FIRST® Longitudinal Study:
Findings at 60 Month Follow-Up

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May 2019

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Background

FIRST (For Inspiration and Recognition of Science and Technology) is a global nonprofit organization that operates after-school robotics programs for young people ages 6-18 in the United States and internationally. The mission of *FIRST* is to inspire young people to be science and technology leaders by engaging them in exciting mentor-based programs that build science, engineering and technology skills, inspire innovation, and foster well-rounded capacities including self-confidence, communication, and leadership. The sequence of *FIRST* programs in the United States begins with the *FIRST*® LEGO® League Jr. program serving elementary school-aged youth (ages 6-9), followed by the *FIRST*® LEGO® League program serving primarily middle school-aged youth (ages 9-14), the *FIRST*® Tech Challenge serving grades 7-12, and *FIRST*® Robotics Competition, serving high school-aged youth (grades 9-12). In 2018-19, *FIRST* estimates that over 575,000 young people will participate in its programs on more than 67,000 teams and will compete in more than 3,000 events worldwide.[2]

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. The goal of the study, building on more than a decade of short-term evaluation studies by Brandeis University and others, is to document the longer-term impacts of *FIRST*'s programs on participating youth and to do so through a design that meets the standards for rigorous, scientifically-based evaluation research. Three major questions guide the study:

- **What are the short and longer-term impacts of the *FIRST* LEGO League, *FIRST* Tech Challenge, and *FIRST* Robotics Competition programs on program participants?** Specifically, what are the program impacts on a core set of participant outcomes that include: interest in STEM and STEM-related careers, college-going and completion, pursuit of STEM-related college majors and careers, and development of 21st century personal and workplace-related skills?

**KEY FINDINGS AT
60 MONTH FOLLOW-UP**

- *FIRST* participants continue to show positive impacts on STEM-related interests and attitudes five years (60 months) after they entered the program. Impacts include increased interest in STEM, involvement in STEM-related activities, STEM identity, STEM knowledge, and interest in STEM careers. *FIRST* team members are 2 to 3 times more likely to show gains on STEM-related measures than comparison students.

- Participants from all three *FIRST* programs in the study (*FIRST* LEGO League, *FIRST* Tech Challenge, and *FIRST* Robotics Competition) and from all major population groups and community types show positive impacts.

- Impacts on STEM attitudes and interests continue to be significantly greater for girls in *FIRST* than those for boys.

- *FIRST*'s impacts persist into college. Among students in their first and second year of college, *FIRST* alumni:

    - continue to show significantly greater gains on STEM-related attitudes than comparison students.

    - report significantly higher interest in majoring in computer science, engineering, and robotics.

    - are more likely to declare a major in computer science, engineering, or a STEM-related field.

    - are 2.3 times more likely to take an engineering course in their freshman year; girls are 3.4 times more likely to take engineering courses.

    - are more likely to be engaged in STEM-related activities, including STEM internships, computer and engineering clubs, engineering competitions, STEM-related summer jobs; and engineering-related grants.

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[1] This report is based on data from the fifth round of follow-up surveys, which were administered approximately 60 months after students entered the study (baseline).
[2] http://www.firstinspires.org/about/at-a-glance

- **What is the relationship between program experience and impact?** To what extent are differences in program experience – such as time in the program, participation in multiple programs, role on the team, access to mentors, quality of the program experience – associated with differences in program outcomes? What can we learn about "what works" to guide program improvement?[3]

- **To what extent are there differences in experiences and impacts among key subpopulations of *FIRST* participants?** In particular, are there differences in impacts for young women, youth of color, low-income youth, and youth from urban or rural communities? If there are differences, what can we learn about why those differences occur and their implications for the program in the future?

To address these questions, the *FIRST* Longitudinal Study has been tracking 1,273 students (822 *FIRST* participants and 451 comparison students) over a five-year period beginning with entry of the *FIRST* participants into the program. Team members were recruited to the study from a nationally representative sample of "veteran" teams from the *FIRST* LEGO League, *FIRST* Tech Challenge, and *FIRST* Robotics Competition programs over a two-year period spanning the 2012-13 and 2013-14 school years. Comparison group students were recruited from math and science classes in the same schools and organizations where the *FIRST* teams were located. Once recruited into the study, team members and comparison students were surveyed at baseline and post-program in their first year, with annual follow-up surveys each spring thereafter. A baseline survey of parents provided additional background information on the family context for team members and comparison students, and Coach/Mentor surveys at the end of the first year of team involvement in the study provided additional contextual data on the *FIRST* teams. In several study years, team member surveys have also been supplemented by interviews and focus groups with team members and comparison group students.
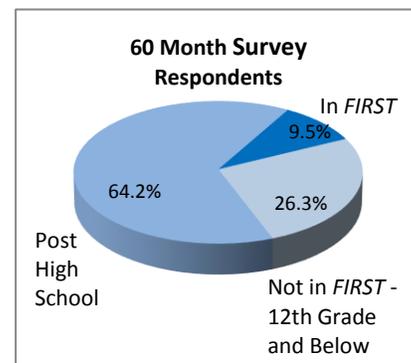
Impacts at 60 Month Follow-Up

This report presents a summary of the impact findings based on five years of data, including survey data from baseline and post-program surveys and four rounds of annual follow-up surveys. As such, it reflects the impacts of participation in *FIRST* five years after study participants entered the program. Of the 1,273 students who began the study, 999 students (79%) completed the 60 month follow-up survey, including 602 *FIRST* participants (73% of those at baseline) and 397 comparison students (88% of those at baseline). Of the *FIRST* participants responding to the follow-up survey, 57 (9.5%) were still active in the program.[4]

Data Collection through 60 Month Follow-Up

GROUP	Baseline	12 Month Follow-Up (Post-Program)	24 Month Follow-Up	36 Month Follow-Up	48 Month Follow-Up	60 Month Follow-Up
FIRST Participants	822	677	665	636	611	602
Comparison Group	451	259*	411	409	406	397
Total	1273	936	1076	1045	1017	999

The initial group of comparison students did not complete a post-program survey but have participated in all subsequent follow-up surveys.

60 Month Survey Respondents

In *FIRST* 9.5%
Post High School 64.2%
Not in *FIRST* - 12th Grade and Below 26.3%

The findings from the 60 month follow-up surveys extend the positive impact findings from the prior (2015-2018) annual impact reports: ***FIRST* participants continue to show significantly *greater* average gains on STEM-**

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[3] To be addressed in later reports.

[4] Of the 544 *FIRST* participants no longer active in the program at the 60 month follow-up, 386 had graduated high school and were no longer eligible for *FIRST*; 158 were still in middle or high school but no longer active in the program. Overall, 36.1% of those eligible to participate in *FIRST* were still active in the program after 5 years.

related attitudes and interests than comparison students and are statistically significantly *more likely* to show gains in STEM-related outcomes than students in the comparison group. These positive impacts hold true for participants who originally enrolled in any one of the three *FIRST* programs in the study (*FIRST* LEGO League, *FIRST* Tech Challenge, and *FIRST* Robotics Competition), across key demographic groups, and for those living in different types of communities (urban, rural, suburban).[5] Data on students in their first two years of college also point to positive, statistically significant long-term impacts. **In both their first and second years of college, *FIRST* alumni show stronger STEM-related attitudes and interests than comparison students; are more interested in majoring in key STEM-related fields (computer science, engineering, and robotics); are more likely to have declared majors in engineering and computer science; are more likely to take engineering and computer science courses; and are more likely to be engaged in other STEM-related activities**. In most cases, these college impacts apply to both male and female *FIRST* alumni. Major findings are as follows:

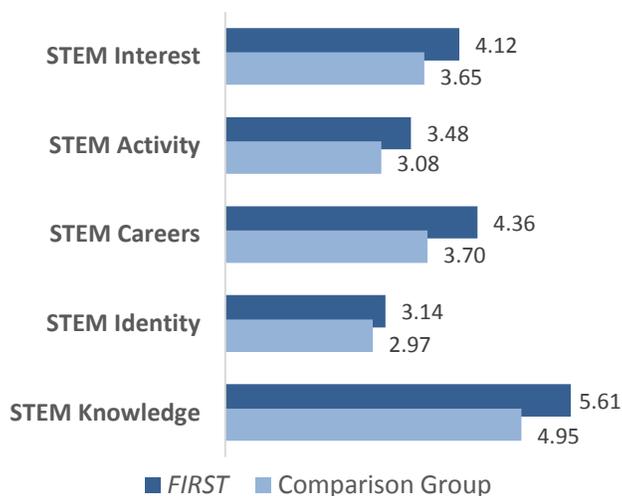### Impacts on STEM-Related Attitudes (All Participants)

At 60 months, *FIRST participants* continue to show positive, statistically significant impacts on all of the STEM-related attitude measures in the study, including interest in STEM, involvement in STEM-related activities, STEM identity, STEM knowledge, and interest in STEM careers. *FIRST* participants are approximately two to three times more likely to show gains on STEM-related measures five years after entering the program than students in the comparison group.

- ***FIRST participants continue to show significantly greater average gains than members of the comparison group on all of the measures of STEM-related interests and attitudes.*** In each case, the "effect size" (a measure of the magnitude of the impact being measured) was large enough to indicate a *practical* difference in attitudes and interests.[6] The STEM-related measures include:

  – *interest in STEM,*
  – *involvement in STEM-related activities*,
  – *interest in STEM careers*,
  – *STEM identity* (for example, "I see myself as a math, science, or technology person"), and
  – *STEM knowledge/understanding* (items include: "I want to learn more about science and

**STEM-Related Interests and Attitudes
at 60 Months**
(Difference in Scale Scores)

	FIRST	Comparison Group
STEM Interest	4.12	3.65
STEM Activity	3.48	3.08
STEM Careers	4.36	3.70
STEM Identity	3.14	2.97
STEM Knowledge	5.61	4.95

Note: All results are statistically significant at p≤.05. All impacts showed a medium to large effect size. STEM Interest, Activity and Careers are based on a 5 point scale; STEM Identity on a 4 point scale, and STEM Knowledge on a 7 point scale.

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[5] Note: Throughout this summary, "impact" refers to the differences in outcomes between *FIRST* participants and corresponding members of the comparison group, after controlling for differences between the two groups on key measures at baseline. For example, impacts for *FIRST* participants as a whole are based on the difference in outcomes between all *FIRST* participants and all comparison group members; impacts for female *FIRST* participants are based on the comparison with female members of the comparison group. Impacts that are "statistically significant" are those that are large enough to be unlikely to have occurred by chance (less than a 5% probability).

[6] Based on "Linear Mixed Models" analysis ("Mixed"). The "mixed" analysis estimates average gains for participants vs. comparison students taking into account differences between the groups at baseline and using data from all available points in time (baseline, post-program, and follow-ups). In this instance, the "mixed" results measure whether the average gains for *FIRST* participants were greater than those experienced by comparison students and whether the differences were large enough to be statistically significant. The effect size (omega squared - ω^2) was "large" for the impact on STEM interest and "medium" for the other STEM outcome measures.

technology," "I have a good understanding of how engineers work to solve problems," "I can use math and science to make a difference in the world).

- ***FIRST participants are also significantly more likely to show an increase on STEM-related measures than comparison students.[7]*** After controlling for differences in baseline characteristics and baseline scale scores, *FIRST* participants at 60 months were:

  - 3.0 times more likely than comparison students to show gains on *STEM interest*;
  - 2.6 times more likely to show gains in involvement in *STEM activity*;
  - 2.5 times more likely to show gains on interest in *STEM careers*;
  - 2.0 times more likely to show gains in STEM *knowledge/understanding of STEM; and*
  - 1.9 times more likely to show gains in *STEM identity*.

- ***The 60-month data also continue to show positive, statistically significant impacts on STEM-related outcomes for participants from all three FIRST programs in the study (FIRST LEGO League, FIRST Tech Challenge, FIRST Robotics Competition).*** Participants in all three *FIRST* programs show significantly greater gains on STEM-related measures than comparison students.

- ***STEM-related impacts are also evident across all major population groups and among students from different types of communities (compared to similar students in the comparison group).*** Each of the following groups – males and females, lower and higher income students (family incomes below and above $50,000), White youth and youth of color, and urban, suburban, and rural youth – shows significantly greater gains for *FIRST* participants than for comparison students from the same group or community type.

| Outcomes	Males	Females	Low Income	High Income	White	Youth of Color	Urban	Suburban	Rural
STEM Interest	+	+	+	+	+	+	+	+	+
STEM Activity	+	+	+	+	+	+	+	+	+
STEM Careers	+	+	+	+	+	+	+	+	+
STEM Identity	+	+	+	+	+	+	+	+	+
STEM Knowledge	+	+	+	+	+	+	+	+	+

Note: Plus mark (+) indicates a positive, significant impact at p≤ .05. Impacts are relative to comparable subgroups in the comparison population (for example, male FIRST participants compare to male comparison group members). Low income is defined as those whose family income is below $50,000. Youth of color group includes Asian, Black or African-American, Native American, Hawaiian/Pacific Islander, and multi-racial. The number of youth who responded as non-gender-binary was too small for analysis.

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[7] Based on "Logistic Regression" analysis ("Logit"). Logit analysis estimates the relative probability that participants and comparison students will achieve a particular outcome, after controlling for differences between the groups at baseline. In this case, the Logit analysis measures whether *FIRST* participants are more (or less) likely than comparison students to show an increase from baseline to follow-up on each STEM-related measure (such as STEM interest) and whether those differences are statistically significant (i.e., unlikely to occur by chance). The "odds ratio" is the measure of the relatively likelihood that *FIRST* participants will achieve that outcome (for example, "3.0 times more likely to show a gain in STEM interest than comparison students").

- *While the data show positive impacts for both male and female participants in FIRST, female participants continue to show greater impacts than male participants on all of the STEM-related measures.* The chart to the right shows the differences in outcomes for girls in *FIRST* compared to girls in the comparison group, and for boys in *FIRST*, compared to boys in the comparison group. While all of the differences between *FIRST* participants and comparison students are statistically significant, the impacts for female participants in *FIRST* on each measure are also significantly greater than those for male participants.

**Impacts on STEM-Related Outcomes
for Male and Female *FIRST* Team Members**
(Scale Scores)

■ Female participants in FIRST vs. Female Comparison Students
■ Male participants in FIRST vs. Male Comparison Students
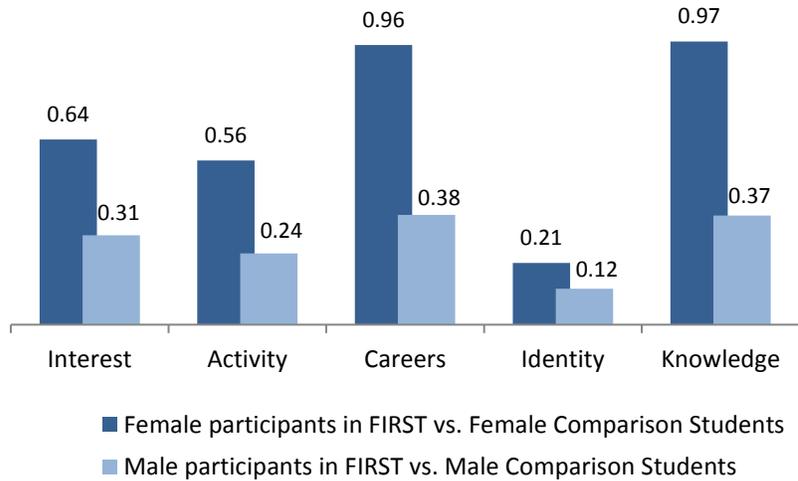
Note: Values on the chart represent the differences in outcomes (estimated scale scores) between *FIRST* participants and students of the same gender in the comparison groups (i.e., the difference in scores between males in *FIRST* and males in the comparison group and between females in *FIRST* and female comparison students). All differences are statistically significant at p≤.05. The impacts for female participants are statistically significantly greater than those for male participants.

College Outcomes

- *FIRST's impacts on STEM-related attitudes and interests persist into college.* Through the first and second year of college, *FIRST* alumni continue to show greater gains than comparison students on measures of STEM-related interest, STEM activity, interest in STEM careers, STEM identity, and STEM knowledge and understanding. Both male and female alumni show significant impacts; however, female *FIRST* alumni continue to show significantly larger gains than male alumni.

STEM-Related Attitudes in 1st and 2nd Years of College
(Scale Scores)

■ FIRST   ■ Comparison Group
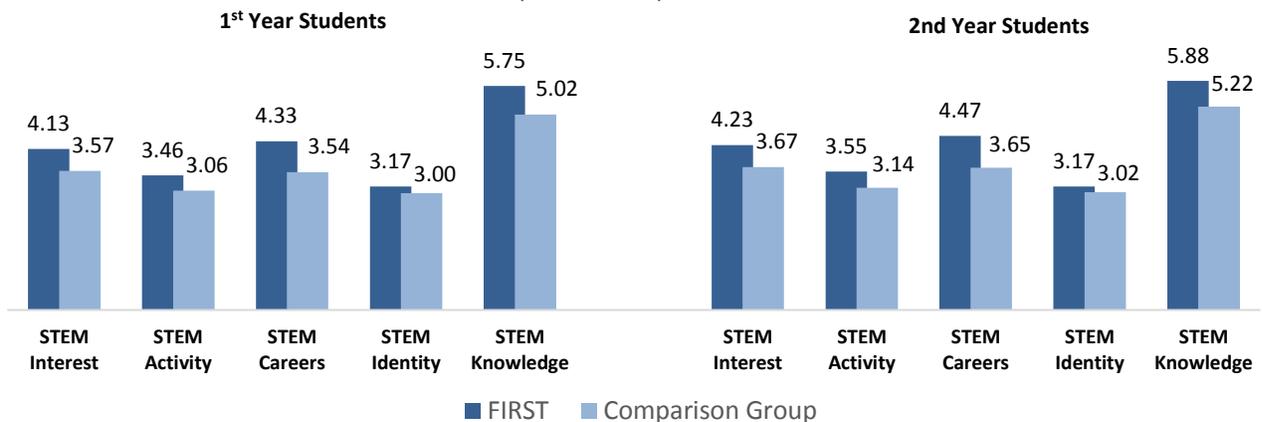
Note: Based on students in the sample with at least 1 or 2 years of college. N=607 for first-year college students, N=444 for second year students. STEM Interest, Activity and Careers are based on a 5 point scale; STEM Identity on a 4 point scale, and STEM Knowledge on a 7 point scale. All results are statistically significant at p≤ .05. All impacts show medium to large effect sizes.

- ***FIRST alumni report significantly greater interest in majoring in computer science, engineering, and robotics than comparison students in the first and second year of college***. In their first year of college, *FIRST* alumni are more than twice as likely (2.3 times) to be interested in majoring in computer science, 3.1 times more likely to be interested in engineering, and 4.2 times more likely to be interested in majoring in robotics than comparison students. The results are similar for students in their second year: *FIRST* alumni are 2.7 times more likely to be interested in majoring in computer science, 2.5 times more interested in engineering, and 2.6 times more interested in majoring in robotics. Each of those differences is statistically significant.
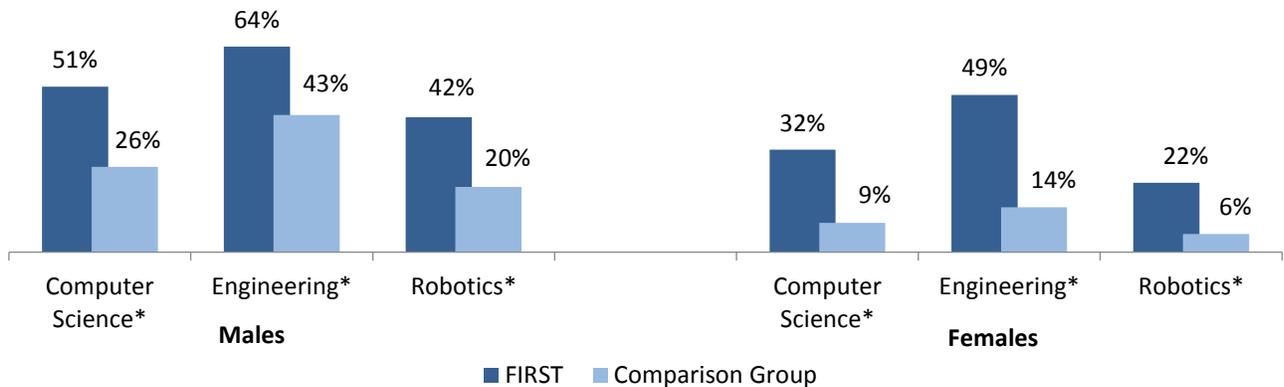
Interest in College Majors - 1st and 2nd Year of College
(Percent "Very Interested")
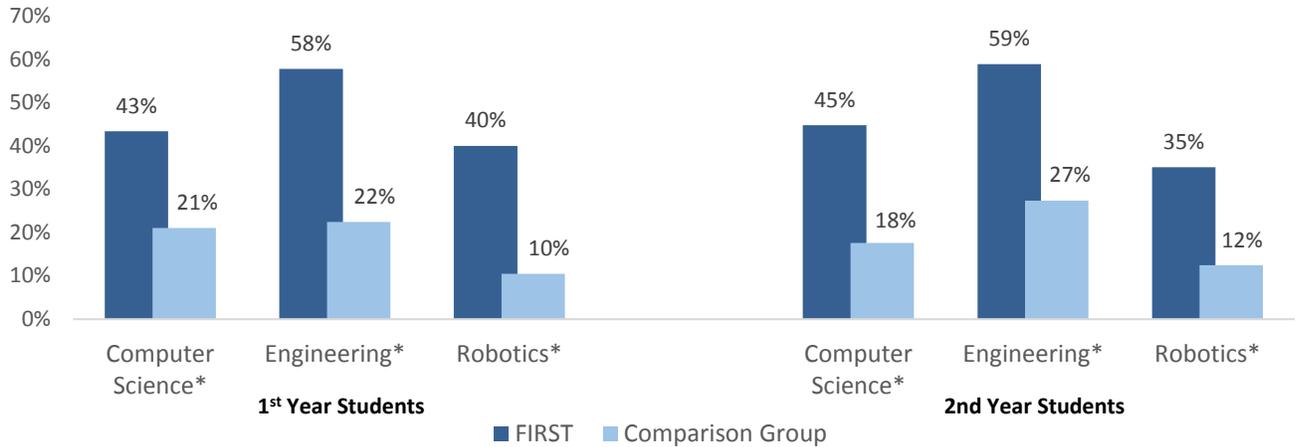
Note: Percent of 1st and 2nd year college students "very interested" in the specified major (i.e., 6 or 7 or "already declared" on 7 point college major interest scale). Asterisk (*) indicates that differences are statistically significant at p≤ .05.

- Greater interest in technology-related majors (computer science, engineering, robotics) is evident among both male and female *FIRST* alumni. By the second year of college, male *FIRST* alumni are more than twice as likely to be "very interested" in majoring in computer science, engineering, and

Interest in College Majors - 2nd Year in College
**by Gender**
(Percent "Very Interested")

Note: Percent of 2nd year college students "very interested" in the specified major (i.e., 6 or 7 or "already declared" on 7 point college interest scale). Asterisk (*) indicates that differences are statistically significant at p≤ .05.

robotics than male comparison students. The differences are even greater among female students: female *FIRST* alumni are more than three times more likely to want to major in the three technology fields than female comparison students. All of those differences are statistically significant. In contrast, while less likely to major in one of the technology majors, comparison group students are significantly more likely to be interested in majoring in two non-technology STEM fields: biology and health professions.

- *FIRST* **alumni are not only more interested in technology-related majors, but are significantly more likely than comparison students to declare a major in engineering or computer science in the first two years of college. They are also significantly more likely to declare a major in a STEM field generally by the end of their second year of college than comparison students**.

  - *STEM majors overall*: Of those who declared a major by the end of the second year of college, 89% of *FIRST* alumni declared a major in a STEM-related field compared to 59% of comparison students. Broken out by gender, 91% of male *FIRST* alumni and 86% of female *FIRST* alumni declared a STEM major vs. 69% and 49% of male and female comparison students respectively.[8] Based on Logit analysis, controlling for baseline differences, *FIRST* alumni were 4.2 times more likely to declare a STEM major than comparison students.

  - *Engineering and computer science majors*: 43% of *FIRST* alumni declared a major in engineering *vs*. 14% of comparison students; 25% declared a major in computer science *vs*. 8% of comparison students. Overall, 70% of *FIRST* alumni declared a major in either computer science or engineering by the end of the second year of college compared to 25% of comparison students (not shown in chart).

  - *Male/female differences in engineering and computer science majors*: Both male and female *FIRST* alumni declare engineering and computer science majors at higher rates than comparison students. Among male *FIRST* alumni, 46% declared a major in engineering and 28% in computer science vs. 21% and 10% of comparison males respectively. Overall, 76% of male *FIRST* alumni declared a major in computer science or engineering vs. 38% of comparison males (not shown). The differences were greater among young women: 37% of female *FIRST* alumni declared a major

Declared Majors in Computer Science, Engineering and STEM Fields in Second Year of College - All Students and by Gender
(Percent of those who declared a major)
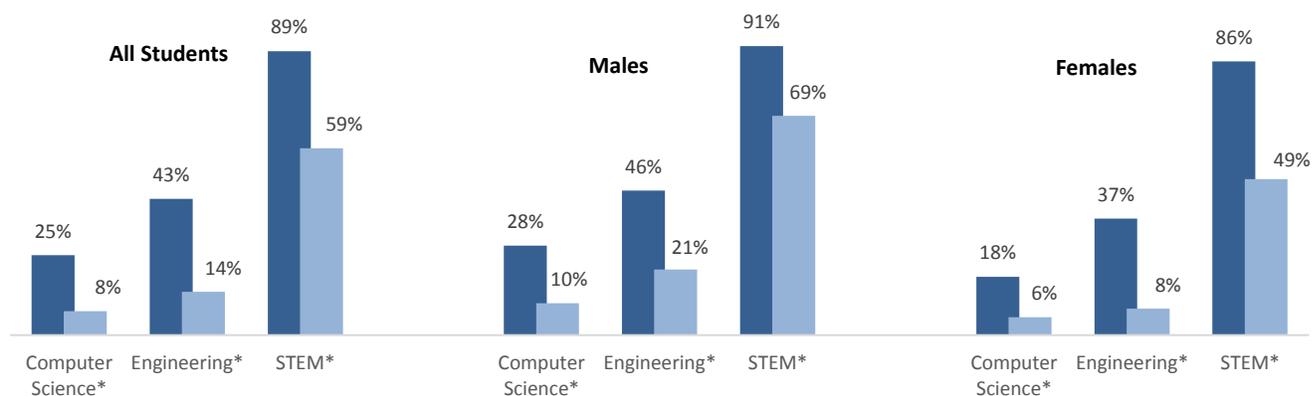
Note: Percent of students who declared a major in specified fields by the end of the second year of college as a percentage of all those who declared a major. Asterisk (*) indicates that difference is statistically significant at p≤.05.

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[8] STEM fields include: Biological Sciences, Computer Science, Engineering, Health Professions, Mathematics, Physical Sciences, vocational/technical professions, and Robotics.

in engineering and 18% a major in computer science vs. 8% and 6% of comparison women respectively. Overall, 59% of female *FIRST* alumni declared a major in either computer science or engineering vs. 12% of comparison women (not shown).[9]

- ***FIRST alumni are also significantly more likely to take an engineering or computer science course during their first two years in college than comparison students***. In their first year of college, *FIRST* alumni were more than twice as likely (2.3 times) to take an engineering course and 1.5 times more likely to take computer science than comparison students. The differences in course-taking continued into the second year of college: *FIRST* alumni were roughly twice as likely to take engineering and computers science courses (2.1 times for both) as comparison students. By the second year of college, 45% of *FIRST* alumni reported taking at least one engineering class and 38% reported taking at least one computer science course compared to 19% of comparison students.
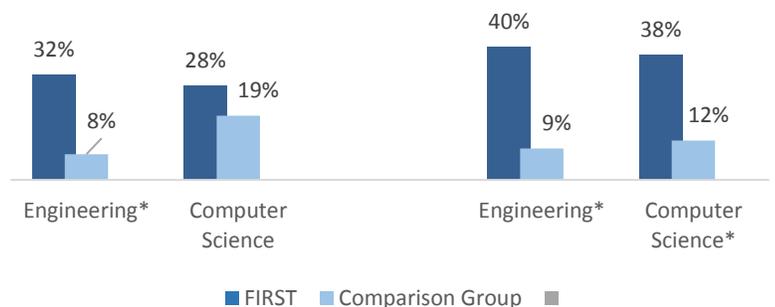
Course-Taking in 1st and 2nd Year of College
(Percent Taking at Least 1 Course)
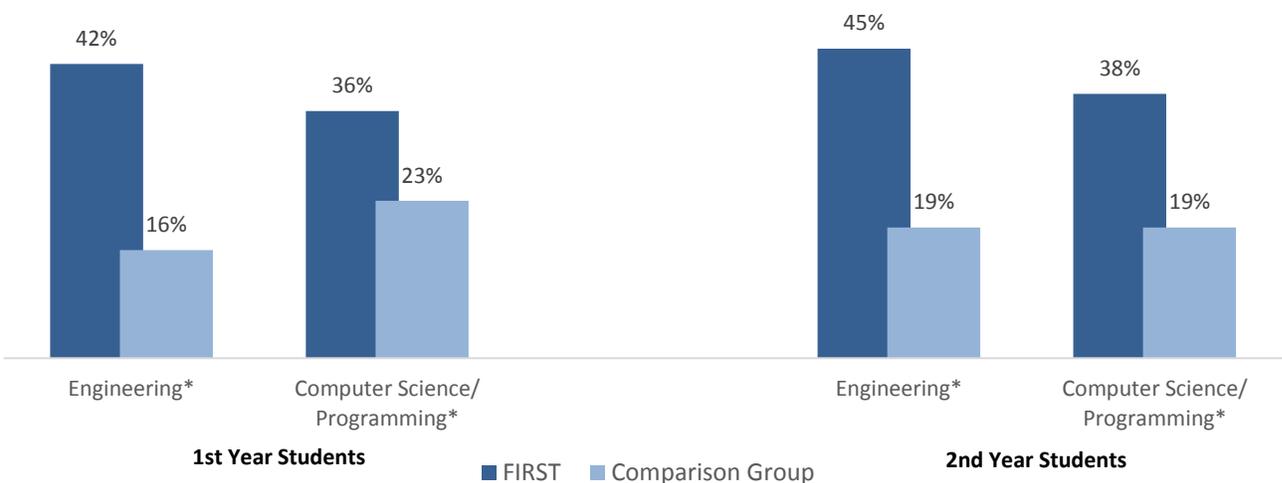
1st Year Students   ■ FIRST   ■ Comparison Group   **2nd Year Students**

Note: Percent of 1st and 2nd year college students taking at least 1 course in listed field. Asterisk (*) indicates that difference is statistically significant at p≤.05.

- Among female students, the differences in course-taking between *FIRST* alumni and comparison students are striking. By the second year in college, female *FIRST* alumni are 3.7 times more likely to take an engineering course and 5.3 times more likely to take computer science than female comparison students. By the second year of college, 40% of female *FIRST* alumni took an engineering course compared to 9% of female comparison students; 38% took computer science compared to 12% of female comparison students.

CS and Engineering Course-Taking in 1st and 2nd Year of College - Female Students
(Percent Taking at Least 1 Course)

■ FIRST   ■ Comparison Group   ■

Note: Percent of 1st and 2nd year female college students taking at least 1 course in listed field. Asterisk (*) indicates that difference is statistically significant at p≤.05.

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[9] All of the differences between *FIRST* alumni and comparison students are statistically significant at p≤ .05.

- ***In addition to their greater likelihood of taking courses and majoring in STEM fields, FIRST alumni were also significantly more likely to be engaged in STEM-related activities during their first and second year at college than comparison students.*** As the table to the right shows, *FIRST* alumni were more likely to have a STEM-related internship, join a computer or engineering club, participate in a computer or engineering competition, receive an engineering-related grant or scholarship, and have a STEM-related summer job than comparison students.

STEM-Related Activities in Year 1 and 2 of College

Activity		FIRST	Comparison
STEM-Related Internship*	Yr1	17.3%	7.3%
	Yr2	26.3%	15.5%
Joined Computer Club*	Yr1	16.3%	7.4%
	Yr2	18.3%	4.8%
Joined Engineering Club*	Yr1	30.8%	12.3%
	Yr2	27.5%	7.1%
Participate in a Computer Competition* (sig. Yr 1 only)	Yr1	10.0%	3.1%
	Yr2	9.2%	3.6%
Participate in an Engineering Competition*	Yr1	11.8%	5.6%
	Yr2	14.1%	6.0%
Received Engineering-Related Grant or Scholarship*	Yr1	8.7%	3.1%
	Yr2	9.9%	0.0%
STEM-Related Summer Job*	Yr1	13.6%	7.2%
	Yr2	15.5%	9.1%

Asterisk (*) indicates differences that are statistically significant at p≤0.05.

Conclusion

Five years after entering *FIRST,* program participants continue to show consistently greater gains on STEM-related interests and attitudes than similar students in the comparison group. Positive impacts on STEM-related attitudes and interests are evident across all three *FIRST* programs in the study and across all of the major population groups. *FIRST*'s impacts on STEM-related attitudes are particularly strong for female participants who generally show significantly greater gains than those experienced by male program participants. Data on students in their first two years of college shows *FIRST*'s positive impacts continue into postsecondary education, with *FIRST* alumni continuing to show positive impacts on STEM-related attitudes, as well as impacts on interest in technology-related majors, declared majors in computer science, engineering, and STEM-related fields more broadly, course-taking in computer science and engineering, and on involvement in STEM-related activities (internships, clubs, competitions, and summer jobs). Here, too, on measures of interest in technology majors, course-taking, and declared majors, the results for female *FIRST* alumni are particularly strong, with female alumni consistently engaging in STEM-related fields at a rate significantly higher than female comparison students. While the study will continue to follow students to and through postsecondary education, the results to date already indicate that *FIRST* is making a lasting difference in career interests and educational choices for the young people who participate in the program.