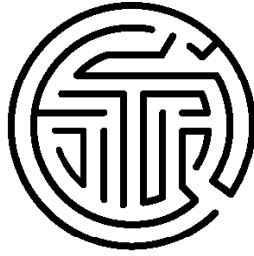




**EVALUATION OF  
NYC FIRST!**



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EVALUATION OF  
NYC FIRST!

PREPARED BY  
LAURA JEFFERS

**CENTER FOR CHILDREN & TECHNOLOGY**

EDUCATION DEVELOPMENT CENTER, INC. 96 Morton Street, 7th floor New York New York 10014 tel 212] 807.4200 fax 212] 633.8804 tty 212] 807.4284 web www.edc.org/CCT

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## EXECUTIVE SUMMARY

**F**IRST (For Inspiration and Recognition of Science and Technology) is a national organization whose mission is to design accessible, innovative programs that help young people build self-confidence, knowledge and life skills while motivating them to pursue opportunities in math, science and technology careers. FIRST engages teams of high school and middle school students, working with adult coaches and mentors, in researching, designing and building robots and participating in games of skill and strategy meant to transfer the enthusiasm youth feel for athletics to the field of math, science and engineering. Founded in 1992 by inventor and entrepreneur Dean Kamen, FIRST has grown from a single event attended by 28 teams to a slate of 23 regional events nationwide and a championship competition serving 800 teams. While the core activity is technological innovation, FIRST is a multidisciplinary activity engaging all academic disciplines in a school-based robotics “enterprise.”

In 1998, NYC FIRST! began an effort to engage New York City high schools in the FIRST experience. Four schools were involved that first year, and by the 2003 competition season there were 26 teams based at New York City high schools and 82 middle schools participating in FIRST-related activities. A major goal of NYC FIRST! is to engage low-income and minority students in science, technology, and engineering, especially in schools where resources and curriculum around these subjects might be limited. In addition to providing day-to-day support and technical assistance to teams, NYC FIRST! established an annual regional tournament in New York City.

In the fall of 2002, NYC FIRST! engaged EDC’s Center for Children and Technology to conduct a preliminary evaluation study of the initiative. For this study, which focused on five high schools, we conducted interviews with a range of stakeholders and observations of FIRST activities, all designed to investigate the following aspects of NYC FIRST!:

- Impact on students’ attitudes and skills
- Influence on school curricula and on teachers’ pedagogy
- Role in developing working relationships between teams, schools, and sponsors
- Effect on corporate partnerships and relationships to the outside community
- Implementation approaches of the schools

In this report, we present the findings of the study and discuss their implications for program development and further research.

## SUMMARY OF KEY FINDINGS

Our findings fell into several categories:

- Program implementation,
- Particularly patterns of recruitment and participation, and the roles of coaches and mentors;
- Impact on students;
- Impact on schools; and
- Impact on relationships with corporate sponsors and the outside community.

### Program Implementation

- Teams are similar in their goals, but vary in implementation depending on the goals and objectives of the school, the approach of the coach, and the interests of the students.
- Schools cast a wide net in their efforts to recruit students to the teams.
- Students participate in NYC FIRST! for a wide range of reasons, from social to academic to work-related.
- Coaches see themselves as facilitators, supporting students in driving the work of the team.
- Coaches are extraordinarily dedicated to their teams, often volunteering many hours of their time.
- Mentors often contribute large amounts of time, as well.
- Mentors often work with students beyond team activities, helping with such things as homework assignments and college applications.

### Impact on students

NYC FIRST! participation has a positive impact on students in three key areas: student engagement, building knowledge and skills, and developing community values.

#### **Student engagement**

NYC FIRST! promotes a high level of engagement among participants, which can raise their engagement in school overall. Several factors appear to contribute to students' engagement:

- Students pursue activities that are interesting to them.
- The program offers opportunities for students of diverse talents and backgrounds to make meaningful contributions to the team effort and to learn new skills.
- NYC FIRST! promotes a strong sense of responsibility among teammates.

- Learning is practical and self-motivated; students rarely seemed to be focused on learning for its own sake, but, instead, were motivated by the desire to complete the task at hand.
- Learning is largely hands-on and experiential.
- Coaches encourage team members to take on leadership roles.

### **Building knowledge and skills**

NYC FIRST! participants develop knowledge and skills in a range of specific content areas, including:

- engineering and design;
- computer programming;
- graphic design;
- mathematics;
- webpage development;
- writing;
- animation;
- marketing and public relations; and
- fundraising.

NYC FIRST! participants also develop and come to value a range of critical thinking and interpersonal skills, regardless of their roles on the team. And, participation helps students develop a sense of self-confidence and self-worth.

### **Developing community values**

NYC FIRST! promotes a set of values that include community service, mutual respect, and “gracious professionalism,” and emphasizes that the competition itself is only a part of the NYC FIRST! experience.

### **Impact on schools**

In examining the impact of NYC FIRST! on schools, we focused on three primary areas: schools’ relationships to the community, science and technology in school curricula, and teachers’ pedagogy.

- NYC FIRST! increased the visibility and the positive image of schools through media coverage and teams’ public appearances, community service activities, and sponsorship relationships with local companies.
- NYC FIRST! helped improve the schools’ images among their own students and teachers.

- NYC FIRST! has had an influence on school curricula in both direct and indirect ways, including:
- establishment of robotics curriculum;
- development of proposals for the creation of small schools with a focus on technology and robotics; and
- adoption and implementation of pre-engineering curriculum.

## Corporate Sponsors

NYC FIRST! provides corporate sponsors with valuable opportunities to contribute to workforce development and community support by enabling employees to share as mentors their skills and expertise with young people and by cultivating potential future employees of diverse backgrounds. Sponsors also feel a strong personal connection to the program and believe that NYC FIRST! offers students a good introduction to the real world of technology and engineering.

## Recommendations

Our recommendations focus on building infrastructure within schools to increase support for the teams and promote connections with curriculum, and the development of additional resources for schools, teams, and coaches.

### Recommendations for schools

- Assign a high-level administrator to act as liaison to the team.
- Engage more school personnel in taking primary responsibility for the teams to alleviate some of the stress on coaches and ensure year-to-year continuity for the teams.
- Help classroom teachers make connections to the work of the NYC FIRST!

### Recommendations for the NYC FIRST! program

- Provide training for coaches in areas related to building and facilitating a team, such as recruiting and supporting diverse students, managing conflict, and managing time.
- Provide training for staff who are not acting as primary coaches or who are facilitating a particular area of a team's work to introduce them to the program.
- Develop additional resources for coaches, including online documents providing guidance and tips for dealing with some of the challenges.
- Conduct a sponsors forum as an efficient way to interest potential sponsors in the program.



## For further research

There are several questions not answered by this study that may be worth exploring.

- What are the longer-term impacts of NYC FIRST! participation?
- Are there any barriers to participation within the schools, other than lack of time or interest?
- How can schools maximize the instructional impact of FIRST?
- How can schools create an infrastructure for FIRST that promotes curriculum connections and team continuity and reduces some of the stress that coaches experience?
- What motivates coaches' extraordinary dedication to their teams?
- What impact do coaches' roles in the schools have on NYC FIRST! teams?

## INTRODUCTION

### Overview of the program

FIRST (For Inspiration and Recognition of Science and Technology) is a national organization whose mission is to design accessible, innovative programs that help young people build self-confidence, knowledge and life skills while motivating them to pursue opportunities in math, science and technology careers. FIRST engages teams of high school and middle school students, working with adult coaches and mentors, in researching, designing and building robots and participating in games of skill and strategy meant to transfer the enthusiasm youth feel for athletics to the field of math, science and engineering. Founded in 1992 by inventor and entrepreneur Dean Kamen, FIRST has grown from a single event attended by 28 teams to a slate of 23 regional events and a championship competition serving 800 teams. In addition to the high-school robotics competition, FIRST runs FIRST LEGO League, designed to provide middle school children with an age-appropriate version of the FIRST experience. FIRST also offers activities and workshops for children and adults at its New Hampshire headquarters.

While the core activity is technological innovation, FIRST is a multidisciplinary activity engaging all academic disciplines in a school-based robotics “enterprise.” In addition to exposing young people to the possibilities of science, technology, and engineering, FIRST promotes community service, good sportsmanship, and what it call “gracious professionalism,” which means treating even opponents with respect and taking responsibility for improving one’s community and introducing others to the value of science, technology, and engineering. These values are espoused in the FIRST materials and are also encouraged through the structure of the game and system of awards.

A pre-competition survey conducted in 2000 and completed by 3,100 new and returning NYC FIRST! participants<sup>1</sup> found that:

- Returning FIRST students’ attitudes about science and math were significantly more positive than those of new students;
- Returning FIRST students’ perceived knowledge of science and math careers was significantly greater than that of new students;
- Returning FIRST students were significantly more likely than new students to indicate their intention to continue pursuing science, math, engineering, and/or technology in the education and career arenas;
- Returning FIRST students had significantly more positive attitudes about the working world than new participants; and
- Returning FIRST students’ self images were significantly more positive than those of first-time participants.

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<sup>1</sup> FIRST – Summary of Performance, Proof of Impact, and Evaluation Efforts [www.usfirst.org/about/impact.pdf](http://www.usfirst.org/about/impact.pdf)

In 1998, FIRST began an effort to engage New York City high schools in the FIRST experience. Four schools were involved that year. By the 2003 competition season, the number of teams based at New York City high schools had grown to 26. To promote and support the program NYC FIRST! undertakes a wide variety of activities, including:

- Providing technical workshops for mentors and coaches;
- Providing technical support for teams;
- Connecting New York City teams with potential corporate sponsors and mentors
- Establishing a NYC FIRST! LEGO League tournament, a robotics activity for students ages nine to fourteen;
- Establishing the NYC FIRST!/Verizon Webmaster Academy, a six-week summer program in which students learn about website technologies and their uses in business and communities;
- Initiating the NYC FIRST! presidential Classroom Scholarship program, through which students attend week-long sessions with leaders from the public and private sectors on the impact of science and technology on social and public policy;
- Presenting Project Lead the Way (PLTW) to NYC FIRST! schools, five of which adopted the pre-engineering program, which provides curriculum and professional development to participating high schools; and
- Advocating for FIRST-related college scholarships at engineering schools throughout the nation.

A major goal of NYC FIRST! is to engage low-income and minority students in science, technology, and engineering, especially in schools where resources and curriculum around these subjects might be limited. As a part of the effort to make the FIRST experience accessible to these students, NYC FIRST! established an annual regional competition in New York City, enabling schools that might be hard pressed to raise travel funds the opportunity to compete locally.

### *NYC FIRST! in the Schools*

A NYC FIRST! team is facilitated by one or more adults from the school, ranging from classroom teachers to assistant principals. In addition, adults from outside the school building participate as mentors. These volunteers are often engineers from large companies, but they may also be parents and other members of the community. In this report, we refer to school personnel as “coaches” and non-school volunteers as “mentors” (though these terms are sometimes used interchangeably by the adults and students we spoke with for this study).

NYC FIRST! teams vary widely with regard to operating structures and available resources. Some have high-powered professional mentors, while others are limited to school-based personnel. Some have access to machine shops and other facilities, while other teams use much more limited resources to build their robots.

Typically, NYC FIRST! teams work outside of class time, mostly after school but also during lunch and free periods. In most cases, teams begin organizing in the fall. While the competition rules aren't announced until January, teams spend the first few months of the school year choosing a theme, raising money, and doing public relations and community service activities. In some cases, team members experiment with new designs for basic components, such as drive trains, that they expect will be part of the robot, practice driving with robots from previous years, and prepare new team members for their roles in designing, building, and operating the robot.

In addition to designing and building robots, there are a number of other activities associated with NYC FIRST! participation. Teams may develop websites, design costumes, mentor rookie robotics teams and middle schools participating in the NYC FIRST! LEGO League, do community service, prepare applications for various awards, and document their activities and impact on the community. Some teams create cheers, dramatizations, mascots, and other expressions of team spirit. There are also administrative jobs – each team has a team captain or two co-captains and students who are responsible for reviewing the complex specifications for the robots and rules for the competition, and tracking the frequent team updates issued by the game organizers.

The parameters of the game, which change every year, are announced in January, and teams have six weeks to design and build their robots. When teams register for a competition they receive a kit of technical components sufficient to build parts of a robot, but they need to use additional, purchased or donated, materials to complete them. Teams have the option of entering any number of regional competitions around the country and can qualify to attend the championship event in a number of ways, including winning a regional event and winning one of a number of regional awards.

FIRST awards are not directly connected to how teams fare in the competition itself, but rather recognize team efforts and accomplishments in such areas as entrepreneurship, team spirit, and website design. The most prestigious of these, the Chairman's Award, is granted to the team that best embodies the FIRST values of gracious professionalism and community service. Several of the awards have college scholarships associated with them- Polytechnic University in NYC, for instance, put up a \$7500 scholarship for each student on the team that won the engineering award at the 2003 regional event in New York City, and \$10k and \$5k scholarships for other accomplishments. All NYC FIRST! participants are eligible to apply for \$4 million in scholarships at colleges around the country, regardless of their teams' standings in the competitions.

The costs of participating in NYC FIRST! typically range from \$15,000 to \$30,000 per year.<sup>2</sup> These costs include registration for one or more competition event (\$5,000 for the first event entered and \$4,000 for each additional event), through which teams receive the kit of technical components, valued at \$15,000, a variety of programming software packages, shipping, and a \$450 credit for catalog purchases of additional parts. In 2003, teams also received a micro robotics kit for introducing students to the basic concepts of robotics. Teams also pay for any additional parts and equipment for the robot; travel and accommodation expenses, and other items such as team

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<sup>2</sup> FIRST Volunteers' Handbook <http://www.usfirst.org/robotics/volbook/#principal>

tee shirts or uniforms, stickers, buttons, and sponsor signs. Teams also provide food for students working into the evening hours and on weekends.

Teams' corporate sponsors underwrite some of these costs and may make in-kind donations of equipment and materials, as well. The teams must raise the rest of the money from other sources or pay for expenses themselves. Some of the fundraising strategies teams employ include recruiting new sponsors, often local businesses; holding car washes or bagging days at local supermarkets (the market allows the students to bag groceries and shoppers are asked to make a contribution to the team); and selling a variety of products within the school community, including cookies, pencils, buttons, and books of coupons to popular stores and restaurants.

## Overview of the evaluation

In the fall of 2002, NYC FIRST! engaged EDC's Center for Children and Technology to conduct a preliminary evaluation study of NYC FIRST! in New York City. In this report, we present the findings of the study and discuss their implications for program development and further research.

The study was designed to provide information about the impact of NYC FIRST! on students, schools, and sponsors in New York City. Specifically, we investigated the program's implementation in the schools; its impact on students' attitudes and skills; its influence on school curricula and on teachers' pedagogy; working relationships between NYC FIRST! teams, schools, and sponsors. and its effect on corporate partnerships.

The study focused on five high schools. These schools were selected to represent the following: geographical diversity; student populations variety in program type, both academic and vocational programs; and variety in length of participation in NYC FIRST!. Two of the schools are located in the Bronx, two in Brooklyn, and one in Staten Island. Three of the schools have academic programs, and two combine vocational training with academics. They have participated in NYC FIRST! between two and four years. In addition, the schools in the sample have varying levels of access to resources such as equipment, work space, engineering and mechanical expertise.<sup>3</sup>

All but one of the schools in the sample have a higher percentage of minority students than the average for New York City public high schools. The sample represents a range of sizes (677 to 3,058 students), eligibility for free lunch (41%-82% of students), average amount spent per student (\$7,331-12,592 annually), and percent of seniors graduating (31%-61%). Four of the schools have more male students than female, the difference being most marked at the schools that offer vocational programs. (See Appendix A for detailed demographics.)

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<sup>3</sup> One of the schools, George Westinghouse High School, is involved in the IT Career Cluster Initiative, a project of EDC in partnership with the Information Technology Association of America and the National Alliance of Business. EDC's Center for Children and Technology has no connection to this initiative, nor do any of the staff associated with the evaluation of NYC FIRST!.

Over a six-month period, we interviewed a variety of stakeholders, including:

- Principals
- Coaches (school personnel)
- Mentors (non-school personnel)
- Corporate and technical sponsors
- Students
- NYC FIRST! program directors

Student interviews were conducted both informally at the teams' working sessions, while they were designing and building their robots, and in formal group interviews, conducted after the New York City regional competition, in which all the teams in the sample participated.

We conducted observations of four of the teams during the design and build phase, and of all of the teams at the regional competition in New York City.

Finally, we reviewed the FIRST website and the websites of individual teams, as well as a variety of documents, including progress reports and team updates.

*(See Appendix B for detailed methodology.)*

## FINDINGS

Our findings fall into four main categories:

- Program implementation
- Impact on students
- Impact on schools
- Impact on relationships with corporate sponsors and the outside community
- Challenges

### Program implementation

#### *Recruitment*

Teams assemble early in the school year, though some begin recruiting new members the year before. According to the coaches and students we spoke with, everyone is welcome to join the team if they have the interest (and in some cases, the minimum academic standing required for participation). Teams make an effort to recruit students from the lower grades so that they have some time to develop skills and expertise and prepare to move into leadership roles as older students graduate.

Students come to the teams in a variety of ways. They may hear about the team through a presentation or demonstration, or they may be recruited by friends, teachers, guidance counselors, or the team coach. Teachers and coaches approach specific students for a range of reasons, as well. In some cases, coaches tap students who excel at math or science to give them an opportunity to apply their knowledge and take on new challenges; students who are struggling may be invited in the hope that the NYC FIRST! experience will help them become more engaged in school. No specific groups appeared to be targeted by the teams we observed, though some of the coaches expressed a concern about recruiting girls which they addressed by approaching girls individually and encouraging them to check the team out.

Students join the NYC FIRST! team for a variety of reasons. Some want to pursue an interest in robotics, mechanics, graphic design, or computer programming. Several students said they had no particular interest in robotics when they joined the team, but, rather, were attracted by one of the other aspects of NYC FIRST!. Some are persuaded by teachers and friends or are attracted by the prospect of meeting new people. One co-captain said that the opportunity to apply for FIRST-related college scholarships was a draw.

#### *Participation*

NYC FIRST! teams assemble in the fall and begin to plan their work and assign roles. A team might start out with 50 students, and at least some students typically leave, usually during the

first few weeks. According to participating students, most who leave do so because they feel the work requires too much time or they have other conflicting commitments, according to students and coaches. One mentor felt that students sometimes leave because they feel overwhelmed by the amount of work involved. In three of the schools we visited, a core group of perhaps 10 to 15 students continued working on the various tasks associated with NYC FIRST! through the spring competitions. In other schools the numbers were higher.

Participation in the sample schools is voluntary, and there are no attendance requirements. Some of the schools do require students to maintain passing grades in order to stay on the team, however, and at any given time a few students might not be participating because of poor grades, but in most cases they are still considered part of the team and return to team meetings and activities when their grades have improved.

Students choose roles on the team based primarily on their own interests. This may shift over the course of the year, depending on students' changing interests and on the needs of the team. On some teams students have fairly specific roles, while on other everyone does a little bit of everything. On several of the teams we observed, students took responsibility for particular areas of work, such as creating a website or working on the robot itself, though this didn't preclude the possibility of getting involved in other areas, either when they themselves were interested or when teammates needed assistance. Students on another team explained that they each did whatever job was needed at the time, and that everyone on the team was involved in most aspects of the work at one time or another.

The students we spoke with said that there were always opportunities to learn something new on a NYC FIRST! team, and that, in fact, if a student expressed an interest in learning something, the rest of the team, both adults and students, would see that they did so.

### *Coaches*

Coaches reported deriving a great deal of satisfaction from their participation in NYC FIRST!. They were proud of their teams' accomplishments, both in terms of the competitions and students' personal growth and achievements. They valued their participation in NYC FIRST! as an opportunity to help students gain self-confidence and a sense of accomplishment, which they felt some students rarely experienced in other parts of their lives. They were also inspired by the students' own dedication and drive. They all felt that because of the benefits to their students the NYC FIRST! experience was worthwhile despite long hours, scarce resources, and the pressures of deadlines and competitions.

This intense involvement appears to contribute to the positive nature of students' experiences, as well. Students are very much aware of the dedication of the coaches. Several students in our interviews told us about the time and effort their coaches put in; they understood that much of this work was done on coaches' personal time, which reinforced their sense of the coaches' personal investment in them and contributed to their own commitment to the team.



As with the organization of the teams, coaches' roles and backgrounds vary from school to school. Two of the lead coaches we spoke with have broad responsibilities within their schools. One is the coordinator of student activities, which include field trips, proms, etc, and the other is an assistant principal. Both of these coaches are familiar with most or all of the students in the school, and are familiar to the students. A third is a mathematics teacher who works closely with a school administrator on the NYC FIRST! project; the teacher handles the day-to-day facilitation of the team while the administrator facilitates access to resources and support. Of the other two coaches in our sample, one runs an entrepreneurship program and the other teaches in the C+ certification program.

While all of the coaches are responsible for overseeing the entire team process, some work closely with students on specific tasks and others maintain a more administrative role. The coaches of four of the teams in our sample participate in designing and building of the robots to various degrees, for instance, while the coach of the fifth team leaves the technical and engineering work to the mentors, one of whom works with students every day after school and on weekends during the design and build period. The degree to which coaches are involved in the hands-on robot work appears to be influenced by a combination of the coaches' own expertise and interest in that area and the availability of other adults to model and supervise the process. In addition, the coaches who are involved in the design and build process reported driving the design process to varying degrees. One coach explained that he and the mentors take the lead on designing the robot, while on other teams the students spearhead the design process and the adults act as advisors.

In virtually all other areas, all the coaches said they encourage students to work things out for themselves. A coach may suggest time management strategies, for instance, but leave it up to the students to mobilize and get work done. Based on our observations, however, it appears that a coach (or mentor) may at times take charge of a specific tasks associated with the robot itself and direct students to do specific jobs. We asked students how much of the actual hands-on work was done by students and how much by adults. Most students estimated about 75% of the work was done by students. Some explained that some of the adult hands-on work was done in demonstrating processes to students.

FIRST materials are candid about the fact that coaching a team requires a great deal of time and effort, especially during the design and build phase, and both coaches and students reported this to be the case. It is not unusual for teams to work seven days a week while building their robots, and coaches are often on hand with their teams after school and into the evening during the week, and as much as twelve hours a day on weekends. Some coaches receive per-session pay for some of this time, though not all of it, but others work entirely on their own time. Coaches often provide food for teams when they work late, as well, and one coach in the study drove students home if the team broke up after dark.

The coaches in our sample identified their schools' relative lack of resources compared with other participating schools outside of New York City as a challenge. They made reference to other schools that have their robots built for them by local manufacturers, and schools and parents that have the financial resources to enable teams to purchase more sophisticated materials.

The degree of support from administrators can pose an additional challenge for coaches. In some cases, administrators take an active role in coordinating and finding resources for teams, which provides some degree of infrastructure for the program within the school. In other cases, the coach bears the majority of the responsibility for these tasks, which increases an already significant burden.

The intensity of the coach's role can have drawbacks for the teams, as well. In one instance, a coach left his school on short notice shortly before the design and build period started, leaving the team without an adult leader. Another adult who had less technical expertise and less day-to-day experience with the team stepped into the role, but students reported that they lost valuable working time as the new coach was getting up to speed.

### *Mentors*

The mentors we spoke with reported a high degree of satisfaction for many of the same reasons as the coaches – they valued being able to help students develop skills and self-confidence and work together to create a product they could be proud of. They felt invested in the students and often support them in efforts outside the team, tutoring them in math and science and advising on college application essays, for examples.

By and large, mentors' roles are related to the designing and building of the robots. They may be employees of sponsoring companies like Con Edison and Keyspan, university faculty, school alumni, or students attending local colleges, some of whom participated in FIRST in their hometown high school and sought out the opportunity to mentor when they arrived in New York. In several cases, alumni returned to act as mentors.

Mentors put in varying amounts of time, ranging from one or two afternoons a week to every day after school and on weekends. The commitment of one veteran mentor paralleled that of the coaches; he took primary responsibility for overseeing the design and build phase, working with the team six or seven days a week.

### **Impact on students**

In examining the impact of NYC FIRST! on students, our findings fall into three categories: student engagement, building knowledge and skills, and developing community values. Our data suggests that NYC FIRST! participation has a positive impact on students in each of these categories.

Students expressed a high degree of long-term commitment to their teams and were invested in a range of the teams' efforts, from preparing the robot for competition to raising funds to publicizing the team to creating websites. The variety of activities involved in NYC FIRST! offered stu-

dents opportunities to develop skills and knowledge in a wide range of areas, including technical skills, academic content knowledge, and interpersonal and leadership skills. Among the aspects of the NYC FIRST! experience that students said they most valued were the supportiveness of the teams and opportunities to work with others.

## Student engagement

A high degree of engagement was evident in students' strong commitment to their teams and sense of responsibility toward their teammates, their enthusiasm for the tasks they were involved in, and the amount of time they voluntarily committed to the team. These observations corresponded with those reported by coaches, mentors, and sponsors. As one mentor put it: "When they start wanting to get their two cents in, you know they're hooked." All the students we spoke with said that they planned to return to NYC FIRST! in the next school year; this included several graduating seniors. Two of the teams we observed included graduates who had returned to act as mentors themselves.

Several factors appear to contribute to students' engagement in NYC FIRST!. There are a variety of ways to make a meaningful contribution to the team, and students reported that they pursued the activities that they were most interested in. There are opportunities both to share their strengths with the team and to learn new skills; students consistently reported that whenever a team member was interested in something they didn't know how to do, the more skilled students would teach them, as would coaches and mentors. A number of students were clearly proud of having some expertise in a particular area, such as electrics, driving (controlling the robot remotely), organization, or computer graphics, many of which they had gained through participation on the team. Students also reported having a strong sense of responsibility to the team and their teammates. They were committed to a shared goal and were motivated to take on tasks that might not otherwise have appealed to them.

Among all of the NYC FIRST! teams we observed, learning is practical, self-motivated, and hands-on. When one team was working on variations of their drive train, for instance, one of the participants set out to learn spreadsheet software and used it calculate and compare the effects of different gear ratios. Students rarely seemed to be focused on learning for its own sake, but, instead, were motivated by the desire to complete the task at hand.

As mentioned earlier, coaches encourage students to take the lead on NYC FIRST! teams, and mentors often take this approach, as well. One mentor, an accomplished engineer, said that he wouldn't do design work for his teams, for instance – he felt that the students learned more by going through the process themselves and making their own mistakes, just as he and his colleagues do every day. As a result, the students see themselves as being in charge of the work; while they reported receiving a great deal of support from the adults involved in the project, they felt that it was their shared responsibility to make critical decisions and carry them out.

Adults also believe that students' high level of engagement in NYC FIRST! raises their engagement in school overall. Several of the schools in this study require NYC FIRST! participants to maintain good academic standing, and coaches, principals, and students told us that team members worked to keep their grades up, specifically, to be able to continue participating on the team. They said that NYC FIRST! participation can have a similar impact on attendance; one student explained that in his freshman year he frequently cut classes, but when he joined the team in his sophomore year, he was motivated to attend team meetings every day, and started attending classes regularly, as well.

## Building knowledge and skills

Students, coaches, and administrators reported that NYC FIRST! participants develop knowledge and skills in a range of specific content areas, including engineering and design, computer programming, graphic design, mathematics, and webpage development, depending on their role on the team.

Students learned the technical aspects of robotics and engineering "on the job" from coaches and mentors, as well as from one another. In the fall and early winter, some of the students (and adults) also attended workshops on topics related to their area of work for the team, such as hydraulics and electrics, where they learned specific skills. A mentoring guide available on the NYC FIRST! website<sup>4</sup> encourages adults to demonstrate a process and then delegate tasks to students, allowing students to do as much of the actual work as is safely possible. In the instances we observed, this was an informal process rather than a structured tutorial and was embedded in the process of building the robot, occurring as the need arose – a mentor or coach would show one or more students how to do a certain task or how to use a particular tool properly, and then supervise as the students practiced.

Each team has marketing and fundraising committees, as well, and these students develop public relations plans and fundraising strategies, which often include writing letters and making presentations to corporate executives and local business owners and mounting fundraising campaigns in the school and the community.

Other activities that students might engage in as part of the NYC FIRST! experience include website development, video documentation of the team's work, and animation.

What students learn in each of these areas depends on what jobs they do on the team, which is largely determined by their own interests. On one team where discrete sub-groups manage each of the areas of work, students working on public relations and fundraising reported learning little about the technical aspects of robotics and engineering, for instance, while their peers who concentrated on building the robot reported little or no involvement in administrative tasks, marketing, or web design. On another team where the work is more distributed, most participants said they learned at least a little bit about all the different areas.

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<sup>4</sup> FIRST Mentor Guide [www.usfirst.org/robotics/mentorgde.pdf](http://www.usfirst.org/robotics/mentorgde.pdf)

Across the board, interviewees reported that NYC FIRST! participants develop and come to value a range of critical thinking and interpersonal skills, regardless of their roles on the team. Foremost among these were teamwork skills, such as developing effective working relationships, working collaboratively, resolving conflicts, communication, and problem solving. Team captains were especially articulate about the process of resolving conflicts among team members and their own role in that process, for instance, and a number of students reported having to learn to work well with teammates they didn't necessarily like. One mentor said: "Younger teams often think it [NYC FIRST!] is about the robot and the competition, but it's really about the team."

Students and adults often reported that NYC FIRST! participation helped students develop a sense of self-confidence and self-worth. They attributed this largely to the fact that participants have multiple opportunities to contribute valuable skills and knowledge to the team effort, and multiple ways in which to succeed. Coaches' and mentors' investment of time and attention and the social and interpersonal skills students gain through collaborating with teammates contribute to this, as well. A coach described a student who was prone to disruptive behavior and whose grades were suffering when he joined the NYC FIRST! team; as the student discovered that he could make key contributions to the team and other team members starting turning to him for guidance, his grades improved and behavior issues virtually disappeared. Students also reported gaining confidence in speaking publicly and contributing their ideas in group discussions.

Certain positions on the teams offer particular opportunities to develop leadership skills. Captains and co-captains we spoke with were quite articulate about their roles and strategies in helping their teams brainstorm ideas, make decisions about robot design and other team issues, and facilitating conflict resolution. One coach talked about his team's captain growing into the role as he faced these challenges. In addition to the captain position, the teams have students who are responsible for reading the complex specifications for the robots and the game rules, which are available on the NYC FIRST! website and are frequently updated, and communicating important information to their teammates.

We asked students if their work on the team had an effect on their class work. Many students reported no specific relationship between their work on the team and their academic studies; however, several did report such connections. In one case, a NYC FIRST! participant explained that he developed a working knowledge of math concepts related to robotics that were later covered in his math class. Several students reported similar experiences, especially related to math. Students also reported learning such things as physics concepts, which they associated with academic disciplines, though they might not directly connect with their studies.

Finally, students and adults mentioned several additional aspects of the NYC FIRST! experience that they felt were important. These included exposing young people to the world beyond their schools and communities, helping them see the importance of math and science, and providing opportunities to exercise their creativity and to develop relationships with adult role models.

## Developing community values

NYC FIRST! promotes a set of values that include community service, mutual respect, and “gracious professionalism” and emphasizes that the competition itself is only a part of the NYC FIRST! experience. A message to returning teams posted on the FIRST website, for instance, says: “As seasoned FIRST teams you now know the importance of ‘Gracious Professionalism.’ You have all helped FIRST become both strong and proud, and differentiate itself from other programs through balancing competition and gracious behavior.”

Students often cited elements of this concept of gracious professionalism, such as working together with their peers and supporting one another and other teams, as among the most important elements of their NYC FIRST! experience, though most of them could not define the term. The adults also talked about how supportive teams are of one another, sometimes offering the use of their facilities or mentoring new teams and giving them advice. While the teams are highly competitive, they also seem to have a “we’re all in this together” attitude towards the other teams.

The structure of the game itself promotes behavior that is consistent with the values that FIRST espouses. For instance, teams compete in pairs and partners switch for each heat, so opponents in one heat may be partners in the next, which discourages teams from developing specific rivalries. Aside from winning the competition, teams also gain public recognition and awards for other achievements, such as graphic design, website design, and team spirit, which further discourages a focus on winning at all costs.

## Impact on schools

In examining the impact of NYC FIRST! on schools, we focused on three primary areas: schools’ relationships to the community, science and technology in school curricula, and teachers’ pedagogy.

### Schools’ relationships to the community

NYC FIRST! has had an impact on school/community relationships on several levels. It has increased the visibility and the positive image of schools through media coverage and teams’ public appearances and community service activities. Sponsorship relationships with local companies in support of the schools’ participation in NYC FIRST! have contributed to this, as well. NYC FIRST! has also helped improve the schools’ images among their own students and teachers.

According to staff and students, all of the schools in this study have benefited to some degree from public attention drawn by participation in NYC FIRST!, having been featured in television and print news stories about NYC FIRST!, and some of the schools actively pursue such opportunities. One school, for example, had long had a reputation for being a vocational program for students with few other prospects. The school had worked for several years to improve its academic profile and to change the image of its students from that of underachievers to that of high achiev-

ers both academically and technically. The principal and the coach believe that the NYC FIRST! Team's successes contributed to establishing that positive image.

At another school, which the adults are quick to point out is in the poorest congressional district in the country, the coach has cultivated media and community service opportunities to raise the school's public profile. Students have received awards from the borough president and made public appearances with the New York Yankees.

These opportunities raise public awareness about both NYC FIRST! and the participating schools. In addition, the exposure helps schools to garner resources.

The NYC FIRST! program promotes community service, and students engage in a variety of service-related activities. Many teams act as mentors to new NYC FIRST! teams and to middle school NYC FIRST! LEGO League teams. The students we spoke with felt strongly about sharing their knowledge and supporting others. Other community service activities cited by coaches and students include visiting the children's ward of a local hospital, bringing along several mini-robots for the children to engage with, and working at a local food pantry during the Thanksgiving holiday. Students on one team spoke explicitly about using these activities as an opportunity to educate others about the value and accessibility of math and science.

Coaches and corporate sponsors also told us about NYC FIRST! graduates going to work for local companies, such as Con Edison and the Metropolitan Transit Authority (MTA). One coach reported that the head of the MTA publicly thanked NYC FIRST! for sending him six of his best workers.

According to both adults and students, NYC FIRST! has helped to raise schools' profile within the internal school community, as well. NYC FIRST! teams' public successes are a point of pride among students and faculty. Trophies and photographs are displayed in school hallways. One team put their robot on display and engaged the whole school in a "where's the robot" game, which was designed to raise awareness of the NYC FIRST! team and its accomplishments. The students on all but one of the teams said that everyone in their school had heard about the team through fundraisers, presentations, or word of mouth.

### Impact on curriculum and pedagogy

NYC FIRST! has had an influence on school curricula in both direct and indirect ways. The coach of one team in this study is leveraging NYC FIRST! to nurture cross-disciplinary work in the school by engaging teachers of a range of subjects in working with the team on various aspects of the competition. This year, drama club participants wrote and staged a play based on the medieval theme chosen by the NYC FIRST! team. The coach has written a proposal to create a small "school within a school" based on this interdisciplinary model. In his vision, students would work on documenting the NYC FIRST! team's work, drafting public relations and fundraising letters, and developing the Chairman's Award application in their English classes, for instance.

One of the schools in our sample is making a transition from one large institution to several small-

er autonomous schools within the same building, each with a different focus or theme. One of these small schools is planned around technology, with robotics as one of the areas of study.

Another school is considering creating a robotics class, which might be combined with the NYC FIRST! team. The coach warned that the class couldn't constitute the entire effort FIRST team, because FIRST involves so much more than the robotics component. He worried that the focus of the class would be too narrow to allow for all the activities that FIRST teams typically engage in. Two of the schools in this sample use the Project Lead the Way (PLTW) curriculum, a four-year cycle of pre-engineering courses designed to prepare middle and high school students to enter college-level engineering studies, and PLTW students are encouraged to participate in NYC FIRST!. One principal reported that NYC FIRST! participants were responsible for resuscitating the school's Junior National Society of Black Engineers.

None of the coaches we spoke with, a number of whom were classroom teachers, believed that NYC FIRST! had an influence on their pedagogy. However, for one coach, a math teacher, NYC FIRST! offered the opportunity to help students learn math through hands-on, real-world, problem-based activities, an approach to learning that he has wished he could implement in his own classes.

## **Impact on Corporate Sponsors and Outside Community**

Each of the NYC FIRST! schools has at least one corporate sponsor. One of the sponsors we spoke with had been supporting a school for some time when the opportunity to participate in NYC FIRST! arose. In other cases, the schools connected with sponsors through NYC FIRST! staff, and NYC FIRST! participation is the focus of the sponsors' support. Those sponsors are likely to support several teams, as well. Sponsors contribute mentors, materials, internships for students, and, of course, money in varying amounts and combinations.

The sponsors in this sample spoke very highly of both the students and the coaches involved in NYC FIRST!- they used words like "awesome" and "extraordinary" when talking about the determination, resiliency, and leadership of the teams they supported.

Corporate sponsors we spoke with value their NYC FIRST! partnerships on a number of counts. In addition to making a significant contribution to the communities in which they operate, their employees have opportunities to share their skills and expertise with young people by serving as mentors. There is also the possibility of cultivating potential future employees of diverse backgrounds. Sponsors feel that NYC FIRST! offers students a good introduction to the real world of technology and engineering.

The sponsors in this sample felt a strong personal connection to the program, as well. Two of the four sponsors we spoke with are or have been mentors themselves, and they found the experience deeply satisfying; one told us that he would have wanted to participate in NYC FIRST! when he was in school. Another sponsor told us she felt that "the value to companies is very personal-[the sponsored school] is in New York City over 100 years; this is something you have to do."



## Challenges

Both students and adults say that time and money are the two biggest day-to-day challenges. Time is especially an issue for the adults, who often sound thoroughly weary when discussing the hours they put in. In addition, while the voluntary nature of participation is a strength of the program, students cited irregular attendance as one of their frustrations. Other challenges include conflicts among team members and access to resources other than money and time, though neither of these is seen as a serious problem.

Money may become a bigger issue for several reasons. First, in the current financial environment, funders across all sectors have fewer dollars to give away. Second, as a representative of one sponsor pointed out, as NYC FIRST! expands to include more schools, financial sponsors may have to choose between continuing to fund teams with which they have longstanding relationships and extending their support to new and less well-established teams.

One mentor pointed out that there is no training for adults in developing and managing teams. He said, for instance, that it took several years of working with teams before he realized the meaning and value of the concept of ‘gracious professionalism’ and started focusing on it with students.

## DISCUSSION AND RECOMMENDATIONS

NYC FIRST! is accomplishing its goal of reaching underserved populations of students attending New York City schools that often have limited resources. In the five schools in this study, students are engaging in a diverse range of activities that help them develop skills and knowledge in a number of academic, interpersonal, personal, and creative areas. Both participating adults and students are deeply invested in their teams, voluntarily commit significant time and effort, and take pride and satisfaction in their teams' efforts and successes. NYC FIRST! is helping schools to improve their public images, establish relationships with businesses and corporations, and raise interest in math, science, and technology among the school population. Through NYC FIRST!, students gain access to professional adult role models, corporate executives, and potential financial support for further education.

NYC FIRST! teams face a number of challenges, many of which are integral to the FIRST experience. In designing and building a robot in six weeks, teams need to figure out how to work together quickly and efficiently under pressure. The cost of participating in NYC FIRST! requires students to learn how to solicit donations of money and support from a variety of sources. Many New York City teams face additional challenges specific to inner-city public schools, most notably limited financial and professional resources. The NYC FIRST! program supports teams in meeting these challenges in a variety of ways, including offering workshops in technical subjects, connecting teams with potential mentors and sponsors, and providing guides to the team process.

In seeking to strengthen the program, there are several possible avenues to pursue. One of these would be to find additional ways to support coaches, and in some cases, mentors. New coaches especially learn as they go along how demanding the work can be, but even seasoned coaches are likely feel some strain. Schools and NYC FIRST! program staff might seek ways to ensure that coaches don't burn out, and that their experience continues to be a positive one.

A related area for possible development is infrastructure within schools. There are opportunities to connect NYC FIRST! participation with curriculum in a number of subject areas, most especially math, science, and technology, but also English/language arts, art, and civics. These connections require planning on both administrative and curricular levels and the structured involvement of school faculty in addition to the team coach. More adults taking primary responsibility for some aspect of the work would further alleviate the pressure on coaches, as well, and would ensure consistency and stability from year to year, and help protect the teams from ill effects of changing staff.

It is worth noting that any innovations in the way NYC FIRST! is implemented need to address the importance of the program's flexibility and of the voluntary nature of participation for both student and adults.

Some of our findings lead to recommendations for schools implementing FIRST, while others suggest possible directions for the NYC FIRST! program.

## Recommendations for schools

- **Assign a high-level administrator to act as liaison to the team** This may be especially helpful for coaches who do not themselves have highly visible roles in the school.
- **Engage more school personnel in taking primary responsibility for the teams** Distributing the responsibility for the NYC FIRST! teams would alleviate some of the burden that now rests on the coaches. This might take the form of assistant coaches or co-coaches, or a different teacher facilitating each of the areas of work on the team (ie, administration, webpage development, fundraising and PR).
- **Help classroom teachers make connections to the work of the NYC FIRST! team** The example of the coach who engages other teachers in aspects of the team's work could serve as a model for extending and building on students' NYC FIRST! experience.

## Recommendations for the NYC FIRST! program

- **Provide training for coaches.** In addition to the technical workshops provided by NYC FIRST!, some coaches may benefit from training in areas related to building and facilitating a team, engaging other teachers and school personnel in NYC FIRST!, and making connections to curriculum.
- **Provide training for additional staff.** Staff who are not acting as primary coaches, or who are facilitating a particular area of a team's work might benefit from an introduction to the program and an exploration of how their particular roles fit in with the overall effort of the team.
- **Develop additional resources for coaches.** These might include documents providing guidance and tips, which could extend the learning of training sessions and provide support to coaches who don't attend trainings, as well. These materials could be made available online.
- **Conduct a sponsors forum.** As the NYC FIRST! program expands, so will the need for financial sponsors. A sponsors forum might offer an efficient way to interest potential sponsors in the program. Current sponsors might be invited to speak about their experiences and the value to their companies of supporting NYC FIRST!, and potential sponsors might be presented a menu of options for supporting NYC FIRST! teams.

## Suggestions for further research

There are several questions not answered by this study that may be worth exploring:

- What are the long-term impacts of NYC FIRST! participation? As cited in the introduction to this report, a survey of 3,100 FIRST participants across the country showed that returning students were more likely to have positive attitudes about science and math than NYC first-time participants, and were more likely to say that they planned to pursue math, science, engineering, or technology in further education or careers, as well. Are these figures similar for NYC FIRST! participants? What are their attitudes, interests, and expectations a few years down the road?

Is their interest sustained beyond their FIRST involvement? How does that play out in the college courses and careers they choose? In addition, it would be useful to examine the impact of NYC FIRST! in other key areas, such as students seeing themselves as learners, as leaders, and as collaborators.

- Are there unidentified barriers to FIRST participation within the schools? Despite the fact that teams are open to all students, for instance, the majority of participants tend to be male. Is there something to be learned from the NYC FIRST! schools about the obstacles to girls' participation and how to address them? Are there other students who could benefit from working on a NYC FIRST! team but do not participate for reasons other than lack of time or interest? If so, are there ways to target those students in recruitment efforts and to support their participation so that they are more likely to remain on the team?
- How can schools maximize the instructional impact of FIRST? It appears that there are few explicit links between the multidisciplinary FIRST activities in these schools and related curricula, and little or no discussion of how FIRST activities might help schools meet curriculum standards. Are there schools that have been especially successful in making these connections, and what are the critical factors in their success?
- How can schools create an infrastructure for FIRST that promotes curriculum connections and team continuity and reduces some of the stress that coaches experience?

*It would also be interesting to take a deeper look at the roles and experiences of FIRST coaches. For example:*

- What motivates their extraordinary dedication to their teams?
- What is the impact of the coaches' roles in the school on NYC FIRST! teams? Does the participation of an assistant principal influence on how the team is viewed in the school, for instance, or the resources available to the team? Is a coach whose responsibilities include school-wide activities able to recruit a more diverse group of students to the team than, say, a classroom teacher?

## APPENDIX A

### *Sample School Demographics*

	Ralph McKee High School	George Westing- house High School	Morris High School	Evander Childs High School	Science Skills Center	NYC average
Location	Staten Island	Brooklyn	Bronx	Bronx	Brooklyn	
Program	academic/ vocational	academic/ vocational	academic	academic	academic	
Total # of students	677	1,159	1,604	3,058	739	
Average spending per student (\$)	12,592	11,563	10,489	8,259	7,331	9,348
Ethnicity						
% white	28.5	1.7	0.7	1.4	6.9	16.2
%black	41.9	75.5	39.0	58.5	82.7	35.7
% hispanic	25.6	20.6	60.0	37.4	8.3	34.4
Gender						
% male	64.7	70.1	48.8	54.4	54.7	50.3
% female	35.3	29.2	51.2	45.6	45.3	49.7
Eligible for free lunch (%)	48.4	42.7	81.2	74.8	46.5	51.8
Seniors graduating (%)*	45.8	47.3	4.1	31.4	61.5	53.2**

## APPENDIX B

### Research Methodology

Interviews were the primary method of data collection for this study.

#### *Ralph McKee High School*

- the principal
- the lead coach
- two additional school personnel involved on a day-to-day basis with the team
- four participating students in informal interviews
- eight students in a group interview

#### *George Westinghouse High School*

- the principal
- the lead coach
- an additional faculty member involved on a day-to-day basis with the team
- three participating students in informal interviews
- eleven students in a group interview

#### *Morris High School*

- the principal
- the lead coach
- the lead mentor
- an additional faculty member involved on a day-to-day basis with the team
- six participating students in informal interviews
- ten students in two group interviews

#### *Evander Childs High School*

- the principal
- the lead coach
- a school administrator involved in coordinating the team

- three participating students in informal interviews
- sixteen students in two group interviews

### *Science Skills Center High School*

- the principal
- the lead coach
- twenty one student in three group interviews (five students participated in two separate group interviews)

In addition, we interviewed representatives of four corporate sponsors, one of whom currently mentored several teams, and another of whom had previously served as a mentor for a number of years.

Finally, we conducted one telephone interview with each of the co-directors of NYC FIRST!, as well as several informal conversations about the program.

We supplemented the interviews with a series of observations:

- we observed four of the teams at work twice each during the design and build phase (due to scheduling complications, we were unable to observe the Science Skills Center team)
- We observed the teams at the NYC regional event in the pit as they prepared their robots for competition and networked with other teams, on the playing field, and in the stands as they cheered one another on.

We further supplemented the data collection by reviewing a range of documents:

- the FIRST website
- team websites
- NYC FIRST interim reports to funders
- school flyers and newsletters