that is close in proximity to their family or hometown. They also prefer to attend a school in-state for tuition savings.

The camps also provide participants with confidence about their science, math, and engineering know-how when they go back to their individual classrooms. Self-esteem and confidence are not only good for the students' mental health, but it can also be a connection to academic achievement and link to their future career goals and aspirations for the future[6]. For example, girls' confidence levels in the perception of being good at a lot of things drops from 45 percent in elementary school to 29 percent in middle school, and declines to 23 percent in high school[6]. Women engineering students have a surprising lack of self-confidence in college, despite their strong high school performances. Most feel unsure feelings of their technical and hands-on abilities[4]. If activities and opportunities such as summer day camps can increase those skill levels and enhance the feelings of esteem, we can continue to encourage all students, as well as potentially impact retention rates of future female college students.

Camps also allow for an environment that is not the typical lecture-style learning that many of the students experience for the majority of their school day. As students age, the classroom environment changes from one that is full of active play and hands-on activities to one that is filled with textbooks and more time spent in lectures. It is at these middle grades where students should be encouraged not to waiver from their interest in math and science[7].

For summer 2005, we hope to offer additional camps including camps specific to advanced LEGO robotics programming, intermediate level engineering camps for 2004 participants, and camps targeted specifically at girls and underrepresented minorities. We anticipate that as participants attend the camps in subsequent years, that the real-world problem solving can allow them to draw on their intuitions and expand their respect for and interest in math, science, and engineering that become relevant for future learning[7].

Kids Club Website

The latest phase in development of ISEK is a web-based kids club for young people interested in engineering and the college. This interactive site will be free of charge to any student interested. The site will contain engineering and science-related activities and links that students can perform with their friends, teachers, or parents in the classroom or at home, a page dedicated to "Ask an Engineer", whereby they can inquire about engineering with professional engineers in industry and academia. There will also be a location where students can problem-solve to create solutions to problems and on-line brain teasers, as well as information on how to prepare for an education or career in engineering and related fields. Members of the kids club and their teachers and parents will also be invited to attend an annual event in their honor on campus filled with college tours, question and answer sessions with a member of the dean team and members of staff and faculty to learn more about college life, and see various engineering activities that college students take part in such as touring the solar car garage, robotics club lab, or experiencing virtual reality.

Children and teachers partnering with the program will also have the opportunity to have activities brought to their classrooms or clubs. We want to partner with teachers so that the activities and engineering concepts can be a part of the classroom experience, disallowing the perception that the programs are remedial learning. The National Research Council reports that bringing real-world problems to classrooms have improved students' abilities to work with one another and communicate their design ideas to real audiences. They report by use of modeling that students learn to enhance their individual problem solving and increase their individual competence. In addition, even one year after engaging in activities, the students remembered them explicitly and discussed them eagerly with pride. The National Research Council, states, "What a child can perform today with assistance, she will be able to perform tomorrow independently, thus preparing her for entry into new and more demanding collaboration"[8].

Conclusions and Future Work

Through hands-on experiences, the program is simulating and emphasizing the workplace, allowing students a fascination with technology, expertise as tinkerers, and the art of self-presentation[7]. However, while ISEK continues to expand and programming continues to be added, we are continually reminded that we need to do more to educate the next generation to become a technologically literate workforce. We also must do more to increase the number of females and under-represented minorities entering the engineering field.

At present, less than one in five degrees in engineering goes to women[9]. Underrepresented minorities (blacks, Hispanics, and American Indians) comprise approximately one-fifth of the total U.S. population, according to census data. However, they account for approximately 10 percent of all engineering bachelor's degrees awarded[10]. Science, engineering, and technology jobs go unfilled from the lack of skilled candidates.

Engineers and technology professionals will continue to be in high demand in the next decade. At present, it is estimated that enrollment at undergraduate computer science and engineering

programs has dropped by approximately 30 percent[11]. However, the Labor Department estimates that jobs for computer software engineers will increase 46 percent from 2002 to 2012[12]. In a report from NSF in 2000, Eamon M. Kelly, chairman of the science board, called for a "revitalization of math-and-science education" for all grades that would increase their interest in pursuing higher education[13]. The engineering and technology needs of the nation in regards to a future engineering workforce may become more of a crisis if enrollments continue to decline. It is frightening to think that without these opportunities, many students might not understand or experience engineering. By promoting engineering role models and activities, our programs hope to entice the next generation to consider careers related to math, science, technology, and engineering through learning and activities that celebrate the subjects through real-world applications. We also hope to entice other universities and entities to consider providing related programming to their constituents.

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