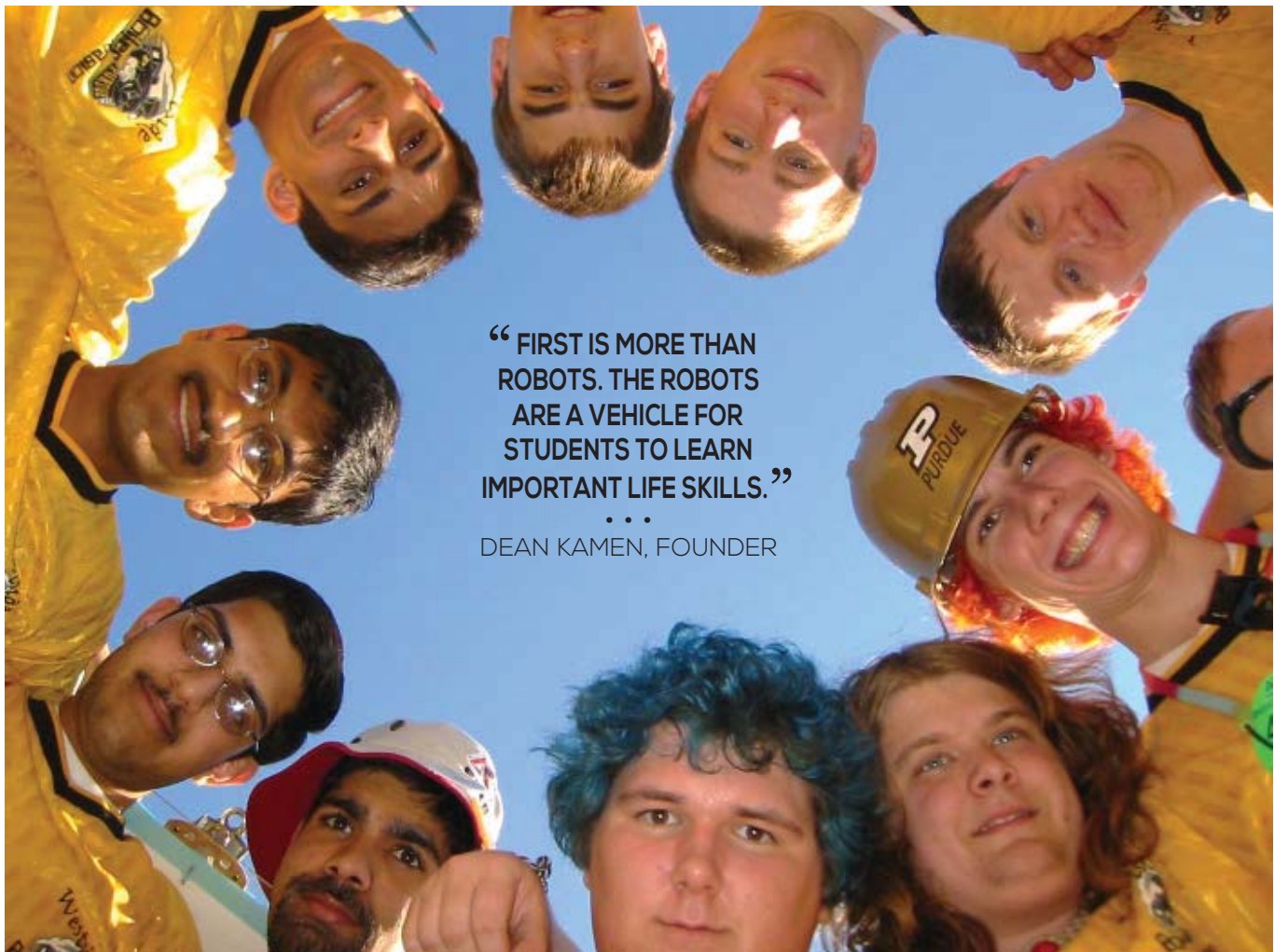


INSPIRING FUTURE GENERATIONS IN STEM FIELD THROUGH ROBOTICS COMPETITION: A COLLEGE STUDENT MENTORING APPROACH

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● **FIRST Lego League Jr. (FLL Jr)**—FLL Jr is designed to introduce STEM concepts to children aged 6 to 10 (grade K-4). Challenged with a real-world problem, FLL Jr students and their adult coaches are asked to research the program and create a Show Me poster and working LEGO model from LEGO® Education WeDo kits

of what they learned. The FLL Jr. season culminates with Expos where teams show off what they learned and created. Some teams are invited to showcase their work at the FIRST LEGO League Jr. World Festival Expos, where teams from all over the world meet, share ideas, and have fun.



FIGURE 1 Projected 2016-17 Reach and Impact of FIRST.

One unique aspect of the FIRST experience is that the reward and recognition for achievements are not necessarily gained on the field of play—excellence in design, demonstrated team spirit, Gracious Professionalism®, community outreach, and more are recognized with awards. In FIRST, winning is always secondary to the quality of the overall experience. As an example, the most prestigious award in FIRST, the Chairman’s Award, does not have any competition performance requirement. It focuses on demonstrated and sustained excellence and impact on promoting the ultimate goal of transforming the culture in ways that will inspire greater levels of respect and honor for science and technology.

IMPACT

Figure 1 shows the global reach and impact of FIRST. Few researchers have studied the impact of FIRST. Most reported studies confirm the correlation of the FIRST experience with improved attitude and engagement with STEM fields [1-5]. From a survey of FIRST alumni in 2015, over 75% of FIRST alumni are in a STEM field as a student or professional. In 2011, FIRST contracted with the Center for Youth and Communities at Brandeis University’s Heller School for Social Policy and Management to conduct a multi-year longitudinal study of FIRST’s middle and high school programs. Recent findings (2017) of that study [6] showed the following:

- FIRST has a positive impact on participants on STEM-related measures (interests, involvement, identity and future career interest)—FIRST team members are 2.3 to 3.7 times more likely to show gains on STEM-related outcomes than the control group.
- FIRST experience also has significantly greater impact on girls than their male counterparts on all of the STEM-related measures—while all of the differences between FIRST participants and control group are significant, the impacts for girls in FIRST on each measure are also significantly larger than those for boys.
- STEM-related impacts of FIRST are evident across all major population groups and

demographics—across racial, gender, income, and urban/rural communities.

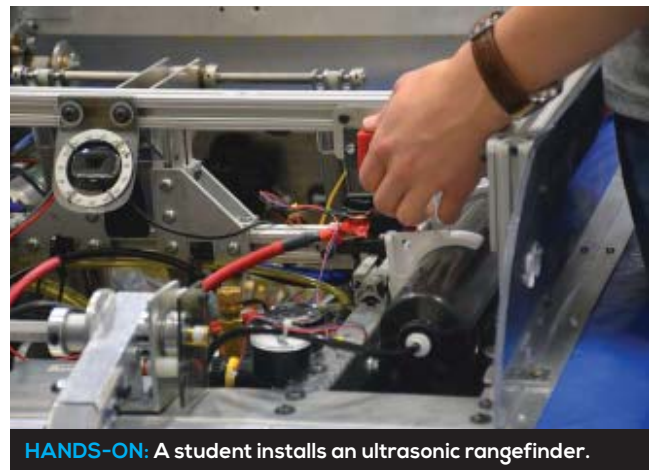
- Initial data on students in their first year of college indicates that FIRST’s positive impacts continue into postsecondary education, with FIRST alumni continuing to show impacts on STEM-related attitudes, as well as impacts on interest in engineering and technology-related majors, engineering course-taking, and STEM-related internships and summer jobs.

THE PURDUE UNIVERSITY APPROACH/EXPERIENCE

The FIRST model has also impacted some college curricula [7]. For example, the dual-level ME 58800 Mechatronics course at Purdue University has adopted the FRC-type completion as its course project. The student responses were overwhelmingly positive and the final project competition/demonstration have always been the highlight of the final week of class that attract faculty, students and their families. A similar model is now common for all Purdue Mechanical Engineering undergraduate core system, measurement and control courses.

The focus of organized FIRST programs is pre-college students. At the college level, there are no formal FIRST programs, except for FIRST-related scholarships. However, as shown in the longitudinal study, the impact of FIRST carries into postsecondary education. There are many different types of FIRST-related organizations and models at the college level. Almost all of the college-level activities are student-led and involve college student volunteers as mentors for their local FIRST teams at different levels. Different institutions provide different levels of staff and/or financial support for their FIRST-related activities.

At Purdue University, Purdue FIRST Programs (PFP) was founded in 1999 as an engineering student outreach activity under the Purdue Student Engineering Foundation and spun off to its own organization in 2002. It is a group composed of approximately 60-90 college-age



HANDS-ON: A student installs an ultrasonic rangefinder.



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students from engineering, technology, science, education and management schools, who work together to support the mission and vision of FIRST, primarily through fundraising and mentoring students in the surrounding Lafayette and West Lafayette communities and hosting different levels of in-season and off-season FIRST events.

Currently, Purdue FIRST Programs supports around 20 elementary and middle school FLL teams, 4 FTC teams and 4 FRC teams from the local high schools. PFP also hosts one of the Indiana FLL qualifying tournaments, an FTC competition and an off-season FRC event. In addition, PFP also participates in outreach events throughout the year on campus and in the community. One such event is the Indiana FIRST Forum, where a one-day workshop-type event is organized in the Fall semester to provide technical, logistics and mentoring training for FIRST teams at all levels around Indiana. PFP members are also volunteers for the FIRST events throughout Indiana as well nationally.

One unique aspect of Purdue FIRST Programs that distinguishes it from other college-level FIRST programs is the accompanied ME29700 FIRST Leadership course. It is a 2-credit hour course that is required for all PFP mem-

bers. It can be taken multiple times and many departments will consider it as elective credits. The course was developed in response to the unique focus of PFP, which is to develop mentorship and leadership skills of college students to be successful professionals and future leaders and mentors in promoting and inspiring future STEM professionals. It serves the following purposes:

- develops leadership and mentoring skills for college students in an engaging, hands-on way,
- provides structure and accountability for PFP students when interacting with FIRST students, and
- acknowledges the time and effort PFP students put into mentoring FIRST students.

During the course of the semester, a sequence of team building, mentoring, project management, fundraising and FIRST robot design topics are given by faculty, senior FIRST mentors, and professional engineers. The topics for each semester are determined collaboratively with the

ABOUT THE AUTHORS



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PFP officers and the faculty and staff advisors. PFP college student then practice what they learned in class during their season-long mentoring of FIRST students. PFP student performance is evaluated based on bidirectional performance evaluations from their supervisors in PFP and their peers as well as self-evaluations combined with class/PFP participation. For the PFP officers, the course becomes a first-hand experiential learning experience for them to practice their leadership skills. The PFP officers' performances are evaluated by the faculty and staff advisors.

Over the past 15 years, the course has gone through many different formats. All of them fit the operation of the PFP at the time. As an example, a 'curriculum' styled course organization was offered for several years between 2009-2011. Each PFP student was required to attend 5 core classes and select 5 elective topics (based on their role in PFP) for the semester. Many of the PFP alumni are in graduate schools or are experienced practicing engineers where they can provide the technical and operational leadership/resource for training new and existing PFP college students. Since its inception in the spring semester of 2002, more than 500 college students have participated in PFP and taken the course.

PERSONAL EXPERIENCE OF A FIRST AND PURDUE FIRST PROGRAMS ALUM NIKHIL BAJAJ

From my perspective, the core of the FIRST experience is inspiring passion, personal growth, and determination (in addition to interest in STEM). In high school, I joined the FIRST robotics team at our school largely because I saw the intense passion it inspired in one of my good friends. I was motivated to get involved when week after week he would show me all his drawings and ideas for a telescoping lift system with a gripping end-effector on it that the team was designing (and would not stop talking about it). FIRST exposed me to technical concepts, relating physics and math courses to the design of electromechanical systems, and learning about the relationship between hardware and the software that controls it. Just as importantly, it taught me how much I could enjoy working hard on difficult problems with a team of motivated and diverse people—high school teachers, college student and professional mentors, and high school students.

One of the things that I most appreciate about my experience is the keen interest of the mentoring team in making sure students had roles that they could grow into naturally but that would also challenge the student. After I had been on the team for a little while and seen how the design process was run, they told me that I would henceforth be an important part of the CAD team (we used Autodesk Inventor software to model the robot subassemblies before manufacturing). I had not used any CAD software before, and they challenged me to learn it

GRACIOUS PROFESSIONALISM IS PART OF THE ETHOS OF FIRST. IT'S A WAY OF DOING THINGS THAT ENCOURAGES HIGH-QUALITY WORK, EMPHASIZES THE VALUE OF OTHERS, AND RESPECTS INDIVIDUALS AND THE COMMUNITY. WITH GRACIOUS PROFESSIONALISM, FIERCE COMPETITION AND MUTUAL GAIN ARE NOT SEPARATE NOTIONS.

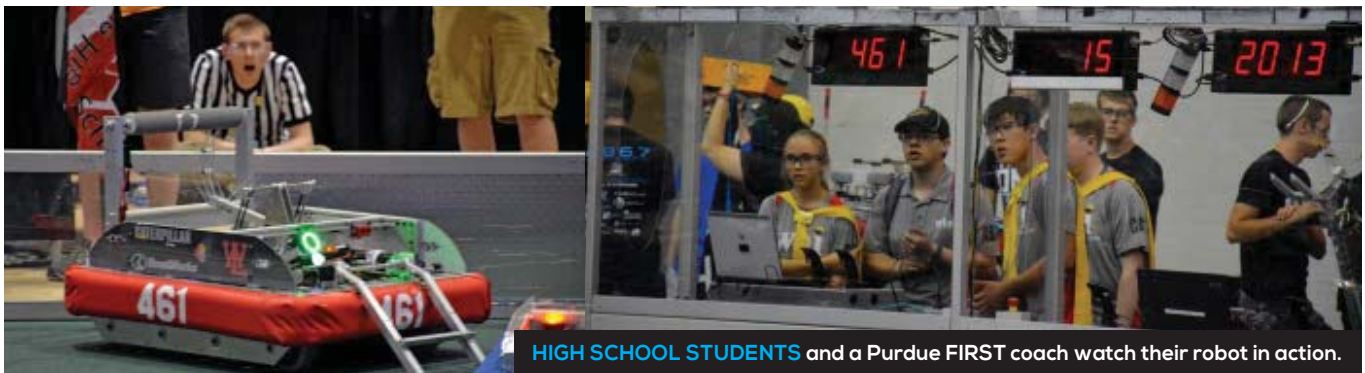


well enough to take up the role of a mechanical designer on the team moving forward.

These experiences helped me to decide to pursue mechanical engineering for my undergraduate degree, and taught me the value of mentorship and “paying it forward”, so I joined Purdue FIRST Programs to do so once I was in college. As I transitioned into a mentorship role, my eyes were opened to higher-level questions and responsibilities. What did it mean to lead a design team? How should meetings and tasks be structured to help make sure students got the most out of the program? I was fortunate to be selected to lead a robot design effort as a technical coordinator and participate in leadership-building activities. I learned a lot about time

management, prioritization, and understanding your assets and limitations (e.g., developing feasible solutions under constraints)!

Even after graduating, I have continued to stay involved, which is a testament to the FIRST programs. I have continued to “consult” and help mentor local teams with technical issues, and have been working at an organizational level, helping to coordinate events and volunteering as a judge and robot inspector. Finally, in my professional life, FIRST has helped me to meet interesting people (for example, engineers who mentor other teams, and teachers from all different types of schools) who share the passion of educating our next generation of STEM leaders. ■



HIGH SCHOOL STUDENTS and a Purdue FIRST coach watch their robot in action.