

**MORE THAN ROBOTS:
AN EVALUATION OF THE FIRST ROBOTICS COMPETITION
PARTICIPANT AND INSTITUTIONAL IMPACTS**

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Summary

In 2002, FIRST contracted with Brandeis University to conduct an evaluation of the FIRST Robotics Competition. The goal of the evaluation was to begin to address three basic questions:

- *What is the impact of the FIRST Robotics Competition on program participants in terms of academic and career trajectories?*
- *What can we learn about the implementation of FIRST in schools, both in terms of better understanding program impact and identifying “best practices”?*
- *What kinds of impact has participation in FIRST had on participating schools and partnering organizations?*

An additional goal of the study was to focus the evaluation on schools in urban communities and/or serving high proportions of low income and minority students. One of the goals of FIRST has been to expand the involvement of low income and minority youth in FRC, and the evaluation was seen as an opportunity to explore the impacts of the program on those groups in particular.

To address these questions, Brandeis conducted a two-part study:

- To assess impacts on program participants, Brandeis conducted a *retrospective* survey of FIRST participants who graduated from the program between 1999 and 2003. The study focused on students from teams from two metropolitan areas – New York City and the Detroit/Pontiac metropolitan area – to ensure the inclusion of schools serving low income, urban or minority students.¹ Approximately 300 FIRST alumni were contacted for the study. 173 (57%) responded and were included in the analysis. In order to provide a comparison with youth who had not been in FIRST, the study also included a comparison of FRC survey results with comparable data from an existing national dataset: the Beginning Postsecondary Student (BPS) Survey, a national sample of college-going students available through the U.S. Department of Education.
- To provide feedback on program implementation and institutional impacts, the evaluation also conducted site visits and interviews with team representatives in 10 participating high schools in the two communities. Those visits were designed to gather information on the implementation of the program and impacts on participating schools and program sponsors.

The purpose of this report is to convey the final results from both the retrospective survey and site visits.

¹ The initial program design called for inclusion of schools from a third area: the San Jose/San Francisco metropolitan area. Because of difficulties in accessing participant data from those teams, only one California team ended up in the study.

KEY FINDINGS

Key findings from the study include the following:

Program Participants

- The FIRST alumni in the study represent a diverse group, including substantial numbers of students who are minorities, women, and from families with a limited educational background. Fifty-five percent of the respondents were non-white (African-American, Asian, Hispanic, and multi-racial); 41% were female; and 37% came from families where neither parent had attended college (including community college).
- At the same time, participants were relatively successful students in high school. The mean high school Grade Point Average for alumni in the sample was 3.5 (B+) and 84% had a B average or above. Average SAT and ACT scores and participation in high school math and science classes among respondents were both above the national averages. What is not clear (and cannot be answered in this study) is whether this strong performance in high school was the result of involvement in FRC, or whether FRC attracted strong students, or both.

Team Members' Assessments of FIRST

Based on the survey responses, FIRST provided a positive experience that gave participants an opportunity to be involved in a challenging team activity, build relationships, learn new skills, and gain a new understanding of and interest in science and technology.

- Almost all participants felt FIRST had provided them with the kinds of challenging experiences and positive relationships considered essential for positive youth development.
 - Eighty-nine percent indicated they had “real responsibilities;” 76% felt they had a chance to play a leadership role; and 74% reported that students made the important decisions. Ninety-six percent reported having fun.
 - Ninety-five percent reported getting to know an adult very well, and 91% felt they learned a lot from the adults on the team. Ninety-one percent felt they “really belonged” on the team.
- Most participants also reported a positive impact on their attitudes towards teamwork, interest in science and technology, and how they saw themselves. Participants reported:
 - An increased understanding of the value of teamwork (95%) and the role of “gracious professionalism” (83%).
 - An increased understanding of the role of science and technology in everyday life (89%), increased interest in science and technology generally (86%), and increased interest in science and technology careers (69%).
 - Increased self-confidence (89%) and an increased motivation to do well in school (70%).
- FIRST also helped increase participants’ interest in serving others: 65% of respondents reported that, as a result of FIRST, they wanted to help younger students learn about math and science; 52% reported that they had become more active in their community.
- The large majority of participants also reported that FIRST had helped them gain communications, interpersonal, and problem-solving skills, and how to apply academic skills in real-world settings.

- More than 90% reported learning important communications skills, such as how to listen and respond to other people's suggestions (94%) and how to talk with people to get information (94%). Seventy-three percent reported learning how to make a presentation in front of people they did not know.
 - Students also learned teamwork and interpersonal skills. Ninety-two percent reported learning how to get along with other students, co-workers, teachers and supervisors; 90% learned to work within the rules of a new organization or team; 88% reported learning new ways of thinking and acting from others; and 73% learned ways to stop or decrease conflicts between people.
 - Students learned problem-solving and time management skills: how to solve unexpected problems (93%); how to manage their time under pressure (90%); how to weigh issues and options before making decisions (94%); and how to gather and analyze information (88%).
 - Students also learned to apply traditional academic skills in real-world setting: 68% reported learning how to use computers to retrieve and analyze data, and 67% reported learning about using practical math skills such as using graphs and tables or estimating costs.
- Overall satisfaction with the program was high. Ninety-five percent of the alumni rated their experience as "good" or "excellent" (27% and 68% respectively). Forty-six percent of respondents indicated that FIRST had been "much more influential" than their other activities during high school.
 - Finally, response to open-ended questions on the survey tended to reinforce these findings: participants cited the team experience as particularly influential and cited team skills, new relationships, an increased focus on science and engineering, and increased self-confidence and motivation, among others, as long-term impacts from the program.

Education, Career and Developmental Outcomes

While participant assessments provide one measure of FIRST's impact, the ultimate measures of FIRST's effectiveness are the degree to which alumni go on to have productive educational experiences, careers, and lives in their communities. The analysis of the alumni survey data indicate that FIRST alumni are making a successful transition to college, and are much more likely to pursue their interests in science and technology and become involved in their communities than is the case for college-going students generally or for the matched group of comparison students.

- The large majority of FIRST alumni graduated high school and went to college at a higher rate than high school graduates nationally.
 - Among those responding to the survey, 99% reported graduating high school and 89% went on to college. At the time of survey, 79% were still in college; most of the others were employed. (Only 5.5% of the alumni reported that they were unemployed.) These figures compare favorably to the national average where (based on U.S. Census data) 65% of recent high school graduates went to college.
 - The high levels of college-going applied across the board to both men and women and across racial and ethnic groups in FIRST. Seventy-seven percent of female FRC alumni were in college, 68% of African-American alumni, and 78% of Hispanic alumni – all above the national averages for those groups.

- Once in college, a substantial proportion of FIRST alumni took courses and participated in jobs and internships related to science, math and technology.
 - Eighty-seven percent took at least one math course and 78% took at least one science course in college. Perhaps more striking, 51% took at least one engineering course.
 - Nearly 60% of FIRST alumni had at least one science or technology-related work experience (internship, apprenticeship, part-time or summer job). Thirteen percent received grants or scholarships related to science or engineering; and 66% reported receiving any kind of grant or scholarship.
 - High proportions of women and minorities also participated in math/science/technology courses and internships. Forty percent of female alumni took engineering classes, 59% had a science/technology internship or job. Forty-six percent of African-American alumni and 53% of Hispanic alumni took engineering courses. Sixty-four percent of African-American alumni (but only 29% of Hispanic alumni) had science/technology internships or jobs.
- FIRST alumni were also substantially more likely to major in Engineering than the average college student nationally.
 - Of those FIRST alumni reporting a college major, 41% reported they had selected Engineering. Based on national data from the U.S. Department of Education’s Beginning Postsecondary Student study, FIRST alumni were nearly *seven* times as likely to become Engineering majors as the average college student nationally (41% for FRC alumni vs. a national average of 6%). FIRST alumni were also twice as likely to enroll as Computer Science majors (11% vs. 5% nationally).
 - Women and minority alumni also majored in Engineering at comparatively high rates. Thirty-three percent of the female FRC alumni, 27% of the African-American alumni, and 47% of the Hispanic alumni reported majoring in Engineering (compared to national averages of 2%, 5% and 6% respectively).
- Finally, FIRST alumni were also substantially more likely to aspire to higher levels of education than the average college student nationally. Seventy-eight percent of FIRST alumni reported expecting to attain a post-graduate degree, either a Master’s degree (47%) or another terminal degree such as a Ph.D., MD, or MBA (32%). Only 2 participants in the study (1.4%) reported that they did not expect to attain any kind of degree. Nationally, 60% of students in the Department of Education’s BPS study aspired to completing a Masters degree or higher and 4.4% did not expect to receive any degrees.

The positive education and career outcomes for FIRST participants were also evident in an analysis that compared FIRST participants with a matched comparison group of students drawn from the national Beginning Postsecondary Student survey data. The comparison students were matched with FRC alumni in terms of their demographic characteristics and their high school academic backgrounds, including similar levels of high school math and science course-taking. Major findings from that comparison group analysis reinforce the positive outcomes associated with participation in FRC. FIRST alumni were:

- Significantly more likely to attend college on a full-time basis than comparison students (88% vs. 53%);
- Nearly two times as likely to major in a science or engineering field (55% vs. 28%) and more than three times as likely to have majored specifically in engineering (41% vs. 13%);

- Roughly 10 times as likely to have had an apprenticeship, internship, or co-op job in their freshman year (27% vs. 2.7%); and
- Significantly more likely to expect to achieve a postgraduate degree (Master's degree or higher: 77% vs. 69%).
- More than twice as likely to expect to pursue a science or technology career (45% vs. 20%) and nearly four times as likely to expect to pursue a career specifically in engineering (31% vs. 8%).

In each case, these differences were statistically significant. The differences in engineering majors and careers also applied to female and non-white FIRST participants, who were significantly more likely to declare engineering majors or expect to enter an engineering career than students in the comparison group.

FIRST alumni were also significantly more likely to be involved in community service and to express a commitment to several positive goals and values than the members of the matched comparison group.

- FRC alumni were more than twice as likely to perform some type of volunteer service in the past year as were students in the matched comparison group (71% vs. 30%),
- FIRST alumni were also significantly more likely to provide some of the specific types of service that might be associated with FIRST team efforts: tutoring, coaching or mentoring with young people (such as helping another team or a younger team), fundraising, and neighborhood improvement. In each of those specific categories of service, FRC alumni reported levels of volunteer service that were four to ten times as high as those of the comparison students.

Finally, the only outcomes in which the data indicate that FRC students did significantly worse than the comparison students were in receipt of grants and scholarships in their freshman year and across all four years of college. This is a somewhat surprising result given FIRST's active efforts to raise scholarship monies for FRC participants and the fact that 66% of FRC participants reported some form of grant or scholarship in college. However, it suggests that, as of the time these FRC students were going on to college (1999-2003), those efforts had not yet resulted in a relative advantage for FRC participants in grant or scholarship funding when compared to students with similar backgrounds.

In sum, the data from the FRC survey shows FIRST as having a strong, positive impact on participating youth, including women and minorities. Based on the data from this study, FIRST appears to be meeting its goals of providing a positive and engaging developmental experience for young people and is succeeding in its efforts to increase the interest and involvement of participating youth in science and technology.

Institutional Contexts: Impacts on Schools, Teachers, and Mentors

- Based on data gathered through site visit interviews and observations, FIRST has also had a positive impact on participating schools and teachers, though that impact was limited in scope.
 - Involvement in FIRST has led to creation of new courses and/or integration of robotics instruction into existing classes in 8 of the 10 schools visited. FIRST has also helped teachers to develop or exercise new skills (primarily planning and management skills) and has had a positive effect on school spirit in a number of schools (one team leader attributed an increase in school enrollment to FRC's impact on school reputation).
 - At the same time, involvement in FRC has not led to broader changes in teaching or curriculum, or to the establishment of broader partnerships with FRC sponsors. In most cases, this was not seen as a goal for the program.

- Mentors played an important role in almost all of the teams visited, with the specific roles varying widely.
 - Most teams reported mentors provided assistance through a combination of topic-based technical workshops for team members and hands-on guidance with individual students. In some cases, mentors also helped students with homework and worked to develop positive relationships with students on the teams. None of the mentors reported receiving any training in preparation for their role, though only two felt that it was needed.
 - Some sponsors took additional steps, including working with multiple teams, establishing workshops for teams in a region, allowing multiple teams to use workshop space, and in some cases branching out to start new or work with new teams.
 - At least 3 of the 10 teams in the study also had FIRST alumni working as mentors.
 - Mentors generally reported positive impacts, including opportunities for career advancement, increased morale and job satisfaction, access to new hires, and a sense of satisfaction and connection to students on the team.
 - In general, company-wide impacts on the sponsoring companies were limited. While some firms did include their involvement in FIRST in promotional materials, most did not. Similarly, while individuals within firms recruited interns from among FIRST participants, most recruiting and hiring of FRC participants took place on an ad hoc basis rather than through consistent company policy.
- Site visit interviews also identified a number of barriers and challenges faced by the teams. Some of those challenges include the following:
 - Start-up challenges: learning how to organize and run the team.
 - Meeting space: access to space and equipment to build the robot.
 - Transportation and safety: transporting students to and from team meetings, particularly during competition season when the team might work until late at night.
 - Financial challenges: obtaining and maintaining sources of funding was overwhelmingly reported to be the primary challenge in doing FRC, with travel (to tournaments) as the biggest cost.
 - Burnout: most coaches noted burnout as a danger and suggested strategies that included dividing the workload among several coaches and “over-organizing” to ensure smooth team operations.
 - Working with sponsoring corporations: several teams reported challenges working with sponsoring companies, including limited team control over the budget and pressure on the mentors to win from the company CEO.
 - Recruiting mentors: experiences varied widely, with Michigan teams generally reporting greater corporate support (most had been approached by companies) and those in NYC reporting greater challenges in securing the interest of sponsors and mentors.
 - Recruiting teachers: another ongoing challenge, but an important step for teams to take in order to share the workload. In some cases recruitment was difficult because non-FRC teachers were

resentful of the attention received by those already involved in FRC or saw the FRC team as “owned” by a particular teacher.

- School administrative and district support: support varied, from strong administrative support and access to resources, to more reluctant support. Similarly, district support ranged from little or none (because of budget cuts) to active support (funding for travel, etc.). One key is making the benefits of participation clear.
- Parent support: most teams indicated they have only low levels of parent volunteer support.
- Several additional challenges were also identified by the mentors who were interviewed as particularly important in working with underserved schools. Those included:
 - Turnover of school administrators: high levels of turnover at urban schools required that administrator ‘buy-in’ be renewed on a regular basis.
 - Attendance of team members at meetings: the need of some team members to balance team participation with after-school responsibilities, including work and child care for siblings, made consistent involvement difficult for students on some teams. Transportation to and from meetings also presented a problem for some team members.
 - Addressing the needs of students from underserved areas: while positive about their experiences, some mentors did note the additional challenges involved in working with students, i.e., difficult personal lives or limited experiences and social skills.
 - Working with school staff: gaining consistent teacher participation, challenges in communicating with teachers, and differences in operating philosophies.

Recommendations

The principal findings of this study provide strong support for the continued growth and expansion of the FIRST robotics programs, particular into communities serving low income and minority youth. The major recommendations are to continue to document the effectiveness of the program and to build a broader base of evidence for the program’s impacts through two mechanisms: a larger-scale longitudinal study that would allow for a more comprehensive analysis of participant impacts, and the development of a participant registration process for FRC that would make it easier to keep in touch with FIRST alumni and to track the longer-term career trajectories of former participants.