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FIRST Robotics Competition

What comes to mind when you think of students relying on teammates and improving their skills to compete in regional tournaments on a basketball court in hopes of making it to the national championship while getting noticed by top colleges? One instantly thinks about a varsity sport, right? WRONG! This is the FIRST Robotics Competition. Today's key challenges of science, technology, engineering, and math (STEM) education and recruitment is two-fold: First, the education system must increase students' interest in STEM, especially students from diverse backgrounds. Second, students must be prepared through education for careers in the STEM field. One proven approach to increase STEM interest, knowledge, skills, and education among students to increase the workforce capacity, is through the implementation of robotics into the curriculum. Robotics can and will transform and enhance students' learning processes. FRC needs more funding and support from local communities and state education departments to prepare more students for postsecondary education, increase the STEM workforce and appreciation of STEM through hands-on based secondary education, and build life skills in high school students. FIRST Robotics Competition (FRC) inspires and prepares students for postsecondary education, increases STEM appreciation to help revive the declining STEM workforce, and helps to build life skills.

For Inspiration and Recognition of Science and Technology (FIRST) is an international not-for-profit organization that was founded in 1989 by inventor Dean Kamen (Gura). Kamen was intrigued when he saw that society was too infatuated with celebrities and sports stars at the expense of nurturing cerebral heroes (Drummond). His

goal in launching FIRST was to generate students' interest and participation in Science, Technology, Engineering, and Mathematics (STEM) robotics (Drummond). It engages students in fun, hands-on, mentor-based robotics programs (Gura). Students also get motivated to get involved and pursue education and career opportunities in STEM fields as an outcome of FIRST (Shapiro). Life skills, knowledge, and self-confidence is gained and built through participation in FIRST (Shapiro). FIRST provides a positive and engaging developmental experience for young people and increases the interest and involvement of participating youth in STEM activities (Melchior).

Since its humble beginnings in New Hampshire, FIRST has grown its programs to reach over 60,000 students worldwide (Drummond). FIRST programs have a strong, positive impact on students, especially women and minorities (Melchior). Junior FIRST Lego League (JFLL), engages younger students in kindergarten through third grade to build models, research challenges, and creatively present their research (Shapiro). FIRST Lego League (FLL), is the program for fourth through eighth grades that has students build Lego Mindstorms NXT robots to tackle simulations of real-world challenges like solving the global energy problem, biomedical engineering problems, or even solving problems faced by senior citizens (Shapiro). In High School, there are two options, the FIRST Tech Challenge (FTC) or FIRST Robotics Competition (FRC) (Shapiro). FTC is the mid-level robotics competition for high school students that was launched in 2005. It was designed to be less costly for teams and schools that can't afford the high overhead of FRC (Shapiro). FRC is the higher-level competition for high-school students that has been the base of FIRST since it was founded in 1989 (Shapiro). All FIRST programs provide opportunities to work in a team environment and to build their sense of

competency and success (Melchior). FIRST has grown their program offerings to cover the entire spectrum of K-12 youth.

FRC was designed to build awareness and interest in STEM in high school students through challenging, yet engaging, learning opportunities that inspires students to pursue careers in STEM, much like how professional sports inspires young people to pursue careers as professional athletes (Welch). Average teams range from ten to twenty high school students, with some teams even having an excess of 50 or more students, all working with adult mentors from schools, universities, professional organizations, and local businesses to help build a robot to use to compete against other teams from across the nation (Welch). While being in FRC, students not only increase their appreciation for STEM, but also their self-confidence and leadership skills (Melchior). A new game is released each year that is played on a carpeted field that is roughly the size of a basketball court that emphasizes cooperation among teams, creativity, professional courtesy, and safety (Shapiro). The yearly game challenges robot designs to go far beyond creating a robot that moves in response to radio control. Teams equip their robots with advanced sensors and other professional components that professional engineers recognize, including accelerometers, gyroscopes, optical and magnetic encoders, and electric motors with gearboxes (Shapiro). Students that have been part of FRC in the designing and building processes throughout high school are often as good in vetting proposed designs than their professional mentors (Shapiro). FRC is not only educational, but it is also very fun. In a research study conducted by Brandeis University, 96 percent of students reported having fun and almost always feeling like they had a chance to win (92 percent) (Melchior). 95 percent of FRC alumni reported their experience in FRC as “good” or

“excellent” (27 percent and 68 percent respectively) and 46 percent of those included in the study said their experience was “much more influential” than any other activity during their years in high school. 78 percent of FRC alumni in the study said their level of involvement was a 4 or 5, where 5 indicated “very involved” (Melchior). Involvement in real and challenging tasks was mentioned the most from FRC alumni. Adult mentors are also very involved with teams usually tutoring students in CAD and animation programs, programming languages, website design and development, machining skills, and robot design (Shapiro). FRC is fun, interactive, and very educational.

FIRST Robotics Competition is more than a robotics competition. FRC requires teams to master many disciplines including marketing and fundraising, something that is easier said than done for students more interested in computers and algorithms than finding team sponsors (Drummond). Implementing robotics into a curriculum is not cheap. Neither is running an FRC team. The average team budget ranges from a bare \$20,000 to a more modest \$50,000+ per season, depending on travel and tournament locations (Shapiro). An initial registration fee of \$5,000 to \$6,000 covers participation in one regional competition and a basic parts kit. Additional regional registration fees cost around \$4,000 and if teams win a regional, the FIRST Championship registration adds an additional \$5,000 onto the total (Shapiro). FIRST works with partners to supply a basic parts kit each year when you initially register. The kit includes donated parts worth more than \$5,000, like cabling, bearings, tubing, hardware, batteries, motors, pneumatic components, servos, and sensing and control electronics (Shapiro). Additional FIRST partners like National Instruments, Autodesk, and PTC donate professional-level software to help teams visualize, design, and program their robots. In addition to the parts

kit, teams recruit local corporate and institutional sponsors that help defray the team's expenses in partial or full (Shapiro). In addition to monetary or in-kind sponsorships, sponsors usually contribute a professional mentor to a team. When professional mentors were asked about their company's involvement in FRC, they summed it up to two main points: 1) Their company sponsored multiple teams and 2) Their company mentored all of their sponsored teams (Shapiro). Some teams even go as far as running off-season events to help raise money. Those off-season events can draw numerous teams with thousands of spectators to a competition that usually mirrors last year's game (Shapiro). Off-season events like these help promote FIRST and act as a training event for rookie members, that provides many opportunities for teams to learn from each other (Shapiro). Even though FRC is very expensive, local businesses always buy-in to the team as a team sponsor through either monetary or in-kind donations.

Like other varsity sports, FRC has developed a system that gets younger players involved earlier and develops the skills needed to compete at the highest levels (Shapiro). There are also awards for design, team spirit, gracious professionalism and maturity, and overcoming obstacles, as well as for scoring the most points in the competitions. During the competition, the robot operates autonomously for part of the time, then it switches to semiautonomous radio control where a driver actually drives it (Shapiro). FRC combines technology with the all the thrills and excitement of varsity sports while engaging students in some of the best STEM learning opportunities available (Gura).

Once the game challenge is announced, teams have a little over a 6 week window, called build season, to complete the tasks of designing, building, testing, programming, and practicing with their robots until they bag it up (Welch). During build season, most

teams rely on their adult mentors who are engineers or students to help them design, build, and program their robots (Shapiro). Even for the professional mentors who understand all of the electrical, computer control, and mechanical concepts involved, designing and building a robot from scratch in six weeks is difficult. Let alone doing it with high school students who aren't professionals and still have school makes it even more challenging (Shapiro). Build season is the fast-paced time window when the robot needs to be built.

FRC prepares students for higher education. Ninety-nine percent of FRC students graduated high school according to a research study conducted by Brandeis University for FIRST (Melchior). This high percentage of graduates shows that when students participate in their learning and enjoy it, through programs like FIRST Robotics, the drop-out dramatically decreases. This leads to students continuing to pursue their interests in engineering and technology by aspiring to much higher levels of postsecondary education than the average student nationally. The study conducted by Brandeis University also found 89 percent of the surveyed FRC alumni continued onto college, a rate substantially above the national average of 65 percent (Melchior, Welch). A reason the percent of students continuing onto college after high school is higher than the national average could be tied to the high school graduation rate of 99 percent. Engaged students are more likely to graduate high school and continue onto college, and FRC engages students in learning.

FRC students chose the more challenging paths to their college diploma. Alumni were significantly more likely to be a full-time student as compared to average students

(88 percent vs 53 percent) (Melchior). These students have decided to either work while educating themselves, or study full time. During their freshman year, FRC alumni were more likely to have an internship or co-op job than their peers (Welch). This high rate of employment is probably due to employers seeking out the knowledgeable and hard-working students that FRC produces. It may also come from the fact that employers attend FRC regionals along with the FIRST Championship to recruit seniors at those events. Students were also more likely to attend a four-year college as compared to the national average (86 percent vs 65 percent) (Melchior). Only seven percent of the alumni who attended a four-year college dropped out, a number much lower than the national average (Melchior). These rates are impressive and show that FRC alumni are dedicated to get educated. Alumni work harder than their peers in college and are rewarded as such.

FRC students like to challenge themselves in college and pursue college courses and career paths in the STEM field. The statistics of college courses that FRC alumni take are higher than their peers, even though not all of the course areas are required for their majors and/or they took required courses during high school. The largest percentage of courses taken by FRC alumni was in mathematics with a 90 percent enrollment rate, followed by science with 78 percent (Melchior). The most astonishing statistic was in engineering courses where 51 percent of alumni said that they were enrolled in engineering courses (Melchior). “While math and science are often part of the core curriculum at many colleges and universities, engineering classes are not. As such, the high degree of involvement in engineering classes is notable (Melchior).” These numbers are much higher than the national averages and prove that FRC alumni challenge themselves more in college. The statistics for minorities were also increased. 53 percent

of Hispanic and 46 percent of African-American FRC alumni enrolled in engineering courses (Melchior). 40 percent of female FRC alumni were also taking engineering classes (Melchior). FRC helps improve the education for minorities. FIRST Robotics alumni show in numbers the positive impact they are making by taking the challenging path.

The impact that FRC has had on undergraduates is enormous. Forty-one percent of FIRST alumni were likely to become engineering majors as compared to the six percent of the average college student (Melchior). Alumni were nearly seven times as likely to become engineering majors. Of the engineering majors, 33 percent of FRC participants were specifically majoring in engineering as compared to the national average of nine percent (Melchior). That statistic shows that FRC is encouraging students to go into the engineering field at a number that is nearly four times the national average. Fifty-five percent of FRC alumni were likely to major in a science or engineering field, a percentage nearly two times the national average of twenty-eight percent (Melchior). The alumni that FRC develops not only continue on to be engineers, they are also scientists and other individuals working in the STEM field. FIRST alumni were over twice the national average of students majoring in computer science (11 percent vs 5 percent) (Melchior). This number that is double the national average, shows that FRC alumni are not just going into engineering, but the sciences behind technology as well. Clearly the statistics show that FRC alumni undergraduates are getting better educated than their peers.

The impact on minorities that were FRC alumni was very large. Thirty-three percent of women in FRC were majoring in engineering, along with 27 percent of the

African-American alumni and 47 percent of Hispanic FRC alumni as compared to the national averages of two percent, five percent, and six percent respectively (Melchior).

This shows that FRC helps engage the minority and gives them a strong presence.

Women were nearly twice as likely to major in a STEM field as compared to their non-FRC peers (41 percent vs 22 percent). It is shocking to think that the ratio of women FRC alumni to their peers in majoring in the STEM field is 2:1. FRC helps the minority stand out from their peers.

Postgraduate Education of FRC participants was also much higher than that of the national average. Seventy-eight percent of FIRST alumni reported expectations that they would receive a postgraduate degree of a Masters or higher, a percentage significantly higher than the national average of 60 percent (Melchior). Again, another statistic that demonstrates the fact that FRC alumni challenge themselves to excel their peers. Of the 78 percent, 47 percent expected to get a masters degree, 32 percent reported they were aiming for a Ph.D., MD, or MBA, while 17 percent said they were going to achieve a bachelor's degree (Melchior). It is shocking that 47 percent were going to graduate school for a masters degree and even more shocking yet is 32 percent were aiming to become a doctor. Only 1.4 percent (two alumni in the research study) of FRC alumni said they were not expecting to obtain any kind of degree, much lower than the national average of 4.4 percent as reported in a DOE study of college student drop-outs (Melchior). This is due to the fact that FRC develops a passion, almost a love, inside students to learn. The passion inside FRC students to continue their education into the graduate field to receive doctorates and masters degrees well exceed the national average.

FRC alumni have valuable skills that employers want, therefore leading to many college internships and eventually employment. FRC alumni were substantially more likely to have an internship, apprenticeship, or co-op of any kind in their freshman year than their peers (27 percent vs 2.7 percent) (Melchior). While FRC students do not receive as much support in the form of grants or scholarships as their peers, they were working in their fields during their freshman year at a rate of more than ten times that of their peers. “Because of my experience in FIRST, I received an internship at General Motors after I got out of high school, which gave me good job skills... and allowed me to see what a career in engineering is like (Melchior).” This quote from an FRC alum is proof that these jobs majorly help students out. Nearly 60 percent of FRC alumni have worked in at least one STEM related work experience, such as an internship or part-time job, during their time in college (Melchior). This also shows that employers value the knowledge of these students. FRC students are in high demand by employers because of their high work ethic and knowledge.

FRC alumni are in high demand by employers once they graduate college. The unique technology platform of robots has excited youth and influenced them to pursue careers in the STEM field. During the next decade, the number of individuals with STEM degrees reaching retirement age is expected to triple (Welch). This is a scary statistic because once all the individuals with STEM education retire, America will not be able to compete with the innovation of other countries. Sixty-nine percent of FRC alumni said that their time in FIRST has increased their interest in STEM careers (Melchior). Thirteen percent said that FRC has influenced their career choice (Melchior). These are exciting statistics that help prove that FIRST programs work very well to get students interested in

the STEM field. Alumni were more likely to pursue a science or technology career (45 percent vs 20 percent) or engineering career (31 percent vs eight percent) compared to their peers once they graduated from college (Melchior). The influence that FRC has had on its participants will help America fill the STEM jobs of those who are retiring. FRC alumni in the study conducted by Brandeis university has a very low unemployment rate that was 5.5 percent as compared to their peers which is often much higher (Melchior). The high employment rate of FRC participants also helps prove that FRC alumni are in high demand. Minorities like African-Americans and Hispanic alumni are also employed in STEM careers at very high rates, 64 percent and 29 percent respectively (Melchior). These statistics prove that FRC alumni are in high demand by employers, which helps students see how participating in FRC will be able to help them in the future.

Life skills gained from participating in FRC are priceless. The results from the Brandeis University study showed that everyone involved in FRC programs saw positive impacts on self-image, teamwork skills, and students' problem solving ability. In fact, FRC participants said that winning in competition was only the third most important aspect of the FIRST experience and even then, only 15 percent said that (Melchior). The life skills that FRC instills in youth can not be easily gained anywhere else, or in a quicker than how FIRST teaches it.

FRC increases self-confidence in its students. Eighty-nine percent said FRC increased their self-confidence (Melchior). High self-confidence levels are often linked to high motivation levels. Motivation to do well in school was also increased in many, 70 percent, of FRC alumni (Melchior). Both of these statistics are high, which is good, since we live in a society that does not look upon geeks and nerds very highly, which can

dramatically decrease self-confidence levels.

Community service contributed by FRC participants is much greater than their peers. FRC has helped increase students' interest in serving others. Fifty-two percent of FRC students said they had become more actively involved in their communities (Melchior). Over half of all FRC students more active in their communities can help produce a better world for everyone. Students also continued on their active involvement in their communities once they graduated high school, as more than 70 percent of alumni said they were volunteering in their communities (Melchior). This number is more than twice the rate of the students who were not in FIRST (30 percent) (Melchior). The number of alumni helping to change the world is much larger than other groups whose alumni may not be actively involved in their communities. More specifically in terms of involvement, 65 percent of FRC alumni wanted to help high school students get involved in STEM (Melchior). The rate that alumni wanted to help students get interested in the same programs that they have experienced themselves helps prove that FIRST works. Otherwise, this statistic would be much lower. Alumni also were four to ten times more likely to provide some of the positive impacts associated with FIRST, such as tutoring, coaching, or mentoring, than their peers (Melchior). Mentoring is a skill that students see while they are in FIRST, and probably is the reason of why alumni are willing to help others out at the enormous rate. FRC instills a spark of helping others out, that many other programs do not teach.

Real-world skills are gained by students participating in FRC. Almost 90 percent said they had real responsibilities (Melchior). Almost all of the alumni said they had real responsibilities that can be linked to gaining real-world skills. One-fourth of students said

they were able to make the important decisions for the team (Melchior). The decision making process is used in jobs and by teams, and the mentors letting the students make the decisions, gives students a vast vault of knowledge of the real world. Seventy-six percent of students gained leadership skills (Melchior). All of the students that gained leadership skills are better prepared to help lead teams through projects and be the decision maker for the teams they lead. Ninety percent of alumni said they gained both time management skills and communication skills (Melchior). Time management skills are learned because students have less time to do school work during the six-week build season. Real responsibilities prepare students for the real world.

Students gain problem-solving skills while working in a real-world environment with teams. Ninety-three percent of alumni said they learned how to solve unexpected problems or finding better ways of doing things (Melchior). Unexpected problems do pop up in the real-world and problem-solvers need to be prepared to solve them. Engineers work towards finding better, more efficient ways of doing things, which most alumni said they experienced and learned. Ninety-four percent learned how to weigh issues and options before making final decisions (Melchior). The decision making process happens everyday in business and it also appears in teamwork as well. Problem-solving is experienced by the students in the design process and working in teams with others.

All of the real-world and problem solving skills can be learned by working in a team environment. Almost half of FRC alumni that were involved in the Brandeis University study said that the most important aspect of FIRST was teamwork (Melchior). Students say that the most important aspect of FRC is teamwork, which was even more important than winning. Ninety-five percent of FRC team members said their

understanding of the value of teamwork increased (Melchior). Almost all FRC participants have experienced teamwork and understand the value of it. Over 90 percent of students said they learned how to get along with their peers and mentors, work within the rules of the team, all while feeling a sense of belonging on their team (Melchior). This is proven time and time again. Teamwork is one of the most valuable skills learned in FRC.

FIRST programs are too costly and do not work. The average team budget ranges from \$20,000 to more than \$50,000 per season, depending on travel and competition locations (Shapiro). The cost is so significant that no local business would even be able to afford funding this. An initial registration fee of \$5,000 to \$6,000 covers participation in one regional competition and a basic kit of parts (Shapiro). Additional regional registration fees cost around \$4,000 and if teams win a regional, the FIRST Championship registration adds an additional \$5,000 onto their expenses (Shapiro). The cost of \$5,000 for a team to attend one event that lasts only a weekend is expensive. FRC is a very pricey sport for youth to be competing in.

Although the cost is high, students and schools almost always never pay that fee. Students find local sponsors for their teams while learning financial and communication skills (Shapiro). Most local businesses are more than happy to fund or support a team. In fact, when professional mentors were asked about their company's involvement in FRC, most of them said that they not only mentor multiple teams, but they also sponsor them as well (Shapiro). This shows that companies are more than willing to sponsor teams to help them grow future employees. The kit of parts that comes with your registration fee includes more than \$5,000 worth of donated parts, like bearings, hardware, motors,

pneumatic components, servos, and other electronics (Shapiro). The kit of parts is well worth the \$5,000 or so dollars that teams pay for a combination of that and the registration fees. The cost of FRC may cost a lot, but students gain valuable skills from the fundraising efforts they put into it. Even though FRC costs a lot, local businesses always buy-in to the team as a team sponsor through either monetary or in-kind donations.

Alumni don't benefit from participating in FRC. Past students that were in FIRST Robotics programs get less support for college from grants and scholarships as compared to their peers (Melchior). Students aren't benefiting from participating in FRC, so why would businesses chip out thousands of dollars of their money to contribute to a student's dim future. Alumni reported receiving 13 percent in STEM specific grants or scholarships and another 66 percent reported receiving a general grant or scholarship (Melchior). These values being low, especially the 13 percent in the STEM area, are quite disappointing for a program that promotes STEM education.

Being a member of a FIRST team helps students fund college. FRC students are given exclusive access to college scholarships totaling over 16 million dollars from over 860 organizations and institutions (Shapiro). FIRST works hard to secure exclusive scholarships for their students. Although the worst outcome of FRC participants was in scholarships and college funding, those that received funding proceeded to continue into engineering. As one FRC alumni and scholarship recipient said, "I never even considered myself in the engineering profession and now I am at a college with a full tuition scholarship, studying to become an engineer (Melchior)." These success stories are worth all the hard work that FIRST puts into securing scholarships.

FIRST Robotics Competition inspires and prepares students for postsecondary education, increases STEM appreciation to help revive the declining STEM workforce, and helps to build life skills. FRC helps students graduate from high school and continue onto a successful college career. Students that go to college usually challenge themselves by taking hard classes, which are usually STEM based. Undergraduate student alumni are almost always looking ahead and most of them always continue onto graduate level education, with very few drop-outs. Businesses recruit FRC alumni to work for them as summer interns. Some of those relationships may even continue onto a job after college. FRC helps increase interest in STEM through robotics which is a proven method of getting youth involved in the STEM field. Finally, FRC builds priceless life skills that students will use no matter where they go. The FIRST Robotics program is a highly successful program with proven results that show students do get hooked on STEM and continue onto pursue the STEM field.

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