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Motivations and Benefits for College Students Serving as Mentors in a High School Robotics Competition

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AC 2011-2846: MOTIVATIONS AND BENEFITS FOR COLLEGE STUDENTS SERVING AS MENTORS IN A HIGH SCHOOL ROBOTICS COMPETITION

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Motivations and Benefits for College Students Serving as Mentors in a High School Robotics Competition

Abstract

Many universities provide space for student organizations, in which undergraduate students are learning leadership skills, mentor other students and bring their engineering skills to practice. Purdue FIRST Programs (PFP) is a service-learning program where students from a large research university mentor predominantly high school student teams participating in the FIRST Robotics Competition (FRC). Whereas most FRC teams are mentored by professional engineers, PFP is unique in both the extent which it relies on student mentors and the overall scope of the organization. Existing models of mentorship do not adequately describe the specific relationship between the college and high schools students: (1) Due to the proximity in both age and experience, the college students cannot be considered more experienced (traditional model of mentorship) and (2) Due to the fact that both student populations are in different educational systems, the college students cannot be considered peer mentors. To help understand this alternative mentoring relationship, this study was guided by two research questions:1) What motivates PFP participants to become mentors to high school students? 2) What do these undergraduate students learn by mentoring high school students? A survey of participants in the year 2010 (n=37 returned) and semi-structured interviews with a purposefully selected sample (n=10) build the basis for this multiple case study. The interview data were transcribed and analyzed using a multiple case study with constant comparison method. Results indicate that college students' primary motivations for mentoring included wanting to continue working with FIRST after high school, wanting to contribute to the community in appreciation of their positive experiences with FIRST in high school, and enjoying doing the technical work associated with robotics competitions. The primary benefits described by the college students were the development of their leadership ability, learning how to work on a team, improving their ability to communicate, and other process skills. The students were able to give examples of applying their technical knowledge and skills as mentors, and found the opportunity to work on an applied project useful to support their classroom learning in college. The main challenges that the mentors faced included conflict resolution on the team, making sure that they understood their role, and not taking over and doing work on the robot that should be done by the high school students. Overall, the participants appreciated being able to stay connected to the FIRST Robotics Competition after high school, the ability to develop communication and leadership skills, the close relationships that they developed with the high school students, and the opportunity to contribute positively to both the local and FIRST Robotics communities. Implications and further research needs will be discussed in the paper.

Introduction

Engineers in the 21st century require much more than just strong technical and analytical abilities. They also need to be able to communicate, work as a team, and assume leadership positions [1]. To help students develop these skills, universities have developed a wide variety of programs that encourage engineering students to solve problems working with people outside of their engineering programs. These activities could include volunteerism and service learning[2], tutoring, or K-12 outreach programs. Each of these programs involves different motivations for participation, different learning outcomes, and different relationships that develop between the student participants and the individuals or communities that they are trying to serve.[3] This study focuses on Purdue FIRST Programs (PFP), a student-led program where predominantly undergraduate students work with high school students to design and build a robot to compete in the FIRST Robotics competition. To understand this program, this study posed the following research questions: 1) What motivates PFP participants to become mentors to high school students? 2) What do these undergraduate students learn by mentoring high school students?

Literature Review

Service Learning

Service learning at the university level involves providing contexts for students to utilize skills that they learn in their classes and further this knowledge by serving their community through the solution of real-world problems[3]. Alumni of engineering service-learning programs suggest that it provides the opportunity to develop a variety of skills that are valuable in the practice of engineering[4]. These include developing teamwork skills, leadership skills, and communication skills[4]. An important component of service-learning is the opportunity for participating students to receive course credit for their experiences[4].

Mentoring

Numerous definitions of mentoring exist, making research in this area challenging as there are divergent views about what constitutes mentoring.[5] Mentoring can be defined in many different ways, depending on the context where the mentoring relationship occurs and the individuals involved in the relationship. Mentoring typically takes the form of either expert/novice mentoring where experienced individuals mentor protégés, or peer mentoring where peers work together to encourage learning. Mentor/expert mentoring can include experienced professionals working with new hires in an industry environment, or professors developing relationships with students outside of the classroom to encourage their success in an academic environment.

Jacobi [6] identified fifteen characteristics of mentoring relationships through a review of the mentoring literature, presented in Table 1.

Table 1: Characteristics of Mentoring Relationships (based on Jacobi[6])

Acceptance/support/Encouragement
Advice/guidance
Bypass bureaucracy/access to resources
Challenge/opportunity
Clarify values/clarify goals
Coaching
Information
Protection
Role model
Social status/reflected credit
Socialization/"host and guide"
Sponsorship/advocacy
Stimulate acquisition of knowledge
Training/Instruction
Visibility/exposure

A commonly measured outcome, particularly of studies of peer mentoring, was increased knowledge or academic performance in the tutoring content area[7,8]. In addition to benefits gained from developing a relationship while mentoring, the act of studying and organizing knowledge with the expectation of teaching can also lead to measurable gains without depending on the act of teaching or mentoring actually occurring[9,10]. Peer mentoring can also be a powerful tool for improving the academic performance of remedial students[11]. The act of peer mentoring can also be a satisfying and enjoyable experience for the mentor[12].

Mentoring high school students by undergraduate university students can provide numerous cognitive and social benefits for the mentor. One of the earliest studies in this area[13] determined that the primary benefits for undergraduate tutors working with K-12 students were learning how to communicate scientific ideas simply, learning about how other people perceive a certain subject, and exposure to people with a different social background.

Existing University/K-12 Relationships

Numerous models exist for developing relationships between university and K-12 students. These can include programs where university students make presentations to high school students to encourage them to pursue degrees in engineering[14]. Bringing high school students on campus to work in engineering design teams with university students can also build interest in engineering[15,16]. University students can also go into the high school to work with high school students to solve engineering design problems and develop relationships with the high school students and provide information to facilitate their enrollment in university engineering programs[17]. University students have also prepared and delivered lessons on engineering in the high school classroom[18]. University students have worked with high school students to develop radio/audio programming related to environmental engineering topics. An evaluation of the benefits for the university student mentors participating in this program found that the mentors developed close relationships with the high school students, communication and teamwork skills, and teaching skills[19]. On-campus, residential engineering camps provide another opportunity for university mentors and high school students to interact, and can lead to "renewed commitment to engineering" for the mentors[20]. Universities can also create service learning courses that utilize undergraduate mentors to create outreach opportunities for K-12 students[21]. Previous research in this area has shown some success at building knowledge and interest in engineering among the K-12 participants, but very limited work has been done on the benefits of participation in these programs for the university students. The present study addresses this gap.

Background on FIRST Robotics

FIRST (For Inspiration and Recognition of Science and Technology) was founded in 1989 by inventor Dean Kamen. His vision in establishing FIRST was "To transform our culture by creating a world where science and technology are celebrated and where young people dream of becoming science and technology heroes."[22] To this end, the organization sponsors competitions that resemble sports competitions in many ways, often taking place in large athletic arenas complete with elaborate staging and enthusiastic fans. The organization sponsors four different robotics competitions: Junior FIRST LEGO League for grades K-3, FIRST LEGO League for grades 4-8, FIRST Tech Challenge for grades 9-12, and FIRST Robotics Competition for grades 9-12. This study focuses on the FIRST Robotics Competition (FRC), the flagship program for the organization. Having started in 1992 with 28 teams, the competition has grown to 1,809 teams in 2010 from 12 countries including all 50 states. The FIRST Robotics Competition involves over 45,000 students, making it one of the largest K-12 engineering outreach programs in the country. [22] Teams of high school students, along with a teacher or teachers from their school and experienced engineering partners, have six weeks to build a robot to compete in a game that changes each year. The teams work with engineering mentors from both industry and academia.

Mentors, typically engineers working in industry, play a critical role in providing technical assistance to FIRST teams. Prior research on FIRST suggested that these mentors benefit from participating in FIRST.[23] Benefits reported by engineering mentors included opportunities for career advancement, increased morale and job satisfaction, access to new hires, and a sense of satisfaction and connection to students on the team. Only three mentors in this study were FIRST alumni, but the alumni appreciated the ability to continue to be involved with FIRST. Challenges identified by the mentors in this study included recruiting mentors, mentor burnout due to the large time commitment, and learning how to mentor. Although of the teams included in this study was mentored by university students, the study did not specifically examine the impact of mentoring for FIRST on these participants. This study builds on this research through specifically examining the impact of mentoring on university students and the challenges that they may face.

Outreach of universities to high-school in the context of FIRST

Several universities have outreach programs where undergraduate students serve as mentors for local FIRST robotics teams. Senior Mechanical Engineering students at Virginia Tech [24-26] work both directly with FIRST robotics teams as mentors and develop technologies to help teach robotics concepts to high school FIRST participants. Students from multiple high schools participate in an evening class for elective credit taught by high school teachers and assisted by

Virginia Tech students. The program is coordinated by faculty members from Mechanical Engineering and Education. Although not explicitly studied, Kasarda et al. [26] suggest that this program facilitates the development of self-efficacy through mastery experiences in the context of the mentoring program.

Students from Michigan Tech also work with a local FIRST robotics team under the auspices of the university's Engineering Enterprise.[27] Students can earn engineering course credit working with both high school students and industry partners. This program grew out of the desire of university students that participated in FIRST in high school to continue that experience at the university. The nature of the relationship between the university and high school students is not described. Although not measured, Oppliger[27] suggests that this program allows university engineering students to develop competencies related to the ABET accreditation criteria.

Virginia Commonwealth University developed a robotics service learning course for students in its engineering program.[28] The course consisted of learning robotics concepts in the classroom followed by a service learning component where the students worked with four different local FIRST robotics teams. Some students mentored along with professional engineers, and committed 20-30 hours per week to working with the students during the six week FIRST build period. Other students were the sole sources of engineering knowledge for their teams, and worked between 40 and 50 hours per week during the same period. The author suggested that benefits for the university students included developing design and teamwork skills, learning how to mentor, and serving their community.

California State University Northridge also worked with a high school to start a FIRST robotics team as a service learning activity in a senior Manufacturing Systems Engineering course.[29] Although not measured, the authors mention several benefits for undergraduate students participating in the program, including the development of project management experience, experience with fabrication and prototyping, and proposal writing. The course also served as a means of building connections between the university and the high school, and as a means of recruiting students for the engineering program at the university. The university also planned to develop a freshman level introduction to robotics course that would be made available to high school students through an agreement between the two institutions.

In addition to mentoring FIRST Robotics Competition teams at local high schools, university students have also worked with FIRST Lego League teams comprised of middle school students as well. A pair of students from the University of South Florida worked with a home schooling group, adapting a university-level introduction to robotics course curriculum for the younger students.[30] The university students took on a more formal teaching role in this situation, as opposed to the mentoring approaches of the previously mentioned university groups.

Each of these studies presented valuable descriptions of how university students can work with the FIRST organization. The authors also suggest numerous benefits for the university students including increased mastery of technical content, development of leadership and communication skills, and satisfaction from serving the local community. These benefits were not formally assessed through surveys or interviews, and the present study attempts to address this gap through formally examining the benefits of mentoring high school FIRST teams as perceived by the university students.

Background on Purdue FIRST Programs

Purdue FIRST Programs was established in the 1999-2000 school year and paired university students with a technology teacher and students at a local high school to create a new team for the FRC. This initial team was comprised of 12 University students, along with 18 high school students. The organization became very popular as an extra-curricular activity for Purdue students, and expanded rapidly. In 2001, PFP started a FIRST Lego League team, and the following year sponsored a FIRST Lego League tournament. By 2004, the organization was working with two FRC teams (adding a third the following year), and started running its own FRC Regional Tournament. At the time of this study, PFP had approximately 65 students working with three FRC teams, along with FIRST LEGO League and FIRST Tech Challenge teams.

Most incoming students to PFP begin as mentors working predominantly with high school students participating in the FRC. There are 8 to 12 mentors per high school, and each high school has a Director of Robotics who serves both as the leader of the mentoring group and a member of the PFP leadership team as well. In addition to the three main technical subgroups of mechanics, electronics, and programming, PFP mentors also assist the high school students with industrial and public relations, developing animations of the robot as one of the competition requirements, and helping the students prepare materials to submit for various judged awards at the competitions. While this study focused on the relationship of undergraduate mentors within the FRC, the mentors also have opportunities to work with younger students participating in the FIRST Tech Challenge and FIRST LEGO League competitions.

Numerous other roles exist within PFP that do not involve working directly with K-12 students. PFP has a President, Vice President, and Treasurer found in almost all student run organizations. PFP participants work to organize a Regional FIRST Robotics competition each year. Members of the Industrial Relations group work with local engineering industries to secure part of the funding of the organization’s annual budget and recruit local engineers to work with PFP and the robotics teams. The Public Relations group helps to present the public face of PFP to both the campus and local communities, and the Information Technology group develops the website and maintains the computers of the organization. PFP provides a wide variety of opportunities for professional skills development in both technical and non-technical fields.

All students involved with PFP are required to enroll in ME297F-FIRST Leadership, a class in the School of Mechanical Engineering to help prepare them for their responsibilities in the organization. While the students are advised by a member of the Mechanical Engineering faculty and a university staff member in charge of P-16 engineering outreach, the program is almost entirely student run.

Methodological Framework

This study used a multiple case study approach to understand the impacts of PFP on the participants. Qualitative case studies allow the researcher to explore a phenomenon in a particular context using multiple data sources[31,32]. In the current study the cases that were subject to analysis were 10 students that elected to be interviewed. Using multiple cases facilitates the development of theory to explain differences and similarities between the cases being examined.

Participants

The participants in this study were current students involved with PFP. Recruitment emails were sent to approximately 65 current students requesting their participation in an online survey, of which 37 completed the majority of the survey. Table 2 shows the gender and ethnicity breakdown of the participants and shows that the majority of participants were Caucasian Males. Table 3 shows the majors of the participants. Two thirds of the participants are majoring in engineering, followed by about one sixth majoring in engineering technology, and the remaining students were from a variety of other majors. 19 students indicated that they had minors. The majority of participants were on a FIRST robotics team for at least one year in high school as shown in Figure 1. Of the 37 participants, only five were not involved with FIRST in high school, and 16 were involved in high school for all four years. A significant number of participants were involved with FIRST robotics programs aimed at younger students along with other co-curricular and extracurricular K-12 robotics and engineering activities as shown in Table 5. The participants were involved with PFP for anywhere from one to six years, as shown in Figure 2.

Table 2
Gender and race of study participants (n=37)

	White/Caucasian	Asian	Hispanic
Male	27	3	1
Female	6	0	0

Table 3
Majors of study participants (n=37)

Major	**Number of Participants**
Engineering (24 Participants)	
Mechanical Engineering	9
Aeronautical and Astronautical Engineering	5
First Year Engineering	3
Electrical Engineering	2
Industrial Engineering	2
Chemical Engineering	1
Materials Science And Engineering	1
Multidisciplinary Engineering	1
Technology (7 participants)	
Electrical and Computer Engineering Technology	3
Computer & Information Technology	2
Aeronautical Engineering Technology	1
Engineering/Technology Teacher Education	1
Other (6 participants)	
Computer Science	3
Actuarial Science	1
Industrial Management	1
PR & Advertising	1

Table 4
Roles of study participants within the PFP organization (n=34)

Technical Robotics	27
Junior Robotics	4
Information Technology	3
Industrial Relations	2
Public Relations	5
Leadership (President, Treasurer, etc.)	10

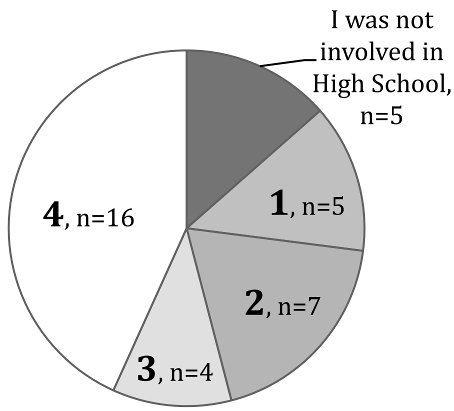

Fig. 1. Number of years study participants were involved with FIRST as high school students (n=37)

Table 5
Study participants' prior K-12 robotics and engineering activities

Other FIRST Programs	
Junior FIRST LEGO League	2
FIRST LEGO League	10
FIRST Tech Challenge (VEX)	9
Other K-12 Robotics Programs	
Science Olympiad	2
High school robotics club	1
Robotics summer camp	1
Underwater ROV	1
Other K-12 Engineering Programs	
Project Lead The Way	8
Other classes	6
Summer camps	6
Junior Engineering Technical Society (JETS)	3
Other	5

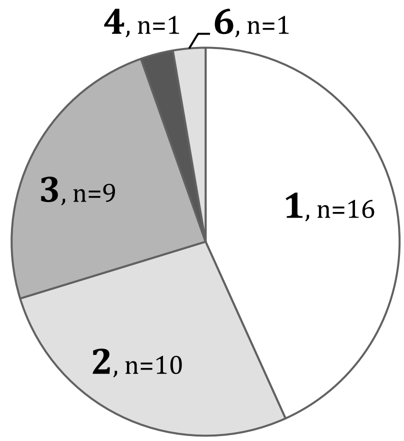

Fig. 2. Number of years study participants were involved with PFP (n=37)

Research Instruments

In addition to collecting demographic and participation information, the survey collected information about the participants' experiences with PFP, including their roles within PFP, the number of hours they committed to it, their reasons for joining PFP, how their time was spent mentoring with PFP, challenges they may have faced, and their enjoyment of the various aspects of working with PFP. The participants also answered questions related to their other extracurricular activities involving engineering or mentoring, and how they were prepared for their roles in PFP. The survey questions were developed in part based on the existing models of mentoring mentioned in the literature review. At the conclusion of the survey, the participants had the option of providing their email addresses if they would be willing to participate in a short follow up interview. Of the 37 student participants, 10 volunteered for interviews and were interviewed.

The interviews were semi-structured and consisted of similar questions to the survey along with follow up questions that helped to understand the experiences of PFP participants. In particular, the interviews helped to clarify how the students used the knowledge gained from their engineering classes to be better mentors, and how their experiences with PFP helped them to become better engineers.

The survey data were analyzed using Microsoft Excel and several tables, charts, and graphs were created to present the data. The small sample (n=37), drawn from a total of approximately 65 students involved in PFP, did not allow for most forms of statistical analysis and the quantitative results are presented primarily to describe the participants in PFP and their motivations for joining the organization. The interviews were transcribed and coded using constant comparison analysis.[33,34] The transcript data were coded using codes that originated from the model of mentoring based on a review of the relevant literature. Data that could not be described or did not relate to this model were assigned open codes. Thus the analysis consisted of both a deductive component that originated in the theory guiding the research and an inductive component that emerged directly from the data. The codes were then grouped together to establish a set of assertions.

Quantitative Results

The participants indicated a variety of reasons for participating in PFP, as shown in Figure 3. Over 90% of the participants indicated that their enjoyment of working with robots and doing other technical work was at least somewhat influential in their decision to join PFP. Over 80% were motivated by their desire to continue the FIRST experience after high school, with similar numbers indicating that they wanted to contribute to the community. Significant numbers of participants also indicated that they were motivated by their interest in teaching, gaining technical skills, the social aspects of being involved with PFP, and wanting to gain management experience.

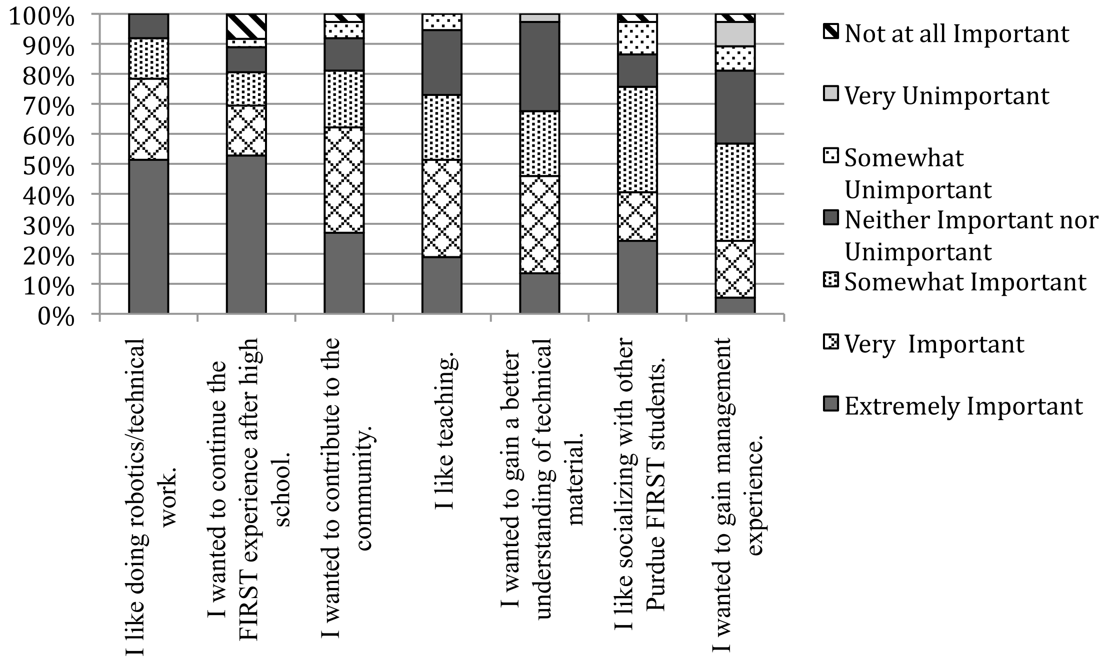

Fig. 3. Study participants reasons for joining PFP (n=37)

The participants perceived numerous benefits stemming from their involvement in PFP, as shown in Figure 4. Almost all of the participants indicated that they developed leadership skills as a result of their involvement, and that PFP contributed positively to their overall college experience. Participants also improved their communication and time management skills. Participants perceived less of a positive impact on their choice of career and major, and only slightly more that half of the participants believed that participation in PFP had a positive effect on their academic performance.

The participants generally did not find their duties as mentors to be difficult, as shown in Figure 5. The most difficult aspect of working with PFP was time management, followed by the technical challenges of working on the robots. A large majority of participants did not find teaching, managing the budget, or communication to be difficult.

Participants reported committing a significant amount of time to working with PFP, as shown in Table 6. While the participants reported an average of only 1.5 meetings and around 4 hours per week before and after the six-week build season, during the build season they reported meeting an average of 4.7 times and 18.7 hours per week. The standard deviations suggest that these times varied widely for different participants. Results of this portion of the survey need to be treated with caution due to the fact that data are not based on logs but memory.

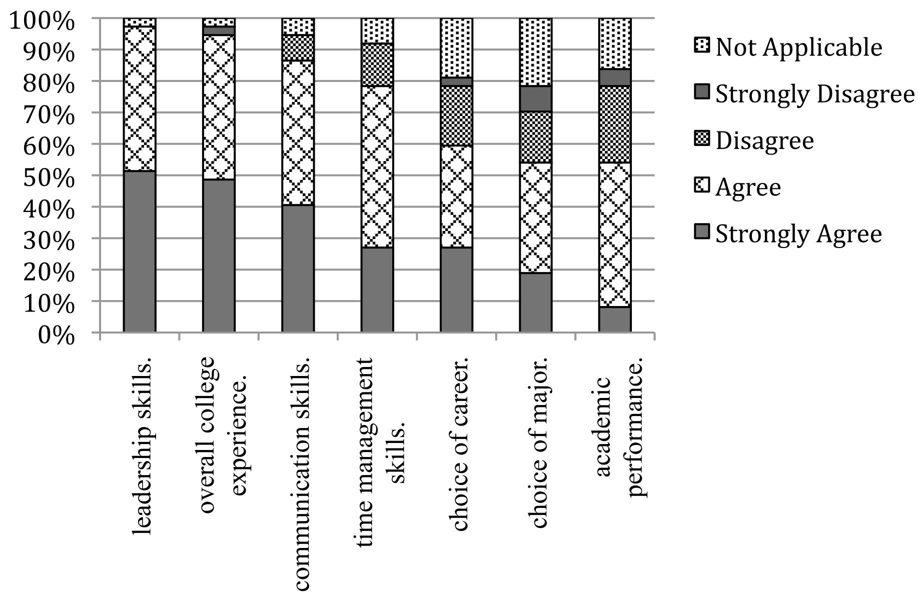

Fig. 4. Study participants answer to the question: PFP had a positive impact on my… (n=37)

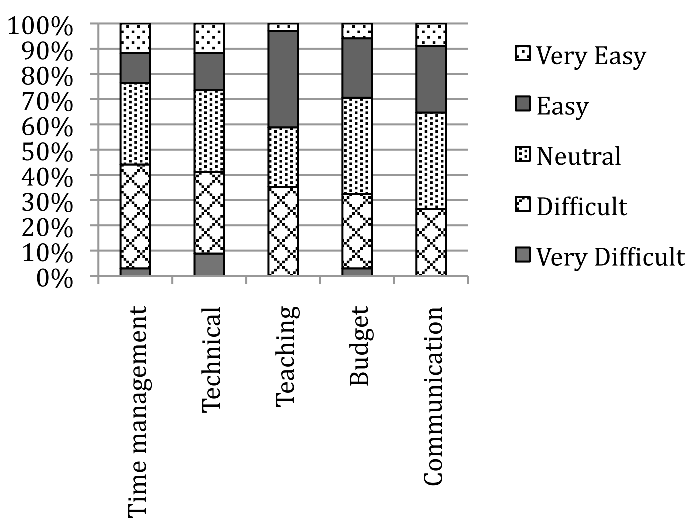

Fig. 5 Study participants ratings of the difficulty of duties they performed as mentors with PFP (n=34)

Table 6
Study participants self-reported time commitments to PFP (n=29)

	Mean	**Standard Deviation**
Pre-Season		
Number of Meetings Per Week	1.4	0.8
Number of Hours per Meeting	2.3	1.1
Calculated Hours Per Week	3.7	2.3
Season		
Number of Meetings Per Week	4.7	2.0
Number of Hours per Meeting	3.7	1.3
Calculated Hours Per Week	18.7	9.2
Post-Season		
Number of Meetings Per Week	1.5	1.2
Number of Hours per Meeting	2.5	1.7
Calculated Hours Per Week	4.4	3.9

Qualitative Results and Discussion

The transcripts were analyzed using constant comparison analysis to understand the benefits, challenges and mentoring relationships of the participants. The following assertions emerged from this analysis. All of the names of participants have been changed to protect their identities.

Assertion 1) Students were motivated to join PFP based on previous experience with FIRST.

All of the interview participants were involved with FIRST as high school students for at least one year, and wanted to continue to be involved with FIRST after high school. Peter, a graduate student in aerospace engineering, stated:

> Originally joined PFP because I graduated from high school and knew that I was coming to (the university) and I wanted to continue working, doing stuff with FIRST because it was a really good program for me when I was in high school and I wanted to keep doing work with it.

Ian, a junior in mechanical engineering, also wanted more time working with FIRST. He stated:

> I joined PFP because I spent two years in high school working on a FIRST team and since I'd only gotten to work on it for two years in my high school instead of some people have gotten four or even five depending on when they start. I really wanted to keep working in FIRST.

The participants had a variety of reasons for wanting to continue working with FIRST. Many felt like it was such a positive experience for them in high school that they wanted to help other high school students have that same experience. Joseph, a first-year engineering student planning on majoring in aeronautical engineering, stated:

> It's something that I liked, I liked building robots and having a challenge to work towards for a good part of the year. I always enjoyed the program as a high school student, so I figured that I could return the favor and help out the students that are doing it now, the high school students, be a mentor.

For several students, the existence of PFP and the ability to continue working with FIRST influenced their decision to attend Purdue University. Several of the participants also worked with PFP as high school students, which also motivated their decision to attend Purdue University. Mary, a first-year engineering student planning on majoring in mechanical engineering who was on a PFP-mentored team in high school, stated:

> For a while I was going to go to (another university), and I was actually set on going there for the longest time, and I had my robotics banquet at the end of this season, or the end of this school year I guess when everything was done with, I pretty much realized that there was no way that I could leave the team, and so because they had PFP robotics, because of PFP at Purdue University I decided to stay here pretty much just so that I could pursue robotics and engineering and Purdue University is a top engineering school so that wasn't really that bad of a decision.

Susan, a sophomore majoring in public relations, stated:

> A lot of students from my high school come to Purdue University so they learned about PFP when they were here and they'd come back and tell us about it and that got me excited about it so when I came here I definitely wanted to do it, I already had my mind set on it…It was one of the factors for coming to Purdue University.

The participants all clearly felt that FIRST was a very positive experience for them in high school. PFP provided the opportunity for them to continue being a part of this program in high school, to help other high school students have a similar positive experience, and even influenced their decision to attend Purdue University.

Assertion 2a) PFP provided a context for the mentors to develop a wide variety of both process and technical skills.

Almost all of the participants mentioned the development of process skills as one of the most useful benefits of mentoring with PFP. Joseph stated:

> I'm learning a lot about how to work with other people, how to work in small groups, how to work in large groups, how do I talk to a few people as to how do I talk to a whole class, stuff like that. So I think that it's really going to help me in the long run working with others for sure.

Mary identified similar positive outcomes, and also mentioned time management:

> I think that it's teaching me leadership skills. I think it's a great program for that, and also is helping me teaching me mentoring skills also, learning new fields I guess, and I'm learning a little about management, learning about time management, learning a lot about how to be a good leader, what are the right things to do, what are the unethical things to do, just kind of a little bit of everything overall.

Peter specifically mentioned developing the ability to communicate technical ideas to a non-technical audience as one skill that he developed as a result of working with PFP:

> It helps me to be able to explain to people who might be less technical or not have quite the background that I have some fairly technical concepts or some fairly important engineering concepts which will help you know if I am working in industry I might need to explain to large groups of people that might not know exactly what I am doing the general outline of whatever my project is, whatever my results are.

Several participants felt like the process skills that they learned through participation in PFP were considered valuable to industry. Trevor, a senior in mechanical engineering stated:

> Communication and interpersonal relationships I think are a big part of what a company would be attracted to. If you're someone who can't along and work well with others they're not going to have you around for long.

Despite perceiving these skills as valuable, they are not necessarily included in the participants' formal engineering classes. Kevin stated:

> It helps develop professional skills that an engineer needs that they won't necessarily learn in a normal classroom, like etiquette and how to present yourself, ethical design, you don't often get that in other classes.

Ian believed that his experiences with PFP were very helpful in obtaining a summer internship:

> I got, the internship that I have this summer, the reason that I even got asked to interview for the company was because FIRST was in my resume … that was something that the recruiter told me when I went to meet him…because it's like an applied leadership experience which is something that in the companies that I've been interviewing for they get really excited about. They like that I've had gotten project management skills, that I've had a chance to apply my technical classes and coursework…they know that I have spent a lot of time working in teams and that I have leadership experience.

Along with developing process skills, PFP provided an opportunity for students to develop their technical skills as well and utilize knowledge that they learned from their engineering and other technical classes. Several participants believed that the opportunity to apply what they learned in their classes to an actual project made them better engineers. Michael, a sophomore majoring in aeronautical engineering technology, stated:

> This year on the robot we had a couple of pieces of carbon fiber, and one of the classes that I took … is a materials class and we focus on composites. So through that I knew how carbon fiber worked and how you go about using it, and effective uses for it, effective application for it. We saw that we had this design issue that we needed to fulfill, and that turned out to be extremely helpful.

Peter was able to apply a variety of skills that he learned in aerospace engineering:

> A lot of things I've learned from class like design methods, ways of optimizing something, ways of designing something or at least just checking to make sure that the computer package you're using to test something is actually giving you some reasonable result. That's stuff I learned in classes that I hadn't really applied until I got, you know I learned it and bring it into FIRST as best I could.

PFP gave the participants a context to develop a variety of process and technical skills that they perceived as being useful as they pursued careers in engineering and related fields. They were also able to apply what they had learned in their engineering classes to the solution of an applied problem, which they also believed would make them better engineers.

Assertion 2b) Mentoring presented numerous challenges that provided further development opportunities for the mentors.

Given than the vast majority of mentors were members of FIRST teams in high school, one of the biggest challenges that the participants faced was making sure that they did not take over the design and construction of the robot and do things themselves. This can be especially difficult for the freshman students. To mitigate this, all students participating in PFP are required to concurrently take a course in the mechanical engineering department that emphasizes appropriate roles and behaviors for the PFP mentors. Incoming students that came from local high school teams that were mentored by PFP are not allowed to work with that same team during their first year to encourage them to make the transition from student to mentor. While most of the participants did not find this transition especially difficult, they did find it difficult to figure out how to deal with other mentors who were too hands-on. Ian stated:

> I guess for me the hardest thing I had or dealt with was … having those mentors who are coming from high school who don't know quite what their role is going to be when they're mentoring, taking that step from being a high school student to a mentor…they're volunteering…so you don't want to offend them and…make them think that their talents aren't needed or valuable, but at the same time you want to be very clear that they shouldn't be the ones who are hands-on, they need to be teaching these kids. I had a mentor the year that I was director that did struggle with that for a long time. We worked things out…I can deal with it when I need to but I don't particularly like confrontation, so dealing with that issue was probably my biggest challenge.

This problem can be compounded by the desire of the mentors to do well and win at the competitions. Michael, in reflecting on some of the challenges that he dealt with over the past season, stated:

> We had done too much, and I don't think it's because we were trying to take over, I think it's just because we wanted to see the team succeed, and a lot of us have huge allegiances to FIRST because of the experiences we had in high school, and so our ultimate goal is to help the team succeed no matter what we have to do. I guess really what we need to remember in the future is that sometimes you have to, you have to let the team fail in some respects in order to do what's best for the team.

Although dealing with these experiences was challenging, it also gave the mentors the opportunity to develop conflict management skills and work with team members that are struggling to stay true to the vision of the team.

The transition from high school student can also provide an opportunity for self-reflection and personal development as the PFP participants learn how to manage a professional persona. Peter stated:

> There's more people looking at them to behave responsibly and act as an adult. I guess like the biggest challenge is…knowing when to behave like a young college student and when to behave like a more mature and more responsible person… learning when to be able to say no and what topics of conversation are not appropriate to talk with someone, even if they are maybe they might even be your same age but because you are in college and they're still in high school certain topics of conversation are just off limits. Learning that, and then sticking to that is I think probably the biggest thing that, biggest challenge I had and the thing that I think is most important for any new college mentor to learn.

PFP helps the participants to learn about what it means to be a responsible adult, and help them to make the transition from high school student to young adult.

Conclusion

The results of this paper suggest that PFP provides a valuable experience for the participants. It allows the participants to continue to work with the FIRST organization after high school, help other high school students have positive experiences with FIRST similar to their own, and contribute to both their local community and the FIRST organization. PFP also serves as a recruiting tool for Purdue University through both attracting students interested in continuing to work with FIRST after high school and building connections with potential students in the local community.

PFP provides a context for the participants to develop technical, teamwork, communication and leadership skills that they perceive as valuable to their future careers. They are able to apply their technical knowledge learned in engineering and other classes to solve applied, real-world problems. They have opportunities to develop process skills valued by industry that are not readily available as part of the engineering curriculum.

Challenges that arose during their mentoring experiences presented the participants further opportunities for growth. Working with high school students helped the participants to transition from a high school student identity to a more mature and aware professional identity. The significant time requirements of working with PFP helped the participants to develop time management skills. Dealing with the problems that arise when people work together helped the participants to develop conflict management skills.

The results of this study suggest that the PFP model of university students mentoring high school students can address the challenge of mentor burnout in larger FIRST program[23]. New students join the organization as others leave or graduate generating constant turnover in the mentoring population, while the organization provides stability to facilitate the transfer of knowledge from experienced to novice mentors. The many alumni of high school FIRST teams that work with PFP have both a wealth of experience to draw from when working with the high school students to design and build their robots and a strong desire to create a positive experience with FIRST for the high school students. The large number of participants with prior experience with FIRST as high school students choosing to continue to be involved with FIRST through PFP also suggests that the FIRST organization may want to formally explore ways of providing opportunities for undergraduate students to remain involved with FIRST. PFP is a good model for supporting FIRST robotics teams while providing numerous benefits to the university student participants.

There are several areas of further research related to PFP. Figure 2 shows that while 17 of the survey respondents were in their first year with PFP, this number drops by approximately half for students with two to three years experience and that there are virtually no students that participate all four years of their undergraduate education. Analyzing the experiences of the students who choose to leave PFP and their reasons for leaving would contribute to understanding PFP and the drawback to participating in this. While this study examined the mentoring relationship from the point of view of the mentor, to understand this relationship requires examining it from the mentees perspective as well. A study that focuses on the high school students and their perceptions of the mentoring relationship with the PFP participants would help provide this missing perspective. Several of the participants in this study believed that knowledge and skills gained from their work with PFP would help them in their careers in the future. Examining the alumni of PFP and how they are able to utilize and capitalize on their experiences with PFP would help to understand if this is truly a valuable benefit from working with PFP.

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