

***FIRST* Longitudinal Study:
Findings at Follow-Up
(Year 3 Report)**

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Background

FIRST (For Inspiration and Recognition of Science and Technology) is a national 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, that inspire innovation, and that 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 (FLL®) program serving primarily middle school-aged youth (ages 9-14), the *FIRST*® Tech Challenge (FTC®) serving grades 7-12, and *FIRST*® Robotics Competition (FRC®), serving high school-aged youth (grades 9-12). In 2014, *FIRST* reported that over 367,000 young people participated in its programs on more than 34,000 teams and competing in more than 1,800 tournaments worldwide.

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 FLL, FTC, and FRC 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?
- **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?

KEY FINDINGS AT FOLLOW-UP

- Follow-up data show *FIRST* has a positive impact on participants on all STEM-related measures, including interest in STEM, involvement in STEM-related activities, STEM identity, STEM knowledge, and interest in STEM careers. *FIRST* team members are 1.6 to 2.7 times more likely to show gains on STEM-related measures than students in the comparison group.
- STEM-related impacts are evident across all three *FIRST* programs in the study (FLL, FTC, and FRC) and across most population groups. Girls in *FIRST* continued to show significantly greater impacts than their male counterparts.
- Students who persist in *FIRST* for more than one year showed greater gains than those who left after a single year. Both groups show significant impacts relative to comparison students.
- On non-STEM measures related to self-concept, self-assessed life and workplace skills, and college readiness, *FIRST* participants and comparison group members showed comparable results, with no significant differences between *FIRST* participants and comparison students on any of the non-STEM outcomes.

- **To what extent are there differences in experiences and impacts among key subpopulations of *FIRST* participants?** In particular, are there differences in impacts among young women, white and non-white youth, and youth from low-income communities? If there are differences, what can we learn about why those differences occur and how to address them in the future?

To address these questions, the Longitudinal Study is tracking 1,270 students (approximately 820 *FIRST* participants and 450 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 FLL, FTC, and FRC 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 Team Leader surveys at the end of the first year of team involvement in the study provided additional contextual data on the *FIRST* teams. In each year of the study, team member surveys have also been supplemented by interviews and focus groups with team members and comparison group students.

Impacts at Follow-Up

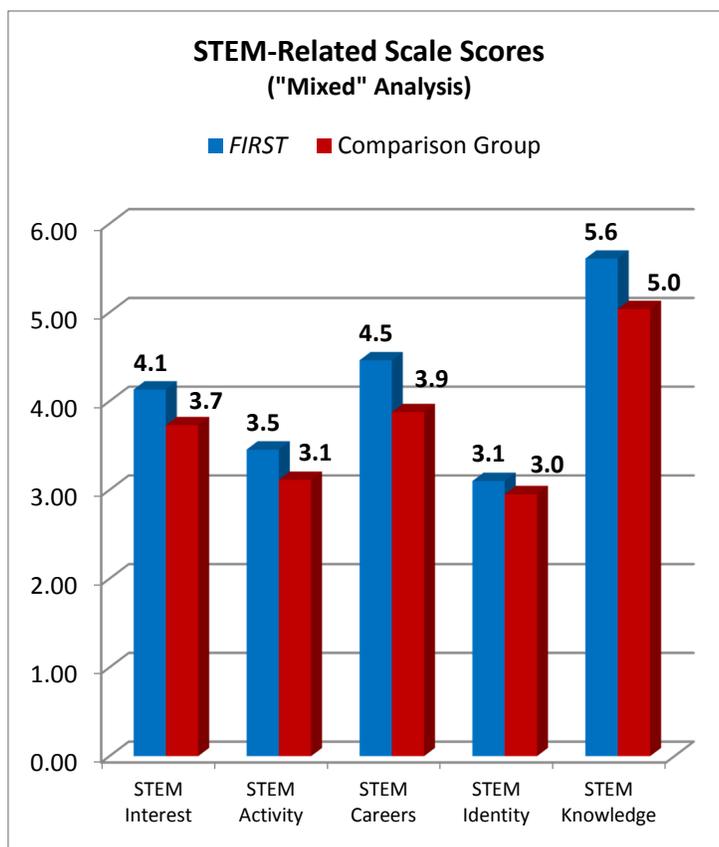
This report presents a summary of the impact findings based on the first three years of data collection, which includes data from baseline, post-program, and the one-year follow-up surveys of study participants. Of the 1273 students who began the study, 1076 students (85%) completed the follow-up survey, including 665 *FIRST* participants and 411 comparison students. (*FIRST* participants included 305 FRC, 189 FTC, and 171 FLL participants.)

This report updates and expands on the impact findings from the Year 2 report (January 2015). That earlier report included findings on the characteristics of *FIRST* participants and their program experience as well as a preliminary impact analysis. The impact findings reported here include additional analyses and are based on the full set of follow-up survey responses.¹ Major findings include the following:

Data from the first three rounds of surveys (baseline, post-program, and follow-up) show *FIRST* has a positive impact on participants on all STEM-related measures, including interest in STEM, involvement in STEM-related activities, STEM identity, STEM knowledge, and interest in STEM careers. *FIRST* team members are 1.6 to 2.7 times more likely to show gains on STEM-related measures than students in the comparison group.

¹ 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.

- **FIRST participants show positive, statistically significant impacts relative to members of the comparison group on all of the scale score measures of STEM-related interests and attitudes.** The average gains for FIRST participants on the STEM measures were significantly greater than those for comparison students (see chart to the right), including:²
 - 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 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 were also significantly more likely to show a gain on STEM-related measures than comparison students.**³ After adjusting for differences in baseline characteristics and baseline scale scores, FIRST participants were:
 - 2.5 times more likely than comparison students to show gains on *STEM interest*;
 - 2.5 times more likely to show gains in involvement in *STEM activity*;
 - 2.7 times more likely to show gains on interest in *STEM careers*;
 - 1.6 times more likely to show gains in *STEM identity*; and
 - 1.9 times more likely to show gains in *understanding of STEM*.

² Based on “Repeated Measures 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 three points in time (baseline, post-program, and follow-up). In this instance, the “mixed” results measure whether the average gains for FIRST participants were significantly greater than the gains experienced by comparison students.

³ Based on “Logistic Regression” analysis (“Logit”). Logit analysis estimates the relative probability that participants and comparison students will achieve a particular outcome, taking into account differences between the groups at baseline. In this case, the Logit analysis measures whether FIRST participants are significantly 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). The “odds ratio” produced by the Logit analysis is a measure of that relative likelihood (for example, “2.5 times more likely to show a gain in STEM interest.”)

- **STEM-related impacts are evident across all three FIRST programs in the study (FLL, FTC, and FRC).** Participants in all three FIRST programs in the study show significantly greater gains on STEM-related measures than comparison students (Exhibit 1). The plus signs in the table (+) indicate those outcomes on which FIRST had a positive, statistically significant impact when compared to the students in the comparison group.

Exhibit 1: Summary of Impacts, for All Participants and by Program

Outcomes	All Participants	FLL	FTC	FRC
STEM Interest	+	+	+	+
STEM Activity	+	+	+	+
STEM Careers	+	+	+	+
STEM Identity	+	+	+	+
STEM Knowledge	+	+	+	+

Note: Plus sign (+) indicates a positive, statistically significant impact at the .05 level or greater. Impacts for FLL are based on comparison to comparison group members in grades 5-8 at baseline; FTC and FRC impacts are based on comparison to comparison group members in grades 9-12.

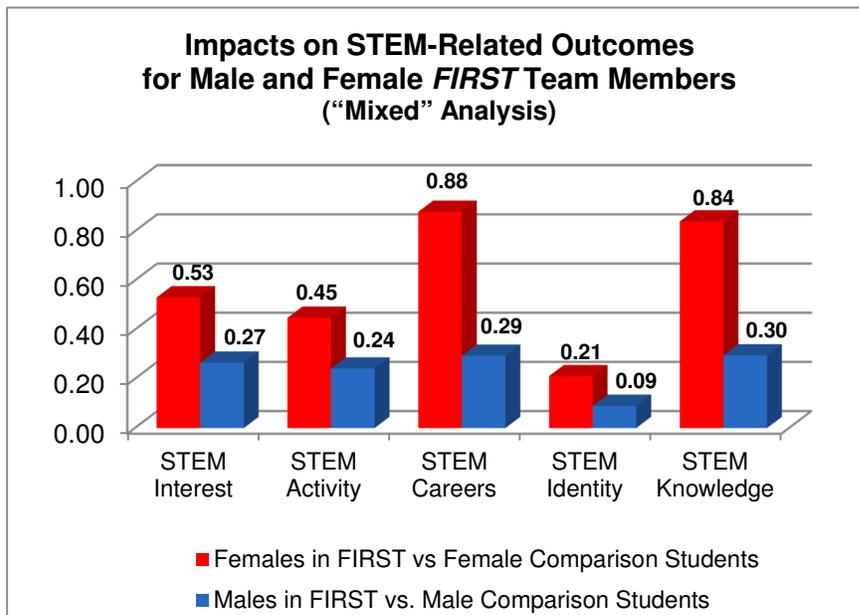
- **STEM-related impacts are also evident for all major population groups (compared to similar students in the comparison group).** Each of the following groups shows significantly greater gains than comparison students from the same population. (Exhibit 2):
 - males and females,
 - lower and higher income students (family incomes below and above \$50,000),
 - White and non-White,
 - lower and higher initial levels of STEM interest.

Exhibit 2: FIRST Shows Positive Impacts on STEM-Related Measures Across Major Population Groups

Outcomes	Males	Females	Low Income	High Income	White	Non-White	Initial STEM Interest Low	Initial STEM Interest High
STEM Interest	+	+	+	+	+	+	NA	NA
STEM Activity	+	+	+	+	+	+		+
STEM Careers	+	+	+	+	+	+	+	+
STEM Identity	+	+	+	+	+	+	+	+
STEM Knowledge	+	+	+	+	+	+	+	+

Notes: Plus sign (+) indicates a positive, significant impact at the .05 level or greater based on the “Mixed” method of analysis. Empty cells indicate no significant impact on that measure. Impacts are relative to comparable subgroups in the comparison population (for example, male FIRST participants compared to male comparison group members). Low income is defined as those whose family income is below \$50,000; High Income is defined as those whose family income is \$50,000 and higher. Students with “Low STEM Interest” were those whose scores on the STEM interest scale were in the bottom 25% of the distribution; “High STEM Interest” included those students in the top 75% of the distribution. NA indicates “Not available.”

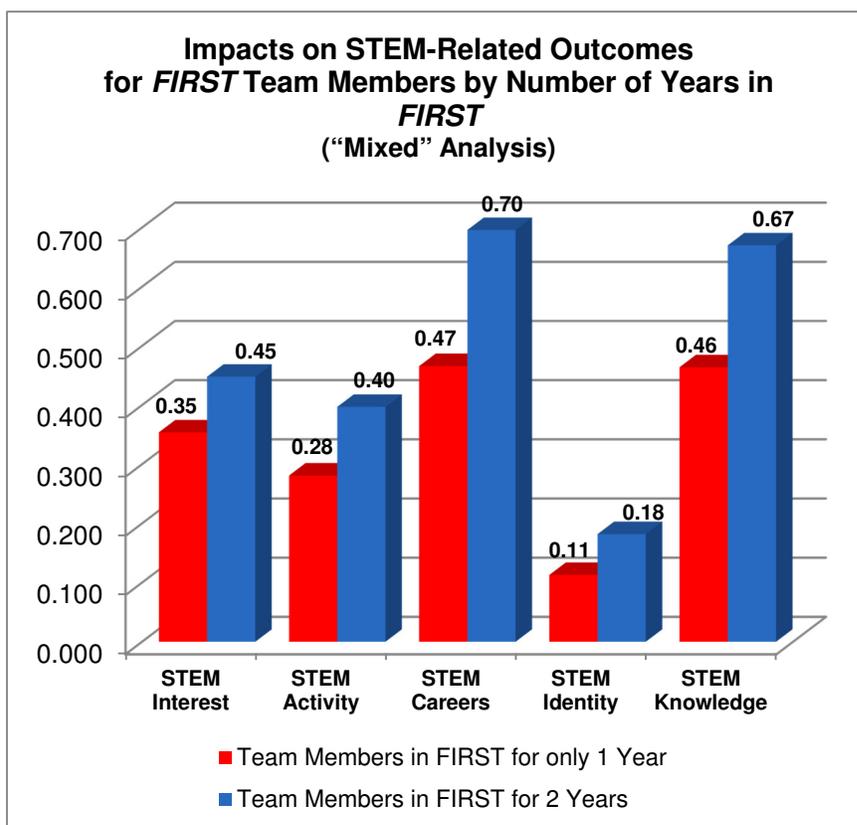
- FIRST continues to show significantly greater impacts on girls than their male counterparts on all of the STEM-related measures.** The chart to the right shows the differences in outcomes for girls in FIRST compared to girls in the comparison group, and for boys in FIRST, compared to comparison group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



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 the .05 level or greater.

- Students who persist in FIRST for more than one year showed significantly greater gains than those who left after a single year, though both groups show significant impacts relative to the comparison students.** Team members who stayed in FIRST for two years were also more likely to show gains than those who left after a year.

It is important to be cautious in interpreting this result, since the students who stayed in FIRST for two years were self-selected, possibly because they had a greater interest in STEM. However, the results do show that the program has a positive impact for those who stay only a single year and that those who persist continue to show positive impacts.



Note: Values on the chart represent the differences in outcomes (estimated scale scores) between FIRST participants and comparison students, showing separate results for FIRST participants who stayed in the program for 1 or 2 years. All differences are statistically significant at the .05 level or greater.

- **Finally, there are differences in outcomes among FIRST participants based on their level of involvement in team activities and the quality of their program experience.** In simple terms, team members with greater, hands-on involvement in team activities and a higher quality program experience were more likely to report gains on a wide variety of measures (Exhibit 3).
 - Team members who report that they were “Involved” or “Very Involved” in core team activities (reviewing rules or planning missions, designing and building the robot, programming the robot, operating the robot at tournaments, and fundraising to support the team) showed significantly greater gains on most STEM-related measures and on several of the non-STEM measures (including measures of self-efficacy, academic self-concept, and 21st Century Skills) than team members who reported being less involved in those activities. In general, team members with a more engaged, hands-on experience were significantly more likely to show positive outcomes than team members who were less actively involved.
 - Similarly, team members who rated their program experience highly (based on a set of questions about specific aspects of their program experience) showed significantly greater gains on **every** measure in the study. In short, the data suggest that the quality of the program experience is strongly associated with achieving positive outcomes.

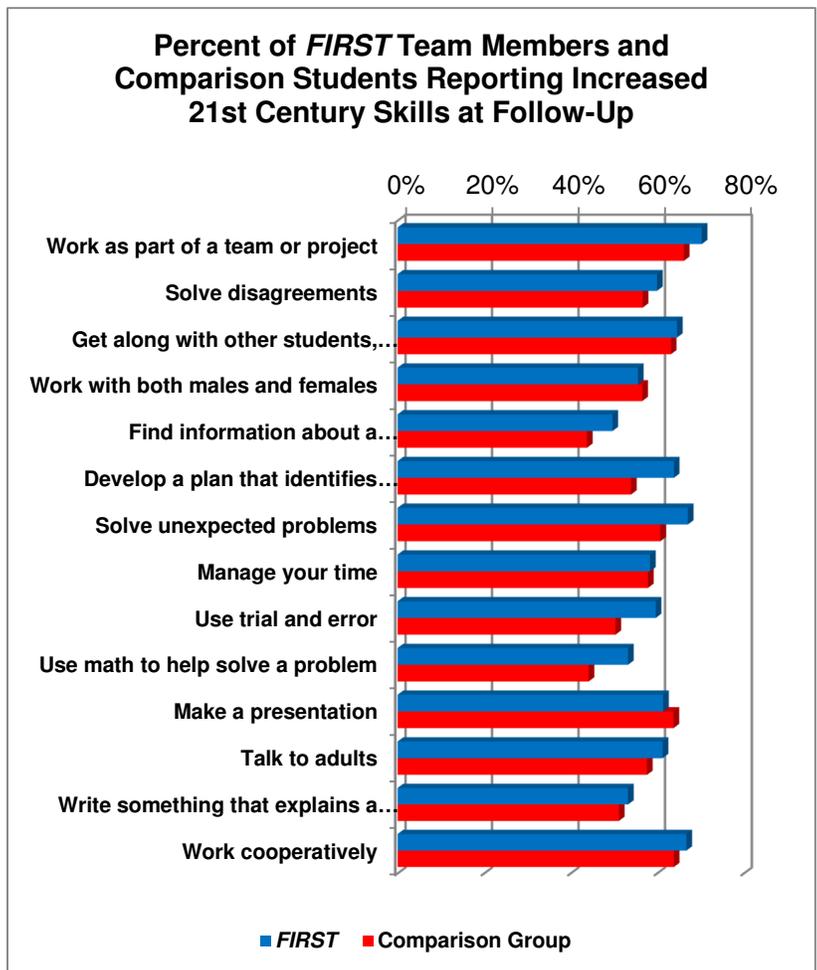
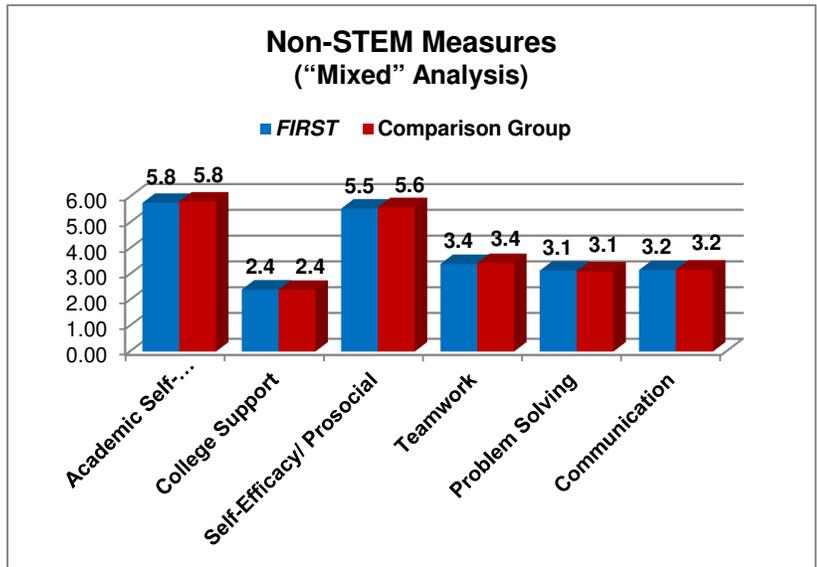
Exhibit 3: Greater Program Involvement and Higher Quality Program Experiences are Associated with Significantly Greater Gains on Key Outcome Measures

Outcomes	Comparing those with higher levels of involvement in each activity to those with lower levels of involvement in each activity:							Quality of Program Experience Scale
	Determining Mission/Strategy	Reviewing competition rules/gathering information	Designing the robot	Building the robot	Programming the robot	Operating Robot at Tournament/Competition	Fund-raising	
STEM Measures								
STEM Interest	+	+	+			+		+
STEM Activity	+	+	+			+		+
STEM Careers	+	+	+	+		+	+	+
STEM Identity	+	+	+	+	+	+		+
STEM Knowledge	+	+	+			+	+	+
Non-STEM Measures								
Academic Self-Concept	+				+	+	+	+
College Support	+	+				+	+	+
Self-Efficacy/ProSocial	+	+	+	+	+	+	+	+
21 st Century Skills (Combined)	+	+	+	+	+	+	+	+
Teamwork	+	+	+	+	+	+	+	+
Problem-Solving	+	+	+	+	+	+	+	+
Communication	+	+	+			+	+	+

Note: Plus sign (+) indicates a positive, significant impact at the .05 level or greater. Impacts are based on comparison between FIRST team members reporting higher and lower levels of involvement in core program activities and between FIRST team members who rate their program experience higher and lower on a measure of the quality of the program experience.

- The study also examined outcomes for a number of non-STEM measures related to self-concept, self-assessed life and workplace skills, and college readiness. On those measures, *FIRST* participants and comparison group members showed comparable results, with no significant differences between *FIRST* participants and comparison students on any of the non-STEM outcomes.⁴

The non-STEM results likely reflect the fact that both *FIRST* team members and comparison group students are engaged in a variety of activities that are designed to help build the same personal and life skills as *FIRST*. As the chart on the right shows, both *FIRST* team members and comparison students reported gains on a variety of teamwork, problem-solving and communications skills during the past year. Focus groups and interviews with *FIRST* participants similarly highlighted gains in those skills as well as in self-confidence and career awareness as a result of their *FIRST* experience. However, while *FIRST* participants report gains from their *FIRST* experience, over 80% of both groups report being engaged in extracurricular activities (sports, performing arts, clubs, etc.). School curricula also now increasingly emphasize the development of 21st Century skills, often through project-based learning activities. Consequently, both *FIRST* team members and comparison students are increasingly involved in an array of experiences and settings that promote personal and life skills development.⁵



⁴ Non-STEM measures include: academic self-concept, college readiness/support, self-efficacy, and self-assessed 21st Century skills (teamwork, problem-solving and communications skills).

⁵ When asked in the follow-up survey where they had learned specific skills, including communications, collaboration, using information, problem-solving and technology skills, roughly half of the *FIRST* participants and more than 60% of comparison students listed school and school projects as the place where those skills were developed. A separate set of telephone interviews with a random sample of *FIRST* participants and comparison students provided a similar set of findings.

Conclusion

Where *FIRST* continues to stand out from other youth programs is in its emphasis on STEM as the context for learning. That emphasis is reflected in the consistent, positive impacts on STEM-related interests and attitudes among those participating in the program. As the study continues, we will begin to see whether these short-term impacts on STEM-related attitudes lead to significantly increased involvement in STEM-related educational and careers for *FIRST* participants.