

The *FIRST*[®] Longitudinal Study

10 Years of Follow-up Data

Final Report

Tatjana Meschede, Marji Erickson Warfield, Matt Hoover, Zora Haque,
Manning Zhang, Alan Melchior, Cathy Burack



Brandeis

THE HELLER SCHOOL
FOR SOCIAL POLICY
AND MANAGEMENT
Center for Youth
and Communities



Acknowledgements

We greatly appreciate all the support we received over the years from members of our external working group Jacquelynne Eccles, Distinguished Professor of Education at the University of California in Irvine, Merredith Portsmore, Director of the Engineering Education and Outreach Center at Tufts University, Dale Blyth, retired Extension Professor in the College of Education & Human Development at the University of Minnesota, Chris Chapman, Statistician, U.S. Department of Education, and Lance Potter, Principal of Evaluation Strategy, LLC and Senior Advisor for Measurement and Learning at New Profit Inc. Sharing their valuable insights on all stages of this study contributed to a more robust evaluation project.

We also thank the study participants from both groups, the *FIRST*[®] participants and the comparison group. Their response to our annual surveys over ten years has been exceptional, and their willingness to respond to our questions has provided the foundation for this remarkable study.

Finally, we could have not completed this study without the continuous support by *FIRST* and the funders of this work. The commitment to this project and the financial support provided by *FIRST*'s senior management and Board have been extraordinary. Our collaboration with the *FIRST* Evaluation Team, in particular Nancy Boyer, Sarah Winters, and Clelia Anna Mannino, has been a pleasure throughout. Thank you for all your good questions, close review of our reports, and contributions to the analyses.

Table of Contents

- Introduction & Background 1**
- 1. Long-Term STEM Related Impacts of *FIRST* 5**
 - Long-term STEM Outcome Measures 5**
 - Long-Term Impacts on STEM Interest and Attitudes 6**
 - Engineering and Computer Science in College 7**
 - Extracurricular Activities 8**
 - STEM Employment and Income 9**
 - Comparison With National Trends 10**
 - Relationship between *FIRST* Program Experience and Outcomes 11**
- 2. Impacts for Key Subgroups Among *FIRST* Participants 14**
 - Consistently Stronger Impacts for Female *FIRST* Participants 14**
 - Course Taking and Majoring in College 15
 - STEM Employment and Income 16
 - National Data on Gender Outcomes in College and Employment 16
 - Gender Differences in *FIRST* Program Experience and Outcomes 17
 - Female *FIRST* Alumni Reflections 18
 - Other Underrepresented Groups in STEM 18**
 - College 19
 - STEM Employment and Income 19
 - Program Experience and Impact..... 20
- 3. Impacts Beyond STEM 21**
 - Gracious Professionalism® and Coopertition® 23**
- 4. Conclusions and Next Steps 25**

Key Takeaways

The long-term impact of *FIRST*[®] (For Inspiration and Recognition of Science and Technology), as evidenced by the multi-method *FIRST* Longitudinal Study that followed *FIRST* participants and a matched comparison group over ten years, can be tracked throughout college and early careers. In particular, ten years after program participation, the following are the key take aways:

- *FIRST* participants continue to report **significantly higher scores** over baseline assessments on STEM interest and attitudes.
- *FIRST* participants are **1.4 to 2.1 times more likely to report higher scores** than comparison students on these STEM scales over preprogram scores.
- Higher gains in scores over baseline assessments and higher likelihood of reporting higher scores have been **consistently stronger for female *FIRST* participants**.
- For the most part, **these results hold true for underrepresented groups in STEM**, such as participants identifying as African American, Latinx, or Native American, participants from lower income families, and participants from urban or rural areas.
- In college, *FIRST* participants are **significantly more likely to take STEM courses and major in STEM overall**, as well as in Engineering and Computer Science specifically.
- **Female *FIRST* participants in college are even more likely to take STEM courses and major in STEM overall**, as well as in Engineering and Computer Science specifically.
- Early careers indicators show that *FIRST* participants are **significantly more likely to be employed in a STEM field**.
- Analyses with a matched group of national students selected from data collected by the National Center for Education Statistics (NCES) underscore these results. In college and their early careers, *FIRST* participants are **significantly more likely to engage with STEM** than their national matched counterpart. The **stronger impacts for female *FIRST* participants** are also supported by these analyses.
- **Qualitative interviews** with over 40 female participants **reveal pathways for these especially strong impacts for female *FIRST* participants** while at the same time underscoring the challenges for women in STEM in general and female participants in *FIRST*.



Introduction and Background

STEM (science, technology, engineering, math) skills are critical for a society to advance, and STEM careers are among the highest paying in the workforce. The U.S. Bureau of Labor Statistics (2023) projects a nearly 11% increase in STEM occupations between 2022 and 2032, emphasizing the need for expanding the presence of highly-trained STEM workers.¹ Yet, educators and policy makers continue to share their concerns over the low levels of math and science achievement among U.S. students and the gradual decline in the numbers of young people moving into STEM careers. While the interest in expanding the numbers of young people moving into science and technology fields has grown, a relatively small proportion of the work on STEM education has focused on the role that after-school programs can play to reinforce STEM learning and help engage young people in educational pathways leading to STEM careers. This report summarizes the results of a 10-year longitudinal study evaluating long-term impacts of the after-school programs at *FIRST*[®].

FIRST[®] (For Inspiration and Recognition of Science and Technology) is a global nonprofit organization that operates in school and after-school team-based robotics programs for young people ages 4-18. The mission of *FIRST* is to “provide life-changing robotics programs that give young people the skills, confidence, and resilience to build a better world”.² *FIRST* programs include *FIRST*[®] LEGO League Discover (ages 4-6), *FIRST*[®] LEGO League Explore (ages 6-10) and *FIRST*[®] LEGO League Challenge (ages 9-14), *FIRST*[®] Tech Challenge serving grades 7-12, and *FIRST*[®] Robotics Competition, serving high school-aged youth (grades 9-12). Class Pack, a school-based model, was introduced in 2016. Overall, *FIRST* estimates that in 2022-2023, the programs reached over 668,000 young people worldwide.³ The quotes on the next page provide a flavor of the experience.

¹ <https://www.bls.gov/emp/tables/stem-employment.htm>

² <https://www.firstinspires.org/about>

³ <http://www.firstinspires.org/about/at-a-glance>

“FIRST challenged me to problem solve in a fast-paced and rewarding environment. It built up my confidence to pursue Engineering. I learned that I am a great problem solver and I very much enjoy it. Having been an artist for so much of my life, FIRST showed me that engineering problem solving tickles the same spot in my brain as creating art; they are both inherently creative processes.”

- FIRST survey respondent

“FIRST has made such a large impact on my life that I don’t know where or who I would be without it. I have been involved with FIRST for seven years, and the experiences that I have had have given me public speaking skills, confidence in my abilities, and life-long friendships. FIRST also has given me the opportunity to inspire others in STEM fields.”

- FIRST survey respondent

In the *FIRST* Longitudinal Study, we recruited from three *FIRST* programs: *FIRST*® LEGO League Challenge, *FIRST*® Tech Challenge, and *FIRST*® Robotics Competition.

The *FIRST*® Longitudinal Study (FLS)

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, was to document the longer-term impacts of *FIRST* programs on participating youth and to do so through a design that meets the standards for rigorous, scientifically-based evaluation research. Three major questions guided the study:

1. 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?
2. 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 subgroups 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, we relied on three complementary data sources.

1. Baseline and 10 follow-up Annual Surveys

The core data collection activity for this evaluation relied on the baseline and ten post program participation annual follow-up surveys in which the *FIRST* Longitudinal Study has been tracking 1,273 students (822 *FIRST* participants and 451 comparison students). Team members were recruited to the study from a nationally representative sample of “veteran” teams from the *FIRST* LEGO League Challenge, *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 that included quantitative data as well as open ended questions. 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.

Of the 1,273 students who began the study, 922 students (72%) completed the 10-year follow-up survey, including 551 *FIRST* participants (67% of those at baseline) and 371 comparison students (82% of those at baseline). Of the study participants responding to the follow-up survey at the 10-year mark, all were post high school, 18% were in college, 17% in graduate school, and 60% employed.

2. In-depth Interviews with Female *FIRST* Participants 10 Years after Participation

To better understand the consistently better outcomes for female *FIRST* participants, we implemented a qualitative study component in Year 10 of data collection. In this study, we conducted in-depth interviews with 42 female *FIRST* alumni from the *FIRST* Longitudinal Study who reflected on their program experience and impacts ten years after participation. Questions focused on STEM coursework in high school and college, the fields female alumni were pursuing in their current careers, their experiences in the *FIRST* program they attended, and how they believed *FIRST* influenced their post-*FIRST* academic and work experiences. The data were analyzed using qualitative analysis software (ATLAS).

3. Restricted National Data

In Year 10, we applied for and were granted access to restricted data collected by the National Center for Education Statistics (NCES), retrieving relevant data from three of their surveys. The High School Longitudinal study presents a nationally representative group of over 23,000 high school students followed throughout secondary and postsecondary years. This study uses many of the *FIRST* Longitudinal Study STEM interest and attitude scales. The Beginning Postsecondary and Beyond study surveys students beginning in their first year of postsecondary education and provides data on course taking and majors. The Baccalaureate and Beyond Study provides nationally representative data following students who completed the requirements for a bachelor’s degree. Graduating seniors are followed for 1, 4, and 10 years after completing their bachelor’s degree.

These studies provide the opportunity to create a national comparison group through Propensity Score Matching. This approach produces another comparable comparison group to test differences between *FIRST* outcomes and national trends.

This final report of the *FIRST* Longitudinal Study is organized by responses to the three research questions posted at the implementation of the study. In each section, we draw on the three data sources listed above, where appropriate. More details on these three complementary data sources can be found in the [2024 FLS Technical report](#). Due to the plethora of data computed in this study, we highlight the major results only. Additional data points can be accessed in these [10-year presentation slides](#) (2024).

“I also loved being in a community where people my age were so dedicated and had a vision in the same way that I did. You don’t really get that in other places when you’re in high school, or just walking around campus, anyone could be pretty much pursuing any goal. But then with FIRST, most of these students were very serious, very passionate about STEM.”

- FIRST interview study participant

“FIRST has allowed for me to learn how important it is to be a holistic person. I have become a better public speaker, documenter, engineer, and teammate because of my time in FIRST. Previously I would only learn one element from other clubs, but FIRST truly made sure we were well rounded individuals.”

- FIRST survey respondent



1. Long-Term STEM Related Impacts of *FIRST*

This section summarizes the long-term impacts of participating in any of the three *FIRST* programs (*FIRST* LEGO League, *FIRST* Tech Challenge, *FIRST* Robotics Competition) based on ten years of data, the interview data with female *FIRST* alumni, and comparisons to national trends through the use of restricted national data.

In Year 10 of the *FIRST* Longitudinal study, all participants had completed high school, 18% were in college, 17% in graduate school, and 60% were in the workforce. Overall, the study participants present as a very high achieving group, with significantly higher rates of completed college degrees than the general population (90% for both *FIRST* and comparison groups vs 55% nationally).

Long-term STEM Outcome Measures

The outcome measures tracked in the annual surveys fall into two overarching domains: STEM interest/attitudes and STEM behavior. STEM attitudes were measured by five validated research scales that assess interest in STEM, STEM activities that involved non-school activities, interest in STEM careers, STEM identity, which measures the extent to which students see themselves as science people, and perceived STEM knowledge which focuses on the awareness of applications of STEM in the real world and interest in learning more about STEM. (Details on these scales can be found in the [2024 FLS Technical Report](#)). For the behavioral outcomes, we examined data on college STEM course taking and majors, particularly in Engineering and Computer Science. We also studied involvement in STEM activities while in college, such as joining clubs, competitions, and experiencing internships and summer jobs. We also looked at STEM-related college grants and scholarships. Finally, we present preliminary early career data.

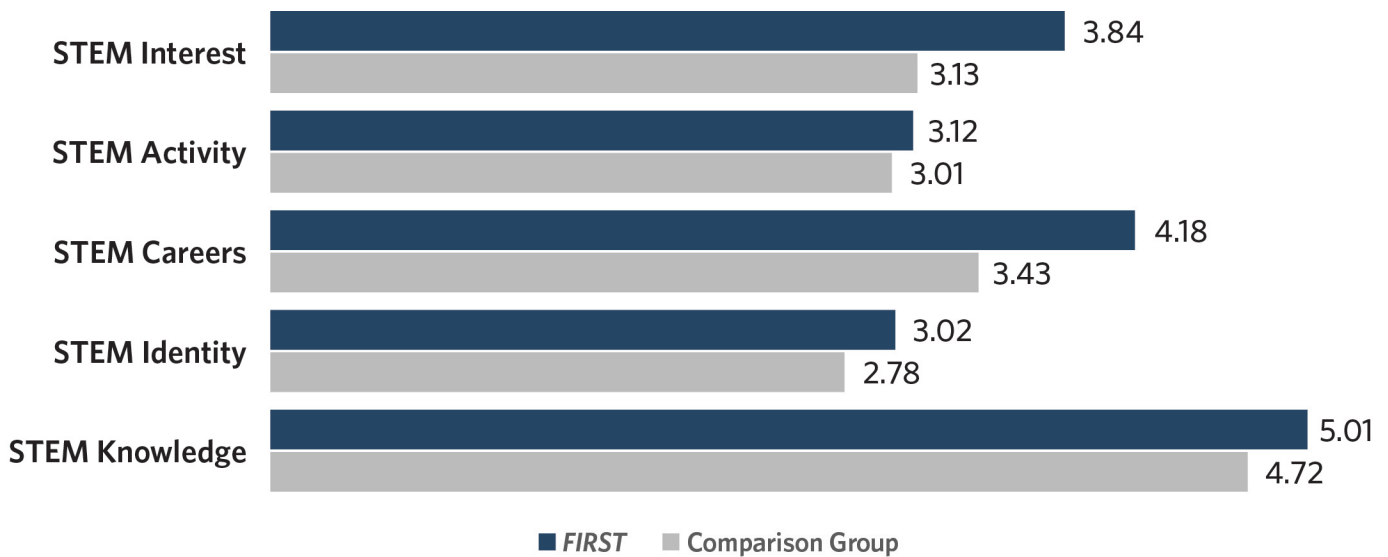
In the initial years of the study, a third domain on personal development and workplace related outcomes was included in the study. This included measures on academic self-concept, college support, self-efficacy, and 21st century skills (problem solving, teamwork, communication). While both groups increased their scores in these domains, we did not find significant differences between the two groups and decided to drop these questions in the first four years of the study. As we noted, the comparison group was similarly high achieving as the *FIRST* group with exposure to these skills through a variety of in-school and extracurricular activities. However, our qualitative data provide insights into these social and emotional outcomes, albeit just for *FIRST* participants.

Long-Term Impacts on STEM Interest and Attitudes

Controlling for baseline differences between the *FIRST* and the comparison groups (gender, race/ethnicity, family income, taking honors courses in high school, and parental support for STEM), we find consistently and significantly higher averages in scale scores over the study period for the *FIRST* participants across all of the five STEM Interest and Attitudes scales⁴ (see Figure 1). In particular, *FIRST* alumni have larger gains than comparison students in their reported interest in STEM, out of school STEM Activities, interest in STEM Careers, STEM Identity, and STEM Knowledge. These differences have been observed in all of the post baseline annual surveys and have not diminished in any significant way over time.

FIRST alumni are more than twice as likely to report an increase in STEM interest than the comparison group.

Figure 1: STEM Related Interests and Attitudes 10 Years Post Program Participation



Controlling for Gender, Race, Honors Courses, Family Income, and Parental Support for STEM. All differences are statistically significant.

⁴ Please note that the size of the differences is not an indication of more impact as these depend on the number of response items, ranging from 4 for STEM Identity to 7 for STEM Careers and STEM Knowledge.

A different way of assessing changes in scales scores is to analyze the likelihood of higher scores 10 years after program participation, compared to the baseline, pre-*FIRST* participation scores. These analyses show the likelihood of higher scores ranging from 2.1 for STEM interest to 1.4 for STEM Careers. In the Year 10 analyses, the measure of perceived STEM Knowledge does not reach statistical significance but the estimate provides an indication of a positive trend .

Figure 2: Likelihood of Higher Scores 10 Years after *FIRST* Program Participation



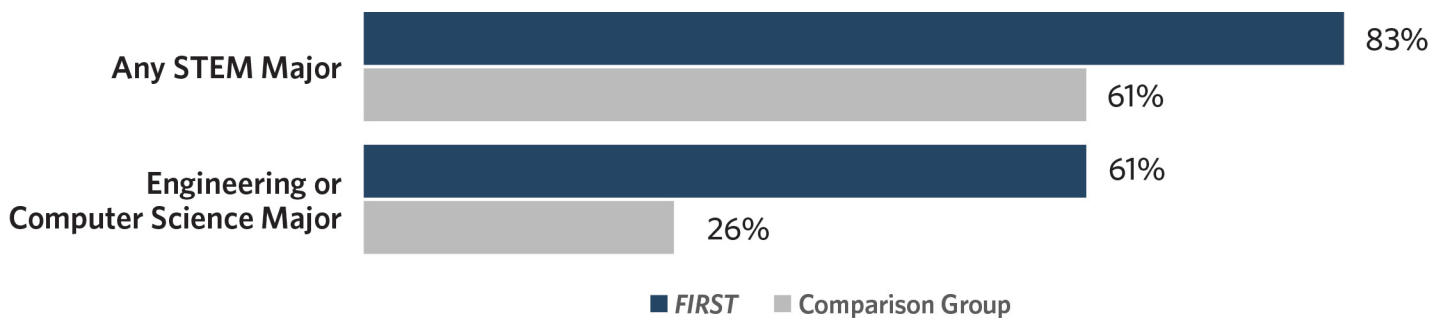
Controlling for Gender, Race, Honors Courses, Family Income, and Parental Support for STEM.

Engineering and Computer Science in College

FIRST alumni are significantly more likely to major in any STEM field (Biology, Computer Science, Engineering, Health Professions, Mathematics, Physical Sciences, Vocational/Technical fields, Robotics). Eighty-three percent of *FIRST* alumni majored in a STEM field, versus 61% among the comparison group. This difference is even larger for Engineering and Computer science majors. Sixty-one percent of *FIRST* alumni reported majoring in one of these fields, compared to just 26% in the comparison group. Comparison group participants, however, are significantly more likely to major in other STEM Fields, such as biological sciences and health professions (data not shown).

61% of FIRST participants majored in either Engineering or Computer Sciences, as compared to just 26% among comparison students.

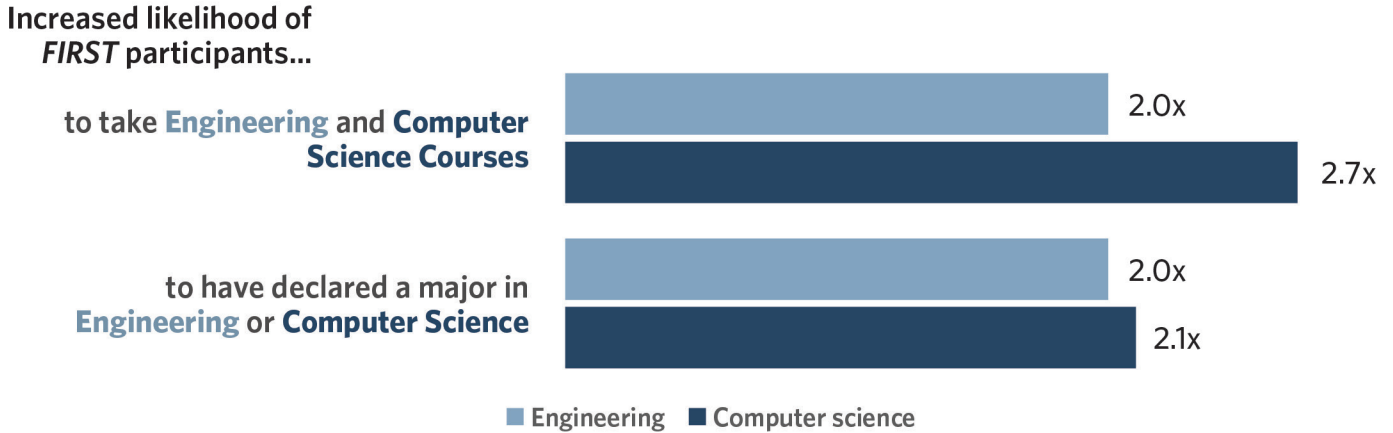
Figure 3: STEM and Engineering or Computer Science Majors



Controlling for Gender, Race, Honors Courses, Family Income, and Parental Support for STEM.

Logistic regression analyses show that *FIRST* alumni are at least twice as likely as comparison students to take Engineering or Computer Sciences courses and declare majors in either of these two fields (see Figure 4)

Figure 4: Likelihood of Selecting Courses and Declaring a Major in Engineering or Computer Science



Controlling for Gender, Race, Honors Courses, Family Income, and Parental Support for STEM.

Based on the qualitative survey data, many of the *FIRST* alumni attributed selecting their college majors to their *FIRST* experience.

“FIRST has helped me become interested in STEM and for that reason I pursued becoming a software engineer in college and am now working at a health care company in which I can use some of the things I experienced in FIRST.”

- *FIRST* survey respondent

“FIRST laid the groundwork for my career. Not only did I gain a solid foundation in Engineering, but I also learned to become more curious in my time in FIRST. I fell in love with Engineering during the 4 FRC seasons I was a part of, and it set me on the path to becoming a well-rounded engineer who loves to solve problems every day.”

- *FIRST* survey respondent

Extracurricular Activities

To assess STEM engagement outside of formal classes during college, the survey included questions on extracurricular engagements. The analysis of these questions reveals that *FIRST* Alumni are significantly more likely in almost all four years of college to:

- Join Engineering and Computer Science clubs (not significant in year 4)
- Engage in Engineering (not significant in year 4) and Computer Science competitions (not significant in year 3)
- Receive STEM-related internships, Engineering scholarships (not significant in year 3), and STEM-summer job.

Figure 5: Differences in Extracurricular Activities

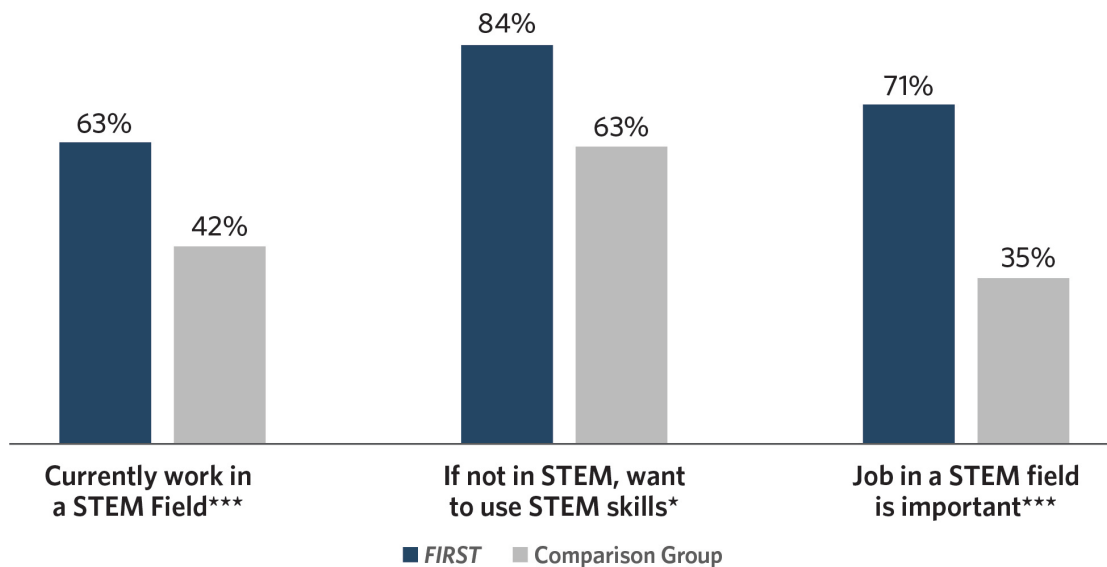
| Participated in/Received | Year in College | | | |
|--------------------------------|-----------------|--------|--------|--------|
| | Year 1 | Year 2 | Year 3 | Year 4 |
| Engineering Club | X | X | X | X |
| Computer Science Club | X | X | X | |
| <hr/> | | | | |
| Engineering Competition | X | X | X | |
| Computer Science Competition | X | X | | X |
| <hr/> | | | | |
| STEM Internships | X | X | X | X |
| Engineering Grants/Scholarship | X | X | X | X |
| Summer STEM Jobs | X | X | | X |

X: Significant Differences

STEM Employment and Income

FIRST participants were significantly more likely to work in manufacturing and STEM industries whereas the comparison group participants were more likely to work in health care industries, food and educational services (data not shown). When asked specifically about STEM, significantly more *FIRST* alumni reported that working in a STEM field is important to them; 71 percent versus 35 percent for the comparison group. When asked about current employment in a STEM field broadly defined, 63 percent of the *FIRST* group reported doing this work versus 42 percent among comparison group participants. Of those not currently working in STEM, more of the *FIRST* alumni indicated that they want to use their STEM skills (84 vs 63 percent).

Figure 6: Working or Wanting to Work in STEM



*p<.05, **p<.01, ***p<.001

Comparisons of annual incomes show higher incomes for *FIRST* participants, \$59,500 versus \$45,000 for the comparison group at the median (midpoint of the income distribution). This difference is not statistically significant.

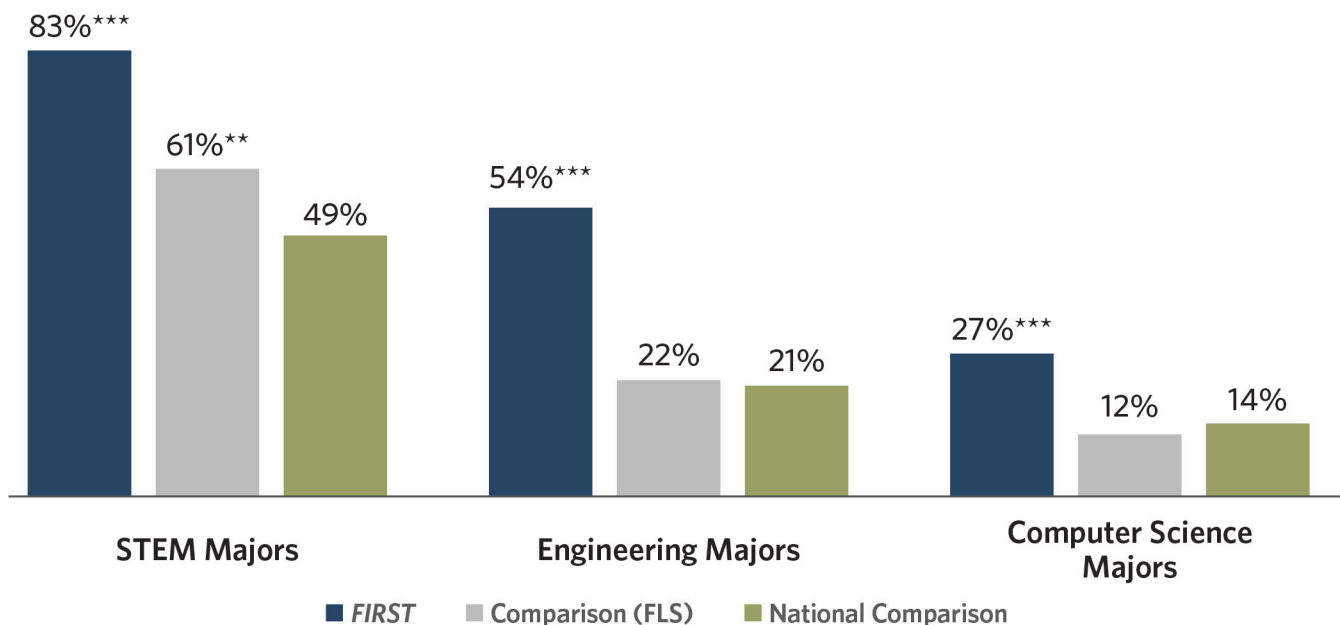
Comparison with National Trends

More than half of FIRST participants majored in Engineering, as compared to just a little over 20% for both the FIRST Longitudinal Study comparison and the matched National comparison groups.

Matched data from national representative surveys underscore the results presented above. Based on data from the National Center for Education Statistics' Baccalaureate and Beyond Study (B&B), *FIRST* participants are significantly more likely to major in STEM overall, as well as in Engineering or Computer Science specifically, compared to their matched national counterparts. In contrast, national comparisons with the *FIRST* Longitudinal Study comparison group show no differences for Engineering or Computer Science majors, underscoring the quality of the comparison group in the *FIRST* study. Both comparison groups report similar trends, solidifying the *FIRST* Longitudinal Study survey results. The

FLS comparison group, however, is significantly more likely to major in STEM overall, compared to national trends. This result is not surprising as many among the FLS comparison group selected other STEM fields as their major.

Figure 7: STEM Related College Majors of *FIRST* Participants, *FIRST* Longitudinal Study Comparison Group, and a Matched National Group



** $p < .01$, *** $p < .001$

National representative data from the NCES Beginning Postsecondary Students Longitudinal Study on post college careers and earnings underscore similar trends. Matched *FIRST* participants are significantly more likely to start a career in a STEM field with significant higher incomes at the median.⁵ The *FIRST* Longitudinal Study comparison group participants are also significantly more likely to embark on a career in STEM. Drawn from advanced math and science classes, we would expect this trend.

Figure 8: Early Career Comparisons of *FIRST* Participants, *FIRST* Longitudinal Study Comparison Group, and a Matched National Group

| | STEM Job | Salary |
|---------------------|----------|-------------|
| <i>FIRST</i> | 59%*** | \$53,500*** |
| Comparison (FLS) | 40%** | \$44,000 |
| National Comparison | 27% | \$44,500 |

** $p < .01$, *** $p < .001$

More detailed information on these comparisons with national data can accessed [here](#).

Relationship between *FIRST* Program Experience and Outcomes

In this section, we explore the relationship of seven program components and quality of the *FIRST* experience on the two impact areas that were evaluated: STEM attitudes and college outcomes. These program components are participating in building the robot, programming the robot, or providing team support in the form of gathering information for the team, raising money, and engaging in publicity. In addition, overall program quality and the quality of the mentor experience are assessed. The additional two components entail time with *FIRST* and the extent of competition participation.

FIRST participants who built the robot, provided team support, and rated the quality of the program and the quality of their mentor experience as high reported significantly higher outcomes on all five STEM attitude scales (Figure 9). Those who participated in seven or more competitions⁶ reported higher levels of interest in STEM, more activities in STEM, and higher perceived knowledge of STEM. Time in *FIRST*, in contrast, was significantly related to interest in STEM Careers and STEM Identity. Participating in programming the robot was only correlated with STEM activities.

⁵ We report results at the median, the mid-point of the distribution, as the mean tends to be highly influenced by very high and very low salaries.

⁶ 7 or more participations in competitions presents the top quartile of the distribution. We explored an alternative approach of measuring competition participation, 0 vs any competition. However, as more than 95% of the *FIRST* participants attended competitions, this extreme skew in the distribution did permit the intended analyses.

Figure 9: Relationship of Program Experience and STEM Interest/Activity

| All <i>FIRST</i> Participants | STEM Interest | STEM Activity | STEM Careers | STEM Identity | STEM Knowledge |
|-----------------------------------|---------------|---------------|--------------|---------------|----------------|
| Building the Robot | + | + | + | + | + |
| Programming | | + | | | |
| Team Support | + | + | + | + | + |
| Quality Scale | + | + | + | + | + |
| Time in Program (> 1 year) | | | + | + | |
| Mentor Scale | + | + | + | + | + |
| Participated in Competitions (7+) | + | + | | | + |

+ = Statistically significant difference

Controlling for Gender, Race, Honors Courses, Family Income, and Parental Support for STEM.

These quotes below speak to the experiences of participants as they related to the different participation domains.

“I have met my biggest mentor through *FIRST*, and he has helped show me different opportunities available to me and encouraged me to explore them. He helped me develop the technical skills needed for these opportunities, and I now work in one of the fields he introduced me to.”

-*FIRST* survey respondent

“Overall my favorite experience out of all of it: There’s always a competition [and] they’re just so full of energy. And you got to learn so much from other people.”

-*FIRST* interview study participant

For majors declared at the end of year 4 in college, building the robot, participation in seven or more competitions, and rating the *FIRST* program as high quality are all significantly correlated with declaring a major in either Computer Science or Engineering. Programming the robot is significantly correlated with majoring in Computer Science or Robotics. The other program experience components (team support, time in *FIRST*, and the mentor experience) are not correlated with these majors in college.

“... introduction to robotics and programming really opened my eyes to the possibilities that are out there. It made it so that making robots and Engineering are something people do, something accessible that I could do too.”

- FIRST survey respondent

“FIRST introduced me to the world of STEM and the different areas in STEM. I first planned to be a mechanical engineer but later decided to be an electrical engineer because electrical problems felt like a puzzle to me and I enjoyed solving them.”

- FIRST survey respondent



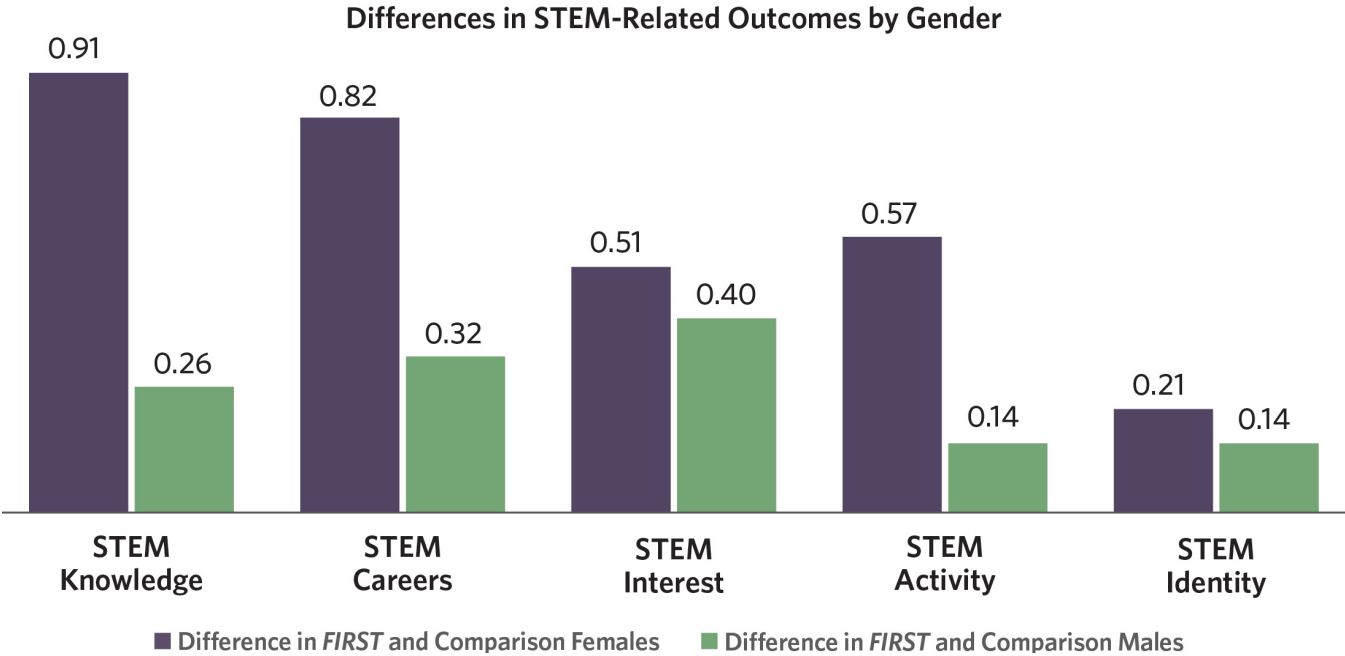
2. Impacts for Key Subgroups Among *FIRST* Participants

In this section, we take a closer look at some of the groups with low representation in STEM, in particular women, those of racial and ethnic backgrounds disproportionately not involved with STEM, those from lower income households, and those residing in urban or rural locations.

Consistently Stronger Impacts for Female *FIRST* Participants

A little over one-third of all STEM degrees in the U.S. go to women. The proportion of women majoring in either Engineering or Computer Science is substantially lower than men, at about 20%.⁷ Given these national trends, the results for female *FIRST* alumni are even more impressive, for both STEM attitudes and college majors. In all annual surveys post baseline, female *FIRST* participants reported comparatively higher gains on all five STEM attitude and interest scales compared to *FIRST* male participants. In Figure 10 below, we show the differences for each scale between the *FIRST* and the comparison groups by gender. These results show that *FIRST* has consistently a stronger impact across the five STEM outcomes and stronger impact after ten years on the female participants.

Figure 10: STEM Attitude Score Differences between *FIRST* and the Comparison Group by Gender, Year 10



Controlling for Race, Honors Courses, Family Income, and Parental Support for STEM.

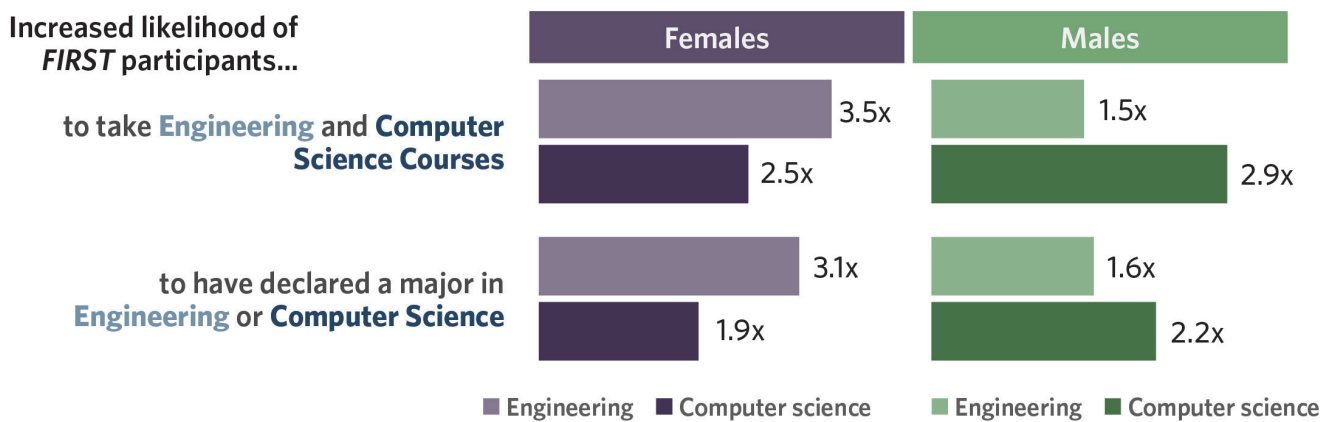
⁷ <https://www.stemwomen.com/women-in-stem-percentages-of-women-in-stem-statistics>

Course Taking and Majoring in College

We also find interesting gender differences in selecting Engineering and Computer Science courses as well as majoring in these fields during the fourth year in college, which for most is their senior year (see Figure 11). While both female and male *FIRST* participants are significantly more likely to take courses and major in these two fields than respective comparison students, the differences for *FIRST* females (vs female comparison students) in the likelihood of taking courses and majoring in Engineering is significantly greater than the difference for male *FIRST* participants. The difference in the likelihood of taking courses and majoring in Computer Science for *FIRST* males is greater than that for their female counterparts. These results show that *FIRST* is especially impactful for women turning to a career in Engineering.

Female FIRST alumni are more than 3 times as likely to major in Engineering than the comparison group females.

Figure 11: Likelihood of Engineering and Computer Science Course Taking and Majoring, Year 4 in College



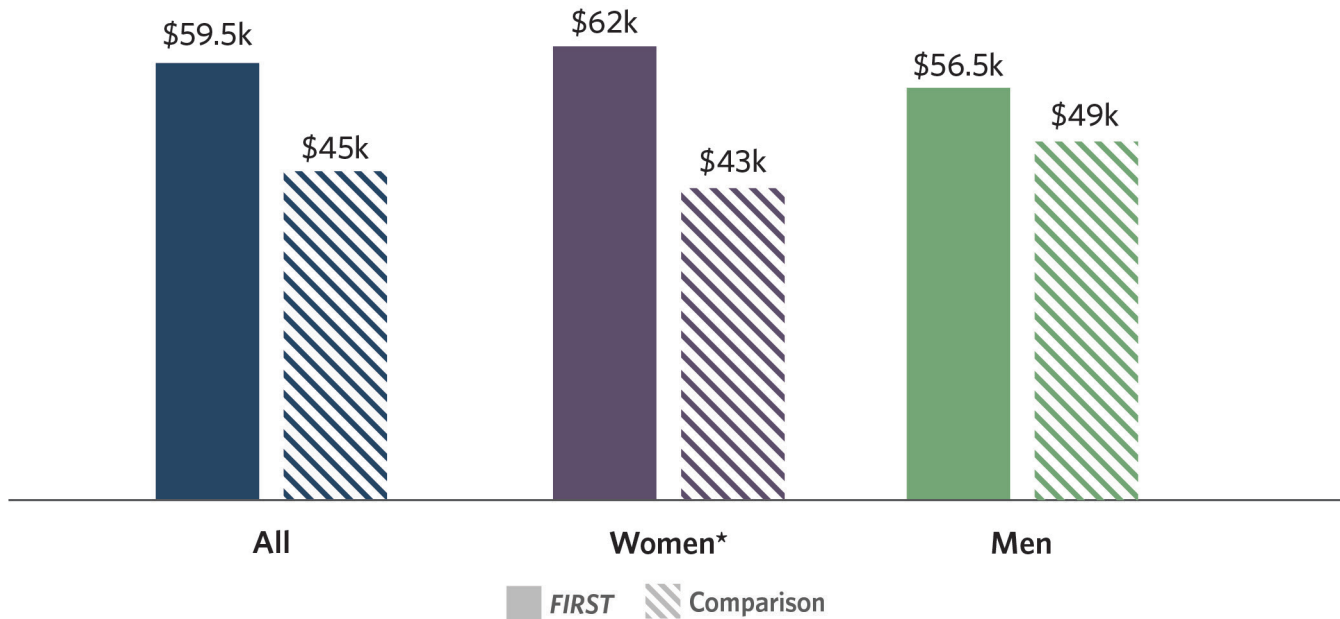
Controlling for, Race, Honors Courses, Family Income, and Parental Support for STEM.

“My FIRST experience helped me learn about my weaknesses and allow myself to get a better grasp on what I could do to improve myself academically and personally.”
- *FIRST* survey respondent

STEM Employment and Income

With just 60% of the entire sample employed at the end of the study, these data on employment outcomes should be regarded as preliminary. However, they depict interesting and promising trends. There are no gender differences on the STEM workforce related questions shown in Figure 6 on page 9. We find however, statistically significant differences on income. While for the entire sample and for men, we find that the higher reported incomes for *FIRST* participants are not statistically significantly different from the incomes for the comparison group, female *FIRST* alumni report significantly higher incomes that are close to \$20,000 more annually than female comparison students (see Figure 12 below).

Figure 12: Median Income overall and by Gender



National Data on Gender Outcomes in College and Employment

*Compared to a matched group of national young adults, female *FIRST* participants are more likely to work in STEM and earn significantly more.*

Results of gender comparisons using the national matched data underscore the survey results showing significantly greater proportions of *FIRST* male and female participants to major in STEM overall, as well as in Engineering and Computer Science specifically. The data also show greater relative likelihood of female *FIRST* participants to major in both Engineering and Computer Science than their male counterparts.

Early career data comparing the matched national sample with *FIRST* participants provide additional evidence on the *FIRST* impacts for females reported earlier in the report. These results show that female *FIRST* participants are more likely to work in STEM in relative terms (2.5 vs 1.7). They report significantly higher incomes over their national comparison group while the salary difference for *FIRST* male participants as compared to their national counterpart is not statistically significant.

Gender Differences in *FIRST* Program Experience and Outcomes

For the whole sample, being involved with building the robot and providing team support, and rating the overall quality of the program and the quality of the mentor relationship as high are important ingredients correlating with higher scores on all five STEM attitudes scales. There are notable differences, however, for female participants. While involvement in building the robot and higher ratings of overall quality of the program are correlated with higher post baseline levels on all five STEM attitude scales, and reporting a quality mentor relationship on three of these scales, providing team support is not correlated with any of the STEM attitude scales for female alumni. This indicates that involvement in the more gender typical work of supporting the team is related to positive outcomes for males, the same does not appear to be true for female *FIRST* participants.

Figure 13: Correlations of Program Experience and STEM Attitudes by Gender

| All <i>FIRST</i> Participants | STEM Interest | STEM Activity | STEM Careers | STEM Identity | STEM Knowledge |
|-----------------------------------|---------------|---------------|--------------|---------------|----------------|
| Males | | | | | |
| Building the Robot | + | + | + | + | + |
| Programming | | + | | | |
| Team Support | + | + | + | + | + |
| Quality Scale | + | + | + | + | + |
| Time in Program (> 1 year) | | | + | | |
| Mentor Scale | + | + | + | + | + |
| Participated in Competitions (7+) | | | | | |
| Females | | | | | |
| Building the Robot | + | + | + | + | + |
| Programming | | | | | |
| Team Support | | | | | |
| Quality Scale | + | + | + | + | + |
| Time in Program (> 1 year) | | | + | | |
| Mentor Scale | | + | + | | + |
| Participated in Competitions (7+) | | + | | | |

+ = Statistically significant difference

Female *FIRST* Alumni Reflections

The interview data with a diverse sample of female *FIRST* alumni shine some light on the consistently stronger impacts of *FIRST* on their female participants and underscore the long-term impacts of *FIRST* participation on young women's college experiences and entry into the workforce. The interviews also revealed gender specific challenges that some women experienced while in the *FIRST* program.

Positive long-term impacts discussed in the interviews include the skill sets developed in *FIRST* that the women described they still draw on. These range from technical presentation and leadership skills, to social emotional learning through the Core Values of *FIRST* including teaching Gracious Professionalism® and helping each other, including members of competing teams.

The interviews also focused on the challenges of being female in a male dominated field, from participating in *FIRST* to the workplace. In response to these challenges, the women developed a range of strategies and drew on what they learned to improve their ability to collaborate, be better prepared to engage with others in situations that called for group work, learn how to present detailed information, and learn how to think critically and ask questions.

The women in the interviews discussed at length the importance of good mentors who served as role models as well as highlighting negative mentor experiences. The lack of female mentors inspired some to take on that role and mentor girls in *FIRST*.

“I now work in aerospace. I don’t think I would’ve had the courage to enter such a male dominated field had it not been for my *FIRST* experience in high school.”

-FIRST interview study participant

A more detailed discussion of these interview data can be found [here](#).

Other Underrepresented Groups in STEM

In the following analyses, we were interested in testing if the differences found for the entire sample would hold true for underrepresented groups in STEM. We are particularly interested in underrepresented racial and ethnic groups. According to national statistics, the STEM workforce includes under 10% of African Americans and just 8% of Latinos.⁸ These analyses should be regarded as preliminary due to small sample sizes for the groups studied.

For the racially/ethnically underrepresented group that includes African Americans, Latinos, and Native Americans, higher post-baseline levels in scores were found for STEM Interest and STEM Careers, and also for STEM Activity and STEM Knowledge at a lower statistical threshold used for small sample sizes ($p < .1$). For the STEM Identity scale, the observed difference was not statistically significant albeit higher scores were found for *FIRST* participants. As can be seen in Figure 14, those from lower income households and those residing in either urban or rural neighborhoods report significantly higher gains in their scores on all five STEM Attitude scales.

⁸ <https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/>

Figure 14: *FIRST* Impacts on STEM Attitudes/Interest for Underrepresented Groups in STEM

| Outcomes | Economically Disadvantaged | Underrepresented Racial/Ethnic Groups | Urban | Rural |
|----------------|----------------------------|---------------------------------------|-------|-------|
| STEM Interest | + | + | + | + |
| STEM Activity | + | +* | + | + |
| STEM Careers | + | + | + | + |
| STEM Identity | + | (+) | + | + |
| STEM Knowledge | + | +* | + | + |

+ = Positive, statistically significant difference at p≤.05 +* = Positive, statistically significant difference at p≤.10
 (+) = positive but not statistically significant difference

College

As for the entire sample, we see significantly higher rates of majors in STEM overall and majors in Engineering and Computer Science specifically for all of the underrepresented groups we studied.⁹ The differences between *FIRST* participants and the comparison group are highest for racially/ethnically underrepresented groups and for those residing in urban areas .

Underrepresented racial and ethnic groups in FIRST are significantly and substantially more likely to major in Computer Science or Engineering.

Figure 15: *FIRST* Impacts on College STEM Majors for Underrepresented Groups in STEM

| | Economically Disadvantaged | Underrepresented Racial/Ethnic Groups | Urban | Rural |
|--|----------------------------|---------------------------------------|-------|-------|
| Any STEM Major | | | | |
| <i>FIRST</i> | 80.6% | 81.5% | 84.7% | 81.2% |
| Comparison | 61.3% | 57.0% | 62.1% | 64.4% |
| Engineering and/or Computer Science Major | | | | |
| <i>FIRST</i> | 60.3% | 58.4% | 61.1% | 57.4% |
| Comparison | 36.7% | 26.5% | 32.2% | 30.1% |

Controlling for baseline differences.

STEM Employment and Income

Resembling results for the entire group, *FIRST* participants in the underrepresented subgroups report significantly higher percentages working in STEM. They also report higher incomes, yet none of these differences are statistically significant.

⁹ Due to the small sample size for these groups, these results should be regarded as preliminary.

Program Experience and Outcomes

Even though the sample for the racially and ethnically underrepresented group in STEM was very small (N=110), we explored correlations between program experience and STEM attitudes for this group. There are some notable correlations between some of the components of program participation and the experience in *FIRST*. In particular, the results for participants of color underscore the importance of participating in building the robot and experiencing a high quality program. Building the robot was significantly correlated with higher scores on all STEM Interest scales (for STEM Careers at a lower significance level). Experience of a higher quality program was correlated with all scales except for STEM Careers (see Figure 16). None of the program components was significantly correlated with college majors, potentially suggesting other barriers during college.

Figure 16: Correlation between Program Experience and STEM Outcomes

| Racially/ethnically Underrepresented groups (N = 110) | STEM Interest | STEM Activity | STEM Careers | STEM Identity | STEM Knowledge |
|---|---------------|---------------|--------------|---------------|----------------|
| Building the Robot | + | + | +* | + | + |
| Programming | | | | | |
| Team Support | | | | | |
| Quality Scale | + | + | | + | + |
| Time in Program (> 1 year) | | | | | |
| Mentor Scale | | | + | | |
| Participated in Competitions (7+) | | | | | |

+ = Positive, statistically significant difference at $p \leq .05$ +* = Positive, statistically significant difference at $p \leq .10$



3. Impacts Beyond STEM

When asked for examples on how *FIRST* made a long-lasting impact, *FIRST* participants shared a range of responses. In this section, we summarize the responses on non-STEM specific impacts.

“FIRST created confidence in myself at a young age and helped me develop skills that I still use today as an adult, even though I am not interested in pursuing robotics/engineering anymore. My participation was a fundamental part of growing my identity as a young girl and definitely encouraged me to pursue a STEM-related career.”

- *FIRST* interview study participant

“FIRST definitely opened up my world at the time. I had played sports and other things like that most of my life, and then when I found robotics, it helped me understand different types of people. How to communicate with different people, and stuff like that. Just helped me be a better and more empathetic person.”

- *FIRST* survey respondent

“Most of what I have taken from my experience in FIRST is confidence. The ability to stand my ground and defend my actions and ideas from the criticism and/or dismissal of my bosses at work, as well as the ability to openly talk about what is important to me with complete strangers and end up with new friends.

- *FIRST* survey respondent

Overall, leadership, teamwork, effective problem solving, communication, public presentations at an early age were mentioned most often as the skills and experiences that stuck with participants and have been used in their work lives 10 years after. These quotes illustrate participant experiences.

“FIRST was actually the first place that I EVER did a public presentation in front of a group of people. Although it was scary at the time, the moment stuck with me to this day and I can confidently say that I used those skills many times in the future.”

- FIRST survey respondent

“FIRST showed me the world of engineering and problem solving. Recently I have been given many tasks that I initially had no clue how to complete, but through my FIRST experience I am both comfortable, confident, and effective in solving problems.”

- FIRST survey respondent

Both, female and male participants underscored impacts on effective communication and leadership skills, and gaining clarity on their career goals. In addition, female participants shared that what they learned in *FIRST* improved their research and advocacy skills. Male participants emphasized resilience and the ability to adapt, learning to take small steps to achieve larger goals, and knowledge on how to get ahead accessing competitive opportunities.

“FIRST robotics has shown me how to advocate for not only myself but my peers in a professional setting. I have no one except FIRST to thank for my excellence in communication, advocacy, and charity. FIRST demonstrated not only the ease of procuring social change but the steps in which are necessary to do so. I now have the professionalism, advocacy, organization, determination, and courtesy needed to advance my career in professional settings. Without FIRST I would not have been able to enact the organization, leadership, networking, and communication I’ve used to achieve the position I am currently in. Since working my way into this role I have received life changing opportunities and employment offers that could very well secure a long-term, stable career before I even complete my degree.”

- FIRST survey respondent

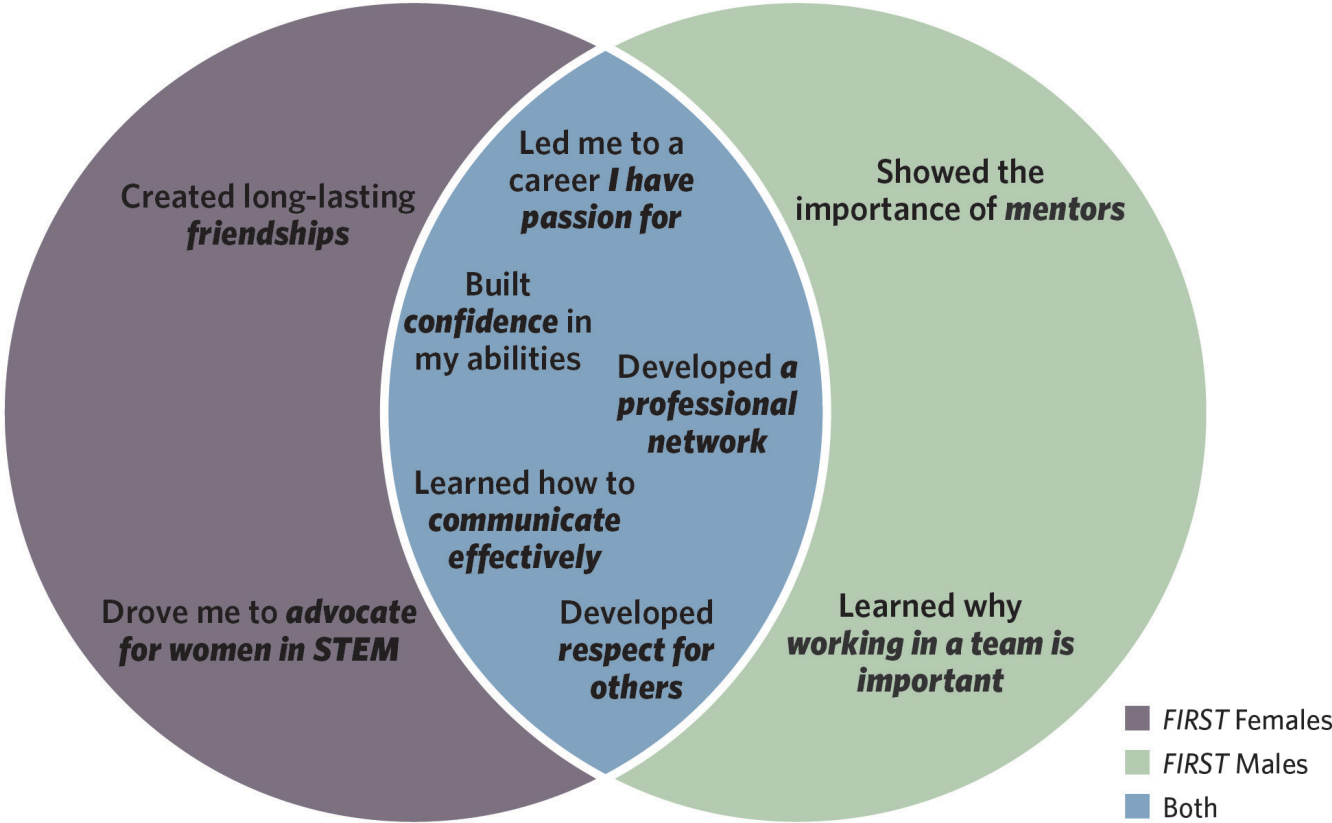
In our interviews with female *FIRST* alumni, many spoke of the challenges in a male dominated field and some alluded to how the *FIRST* experience prepared them for academic work and a career in STEM.

“In robotics engineering, everything tends to be very male-dominated, and being exposed early on and being able to take on leadership roles at a younger age in a male-dominated field just definitely makes you uncomfortable at first, but it’s something that you just start to realize, is very much important and very much needed in order to have that representation [of women]. And to keep driving that inclusiveness in those fields as much as possible.”

- FIRST interview study participant

Figure 17 below highlights lasting impacts on interpersonal skills, for all participants in blue, for female participants in purple on the left, and for male participants in green on the right. Confidence, passion, respect for others were influences highlighted by all, as was effective communication and creating a professional network. For women, long-lasting friendships and advocacy for women in STEM stood out. For men, the importance of good mentors and working in teams were critical.

Figure 17: Lasting Impacts on Interpersonal Skills



Gracious Professionalism® and Coopertition®

The Core Values of *FIRST*, Gracious Professionalism® (“encouragement of high-quality work, emphasis on valuing others, and respect for individuals and the community”)¹⁰ and Coopertition® (“embodies the spirit of competing while assisting and enabling others whenever possible”),¹¹ were central themes in the interviews with female *FIRST* alumni. Women often reflected on how these values were taught to them and have since become a part of their academic and professional lives. Some spoke about how they felt they learned emotional maturity from their time in the program, citing instances where conflict resolution was something they had to push for to keep order in tense moments.

¹⁰ <https://www.firstinspires.org/about>
¹¹ <https://www.firstinspires.org/about>

“Our group was such a group of ‘We’re doing what’s best for the group not best for the individual. How are we getting better as individuals to be better as a group?’ And I experienced the same thing. I got to college and people were cutthroat. I asked myself, how do I get better for myself instead? And whatever happens, I use the same gracious professionalism that I still carry in my life. That’s how I go about my day-to-day full-time job. It’s how I interact with people around me because you may not always like somebody, but you can always work with them and be gracious while doing it. I use it every single day. And I live by it now. It’s just been a part of my life for so long. I can’t imagine it being any other way.”

- FIRST interview study participant

“With coopertition, I will say FIRST does a great job in saying ‘your opponent in one match might be your ally in the next match.’ So you’re taught to always have a good competitive spirit...There’s no smack-talking. Everyone’s cordial, and they work well.”

- FIRST interview study participant

“And then in terms of coopertition, that was our MO. Some of the teams are like, ‘We’re not really into coopertition so much,’ but we were very much like, ‘Okay, if we can help other teams, we will because other teams help us too.’ It was great.”

- FIRST interview study participant

“I fully believe that gracious professionalism and coopertition fit into the right mindset to have. That’s what I teach my kids [on the team I now mentor]. I really think that trying to teach those values first helps with understanding how to run a team in the best way possible...For me, FIRST is about learning, growing, making mistakes, and becoming better people. But that’s not what a lot of teams think.”

- FIRST interview study participant





4. Conclusions and Next Steps

This unique longitudinal study that evaluated long-term outcomes provides ample evidence for the impact of *FIRST* on the participants in three of its out of school programs: *FIRST* LEGO League, *FIRST* Tech Challenge, and *FIRST* Robotics Competition. Consistently significantly higher scores on the STEM attitudes scales compared to the matched comparison group in all annual surveys show that *FIRST* can offer students the experiences that influence their school and career choices toward STEM into young adulthood. Similarly, significantly higher proportions of Engineering and Computer Science majors, and consideration of using STEM skills in their starting careers point to the long-term impacts that participation in any of the three *FIRST* programs can have. The results highlight the critical role that *FIRST* after school programs have in contributing to a more skilled STEM workforce.

Women are half of the workforce, yet only 26% work in a STEM field and just 15% as Engineers (U.S. Department of Labor, 2024). As the *FIRST* Longitudinal Study shows, the impacts on girls and young women are especially strong, with even greater impacts for them than for their male counterparts on all STEM attitude scales, on selecting college Engineering courses and majoring in Engineering, and on significantly higher incomes than the comparison group. This indicates the impact that *FIRST* can have on reducing gender disparities in STEM. Matched national data further support this trend and add scientific rigor to the results.

Further, significantly greater increases in STEM attitudes can be found for all groups typically underrepresented in STEM, including participants of color, participants from lower income families, and participants residing in urban and rural areas. These analyses for underrepresented groups in STEM, in particular for participants of color, are limited due to the small sample size for each of the underrepresented groups in STEM. However, the trends summarized in this report are promising and we plan to take a closer look at these groups in future work.

The interview study with female *FIRST* participants provides insights on why we see stronger long-term impacts for female participants and how they tap into the skills they acquired during their *FIRST* participation. These include technical, presentation, and leadership skills. These interview data also point to challenges that this group faces in the STEM field, at college, in the labor force, and for some also during their *FIRST* program participation, highlighting the importance of good mentors for female participants. Together with the program experience data, these results point to the importance of having female participants involved with the process of building the robot and in competition at the same rate as their male counterparts. *FIRST* coaches and mentors should support girls in *FIRST* in all technical aspects of the program and not assign them to more traditionally female tasks, such as providing team support, which are not correlated with better outcomes for them.

Aside from these very strong outcomes for the STEM fields, *FIRST*'s core components of Gracious Professionalism and Coopertition and other social and emotional learning impacts stay with participants 10 years after their engagement with *FIRST*. Participants report how these core principles stay with them during college and employment, and how they tap into them when having difficult interactions in these settings.

FIRST's interest and support for rigorous evaluation research is exceptional. Planning for a new evaluation study is under way. The tasks ahead will include broad and diverse *FIRST* stakeholder input to finalize the goals, target groups, measures, and comparison group for this new evaluation research. This new work will benefit from the changes that *FIRST* has implemented in the 12 years since the *FIRST* Longitudinal Study has been implemented and reveal important information shaping the field of STEM education in the future.