High School Technical Team Participation and Success in Undergraduate Engineering

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The dissertation examines the impact that participation on a high school technical team has on students' abilities to succeed in an undergraduate Bachelor of Science degree program. The central question of the study involved understanding if participation on a high school technical team affected the ability of students to persist and succeed during the first year of undergraduate engineering and also to graduate successfully with a Bachelor of Science degree in engineering. The study hypothesized that undergraduate engineering students who were members of an extracurricular technical teams in high school were more likely to succeed and persist in undergraduate engineering education than students who were not members of such technical teams. To test the central study hypothesis, technical team participants (leaders and non-leaders) and non-technical team participants' relative levels of self-efficacy, grade point averages, confidence in a range of engineering-related abilities, and engineering-specific social capital resources were measured. Dependent variables included eleven confidence factors, a self-efficacy scale, cumulative grade point average of engineering students after their first and fourth years of engineering, and eleven social capital variables. Independent variables included self-reported high school technical team experience, self-reported high school technical team leadership experience, engineering admissions committee–identified high school technical team experience, and engineering admissions–identified high school technical team leadership experience. Control variables included gender, under-represented minority/majority status, and socio-economic status. Data were collected via paper-and-pencil surveys, online electronic surveys, institutional archives, interviews, and observations. The dissertation found that participation and leadership on a high school technical team has a statistically significant impact on several confidence factors relative to engineering. The results varied by gender and ethnicity. Likewise, participation on a high school technical team affects students' levels of self-efficacy and engineering social capital resources.

BIOGRAPHICAL SKETCH

Scott Campbell, son of May Elizabeth and Gordon Campbell, was born in Melbourne, Australia on August 29, 1966. Scott attended Dryden Central School, graduating in 1984. He continued his education at Ithaca College, where he was awarded a Bachelor of Arts degree in 1990. He enrolled in the Rockefeller College of Public Affairs and Policy, University at Albany, State University of New York and was awarded a Master of Public Administration degree in 1997. In October 1997, Scott began working as an Assistant Director of Admissions at Cornell University's College of Engineering. It was through his work in admissions that he became interested in the topic addressed by this dissertation. In 2006 he was awarded Master of Science degree in education from Cornell University as part of the progression of his doctoral work. Currently, he is employed as the Director of Admissions for the College of Engineering at Cornell University.

DEDICATION

This dissertation is dedicated to my parents, Beth and Gordon Campbell, for their consistent emphasis on the critical importance of education and for their fundamental belief in equity, particularly as it relates to life opportunities for people of all backgrounds. It is also dedicated to my wife who has supported and encouraged me throughout all phases of my doctoral work. Without the kindness, support, un-wavering encouragement, and wonderful feedback of Dr. John Sipple, this dissertation would not have come to fruition. I could not have asked for a better intellectual mentor and friend as I worked on this project. Finally, this dissertation is dedicated to my children, Cal, Sam, and Max. These three boys provided the motivation for me to work through the final years of completing this degree and finishing this project. I want them to always remember that life-long learning is the key to professional and personal fulfillment.

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Dr. David Gries brought curiosity and grounded the work as only a mathematician can do. Not being a social scientist, David saw the work through an

entirely different set of lenses, often bringing fresh perspective and practicality back into the frame.

Tyler Garzo deserves credit for the construction and delivery of the electronic survey mechanisms. Although has was an undergraduate at the time, Tyler designed and built the electronic, online surveys at a time when there was no other way to collect the data. He visualized my ideas and turned them into stable and reliable data collection mechanisms that were sleek and far before their time.

Finally, I appreciate the help, advice, support, and collegiality of my friends and colleagues in the College of Engineering at Cornell University. In particular, a doff of the Campbell cap is due to Danyel Logevall in the Engineering Admissions Office and Sara Hernandez in the Diversity Programs in Engineering Office. Their support, assistance, and good humor were foundational to the completion of this dissertation.

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Chapter 1 – Introduction

Brief Introduction to Issues in Undergraduate Engineering Enrollments

It is well documented that, despite recent gains in enrollment, women, minorities, and first-generation college students remain disproportionately underrepresented in undergraduate engineering (Landiver, 2013; Fouad & Singh, 2011). Engineering also suffers from one of the highest attrition rates of any undergraduate academic major (Astin, 1993; Felder, 1998; Seymour, 1992). To address these issues, researchers have examined ways to increase the numbers of high school students applying to, and entering, engineering programs while also examining factors contributing to the premature departure of students from the field. Many studies examining these issues focus on dynamics such as students' study skills and confidence in their abilities to succeed in engineering, learning styles, curricular adjustments, and technical prowess in math and science (Felder, 2002; Starrett & Morcos, 2001; Haneisan & Perna, 1999; Tryggvason, et al., 2001). Very few studies address the issue of how students bridge the gap from high school to engineering, develop an engineering identity (or identify the attributes that comprise an engineering identity), and "fit into" the engineering culture they enter when they enroll in undergraduate engineering programs. A recent series of papers reviewing the literature covering the transition from high school to college in all fields found that our understanding of how students bridge that transition leaves many questions unanswered (Trent, Orr, Ranis & Holdaway, 2007; Questions That Matter, 2007). These studies call for expanding research that broadens our understanding of the ways in which students move from high school to college and the factors that influence decisions either to remain in higher education or leave.

The present study accomplishes one element of this goal by examining how high school technical team (TT) participation interacts with individual social capital networks, particularly for undergraduate engineering students. I am interested primarily in understanding whether and how high school TT participation may introduce students to engineering-specific social capital networks that they can leverage to gain various forms of advantage relative to students who do not participate on TTs in high school. This project assumes that the social structure in which these students participate is competitive in terms of both admission to undergraduate engineering and academic survivability once enrolled in engineering. Perhaps the most salient evidence supporting this notion is (a) the selective admissions process whereby applicants have roughly a one-in-ten chance of being offered admission to the engineering program under study, and (b) the predominance in the engineering college where the study took place of a grading system based on a normal curve; academically, a student's performance is routinely judged against that of his or her classmates. If indeed engineering is a competitive environment, this work may offer insight into how students from various backgrounds—ethnic, gender, and socio-economic—are able to utilize relative levels of exposure to high school TT experiences to find their place in the engineering community.

It must be said that my conceptual belief that engineering has its own unique culture (norms, values, myths, a unique vernacular, and practices) lies at the heart of this project. If there exists such a culture, then engineering programs must acknowledge that students cross the bridge from high school academic and social environments to enter the engineering community with varying degrees of expertise and facility in navigating the engineering culture they encounter once they arrive. Examining and verifying this assumption is, of necessity, one of the first steps I take in this project. "Identity congruence"—a term I use to describe how well a student "fits" into the engineering culture—may determine whether some novice engineers stay while others either choose, or are required, to leave. We may be able to understand *why* a given student leaves engineering by measuring the extent to which he or she identifies with existing engineering norms, behaviors, and language and the relative ease with which he or she adopts the engineering persona. It may also provide insight into which students are predisposed to find actual success (good grades, enhanced opportunities such as research project team participation, choice internships, and post-graduation jobs) and self-perceived success (satisfaction with engineering, overall confidence and happiness, self-integration into the College of Engineering) in the engineering community.

Statement of the Problem

I am an admissions officer at a highly selective engineering college in the northeastern United States. As an engineering admissions professional, I have an institutional mandate to recruit and offer admission to first-year and transfer applicants who demonstrate the aptitude to succeed as engineering students. Three related dynamics are the impetus for this research project:

1. The number of engineering applicants who discuss high school TT participation in their applications for admission has annually increased in complexity and scale.
2. When comparing applicants who have participated on a high school TT with those who have not, TT participants typically describe their engineering aspirations in

more profound terms than non-participants. (See Appendix 1 for an excerpt from the academic interest statement of a TT participant).

3. TT participants present their experiences, in their applications for admission, in ways that are attractive to engineering admissions officers. While perhaps not always a decisive factor, TT participation has become a positive factor in the application process that can "boost" candidates' chances of being admitted. All other things being equal, a candidate with a well-described TT experience would enjoy an admissions advantage over another candidate lacking such experience.

These three factors piqued my curiosity and led to the baseline question: Do students who participate on high school TTs succeed during the first year of engineering programs at higher rates than their classmates who do not participate on TTs?

Justification for the Study

Historical Calls for Training More Domestic Engineers

For more than half a century we have heard periodic clarion calls to increase the domestic supply of engineers. In June 1956, Arthur Flemming, the Director of the Office of Defense Mobilization, wrote an article in *The Scientific Monthly* presaging many subsequent appeals and proposals for bolstering the United States' science and engineering talent pool and workforce. Citing the spread of Communism as the pre-eminent threat to the United States, Flemming (1956) argued that:

> Specific and effective efforts must be made by business, government, and education to utilize more effectively those who have been trained as scientists and engineers. It is conceivable that the years that lie immediately ahead may constitute our most important years in terms of maintaining technological superiority for the free world. One group that has been studying this problem puts it thus: "Unless the short-run problem in the decisive period which we are approaching is successfully

> solved, there may be no long run. . . . Today's manpower problems in science and engineering must be solved today (Flemming, 1956, p. 283)
>
> Our educational system must provide us with more and better trained scientists and engineers. This means that our secondary school system must be strengthened. . . . In the field of higher education, our most difficult problems and our greatest opportunities lie ahead. I have no sympathy with those who would attempt to solve tomorrow's enrollment problems by reducing the percentage of high-school graduates attending college. The percentage must increase. We know that many exceptionally well-qualified young men and women are not receiving a college education. This is one of the reasons why we are up against serious problems in the fields of science and engineering as well as in other fields. (Flemming, 1956, p. 284)

Flemming's warning was punctuated by public hysteria in the United States when in 1958 the Soviets launched the Sputnik satellite, an astonishing technological feat at the time that underscored the magnitude of the United States' relative disadvantage in its efforts to cultivate its own engineering talent. In 1958 the federal government responded immediately by passing two bills designed to counter the Soviet threat: the National Defense Education Act (P.L. 85-864; hereafter "NDEA") and the National Aeronautics and Space Act (P.L. 85-568). The bills were designed to complement one another, boosting the capacity of American society to produce high-caliber math and science students while providing the financial resources necessary for individuals to pursue post-secondary degrees in math, science, and engineering (Flattau, Bracken, Van Atta, et al., 2006). Since Flemming's article appeared, there have been repeated calls for increasing the quantity, quality, and diversity of students entering undergraduate engineering programs. Such calls can generally be classified into four categories based on distinct rationales, citing concerns about the economy, social equity, health, or national security.

Imperatives for Increasing the Supply of Students Entering Engineering

Contemporary calls for increasing, and diversifying, the engineering talent pool center on three inter-related categories.

1. Economic -
    a. The global economy rewards technological innovation. The United States must produce domestic engineers capable of technological innovation that will retain the U.S. economy's capacity to compete internationally. Asian rim countries are producing more engineers than the United States (Olson, 2014; Public Law 111-358, 2011).
    b. The existing U.S. engineering workforce is retiring in greater numbers than are currently being replaced. Moreover, engineering features a relatively large portion of individuals who transfer to non-engineering professions (U.S. Department of Labor, 2007).
2. Equity – Engineering provides graduates with rapid social mobility, lucrative salaries, and job security (National Research Council, 2012; Fox, 2003).
3. National security – The recent promulgation of the "War on Terror" requires high technology to combat the threat of terrorism (Olson, 2014).

The NDEA recently enjoyed a brief legislative renaissance in the guise of the 21st Century National Defense Education Act (Bill H.R.4734). Introduced in Congress in February 2006, the bill used the dual specter of national security and a rapidly developing global economy as a rationale for increasing the number of American engineering graduates, proposing to "strengthen national security and ensure the competitiveness of the United States' economy by (1) developing the skills and expertise of the Nation's younger generations in science, technology, engineering, and math; and (2) increasing American students' knowledge of languages, cultures, and areas around the globe."

The current state of undergraduate engineering enrollments

Despite declining in the 1990s, engineering enrollments are rebounding and the general trend has been upward (Yoder, 2015). As the demand for highly qualified engineers has grown in recent years, two issues have increasingly taken on national importance: attracting a diverse and qualified group of students to pursue engineering as an undergraduate major and ensuring that students who choose to enter engineering remain enrolled through graduation. However, while demand for engineers has increased, the number of students matriculating in undergraduate engineering programs had consistently dropped until the late 1990s. From 1983 through 1999 undergraduate engineering enrollments dropped by more than 20 percent (Hill, 2002; National Science Foundation, 2002). While college graduation rates have increased substantially since the year 2000, the share of engineering degrees has remained static, at approximately one-sixth of the total (National Science Foundation, 2014a). In the face of declining, or static, undergraduate engineering enrollments, a retiring engineering workforce, and expanding demand for a larger pool of national engineering expertise, voices from government, industry, and academia have underscored the need to attract a diverse range of students to the field and retain them once they enroll (Wulf, 2002; Gance, 1998; Lane, 1999; Ramsey, 1999; Greenspan, 2000; National Science Board, 2003).

If the United States is to maintain its global position as an economic leader, it must continue to produce cutting-edge technological products and services. To accomplish this, the U.S. education system (K–12 through higher education) must produce a sufficient number of engineers.

Women and underrepresented minority students represent a potential wellspring of engineering talent that remains underutilized. Fifty-one percent of the overall population and 46% of the total labor force are women, but women comprised only 30% of the science and engineering labor force in 2010 (National Science Foundation, 1999, 2014a). Underrepresented minority populations mirror this pattern. African Americans, Hispanics, and Native Americans make up 23% of the total population, but African Americans comprise only 3%, Hispanics only 3%, and Native Americans less than 1% of the total science and engineering labor force (National Science Foundation, 1999). It remains an important national goal to increase the numbers of women and underrepresented minorities in engineering until their participation rates represent their portions of the population at large (Hill, 2002; U.S. Census Bureau, 2001; Jackson, 2003). If the United States is to make progress in attracting a larger cadre of students into the field of engineering, we must identify the factors that encourage all students, but particularly women and underrepresented minority students, to pursue engineering as an academic and professional interest as well as the factors that contribute to their success or failure.

Factors Contributing to Engineering Attrition

Recent declines in engineering enrollment reflect in part one of the highest attrition rates of any undergraduate major. Recent studies have found that less than half of all students who enter engineering eventually graduate with an engineering degree (National Science Board, 2003; Astin, 1993; Felder, et al, 1998; Suter, 1996; National Science Foundation, 2014b). Engineering graduation rates are even starker for women and underrepresented minorities than for their majority Caucasian male classmates. According to the National Science Board, “Women and underrepresented minorities dropped out of S&E [science and engineering] programs at a higher rate than men and non-minority students” (Guo, 2005. p. 33). Enrollment of women has increased in recent years. It has, however, done so modestly, rising from 17.9% of engineering bachelor’s degrees received in 2009 to 19.1% in 2013 (American Society for Engineering Education, 2014). The same can be said for underrepresented minority students, as “just 2.7 percent of African Americans, 3.3 percent of Native Americans and Alaska Natives, and 2.2 percent of Hispanics and Latinos who are 24 years old have earned a first university degree in the natural sciences or engineering” (National Academy of Sciences, 2011, p. 4).

Moreover, lack of academic preparation is generally not the reason students choose to leave engineering; students entering engineering programs are among the most academically able high school talent available for post-secondary enrollment. “At issue here, then, is the loss of well-qualified students before, and at some point after, SME [science, math, engineering] enrollment” (Seymour, 1992).

Many studies have sought to identify factors that might explain why students leave engineering. Stating that "[t]here is strong evidence that among all factors studied, attitudes are the most correlated with retention," Besterfield-Sacre et al. (1997, p. 140) point to an initial set of student attitudes toward engineering and their prospects for success that serve as defining variables for aspiring engineers as they begin their college educations. Anderson-Rowland (1998) also found *confidence* to be a significant factor when students decide to leave engineering and, in particular, found that confidence levels for women and minority students were lower than those of majority male students. Observing that "[m]any beginning freshmen engineering students do not have much understanding of an engineering career. Engineering is not a topic taught in middle school or high school," Anderson-Rowland (1997, p. 1) suggests that women often leave engineering because their reasons for choosing the field initially proved inappropriate or incongruous with what they actually experienced once they matriculated. She concludes by suggesting that first-year engineering seminars be utilized to help students feel more confident in the decision to enroll in engineering.

Reinforcing the findings of Anderson-Rowland (1998) and Besterfield-Sacre et al. (1997), Felder, et al. (1995) found that poor-quality interactions between students and their instructors or peers, along with doubts about having the aptitude for engineering, can discourage engineering students and erode their confidence. Directly linking student success with the tenor of the undergraduate engineering curriculum, Felder, et al. (1995) also found that women enter the engineering curriculum with greater anxiety and less confidence in their preparation than their male classmates. Moreover, women are discouraged by "discounting by male classmates, including (and perhaps especially) in cooperative learning groups" (Felder, et. al., 1995, p. 16). Given that most engineering classes stress theory over application, Felder et al. (1995) suggest several remedies with which to address these issues and improve gender equity, including urging engineering programs to adopt cooperative learning strategies that are carefully designed to mitigate the risks of men dominating group activities while ensuring that both men and women benefit equally from collaborative work.

Student perceptions of engineering also played a significant role in Seymour's (1995) findings regarding "switchers" (those who choose to leave) and "non-switchers" (those who choose to persist) in science, technology, engineering, and math (STEM) fields. Seymour outlines four factors that encourage "switchers" to leave engineering that are not shared by "non-switchers":

1. The perception that job opportunities, or the material rewards, of STEM careers are not worth the effort involved in earning an STEM degree.
2. The perception that job satisfaction and lifestyles associated with STEM careers are unappealing.
3. The greater appeal of careers in non-STEM fields.
4. Discouragement and loss of confidence suffered because of low grades and grade curving in the first two years of the engineering curriculum.

Finally, Kramer-Koehler, Tooney, and Beke (1995) found that engineering students must meet industry demand for employees who exhibit strong teamwork, leadership, and communication skills. They found that women and minority engineering students are less likely to have had experiences that build such skills.

Tinto (1993), Bean (1986), and Cabrera, Nora, and Castañeda (1993) developed, and tested, post-secondary education attrition models that illustrate how characteristics developed prior to college matriculation affect the capacity to persist through the initial college years. Conceptually, Tinto's interactionist theory focused on the transition from one environment to another, family and high school to college and the transition inherent to leaving one group to join another (Tinto, 1993). For Tinto, the heart of the matter lies in the social relations this transition involves; making new friends, relating to peers, and establishing relationships with faculty and staff are critically important steps toward gaining a social and academic foothold in the new environment (Kuh, et al., 2006). In the case of engineering students, and of women and minority students in particular, it is conceivable that the science, math, and technology experiences they encounter in high school (or do not encounter in high school), and the perceptions they form about engineering as a consequence, affect their capacity, or willingness, to persist and succeed in an engineering curriculum. For engineering, this is particularly relevant insofar as many students enter engineering without a clear idea of what becoming an engineer entails (Besterfield-Sacre et al, 1998; Penn State, 2007).

Kuh and Love's (2000) conception of social networks offers relevant and interesting insights into the effects that immediate social "life rafts" may have on the capacity to succeed in college. I use the term "life rafts" to refer to Kuh and Love's conception of small social affinity groups that may offer gateways into the larger social milieu of the college environment (Kuh and Love, 2000; see also Braxton & Hirschy, 2005). When these notions are combined with engineering curriculums that have historically stressed *individual* achievement and competition—which in my view reflects an unclear vision of what engineering really is—coupled with relatively lower self-confidence, there is considerable potential for significant discord between what students expect to do as undergraduate engineering majors and the day-to-day reality of engineering education. This may be acutely true for groups that are most at risk, particularly women and underrepresented minorities.

In summary, some students enter engineering with perceptions, confidence levels, skill-sets, and social networking abilities that may not align with the existing engineering teaching and learning culture. The net result is that critical segments of the population choose either to depart shortly after entering the major or avoid engineering altogether.

Significance of the study

The significance of this study lies in its potential to provide a framework for understanding the effects that high school TT participation may have on the success of first-year engineering students. While many organizations providing TT experiences proclaim the positive effects of participation in these programs, these claims remain largely anecdotal and untested. This study takes an initial step toward understanding whether these programs *do* have residual effects on students enrolling in engineering. I am particularly interested in whether these effects differ across specific groups. Finally, assuming that TT participation does have a positive effect on first-year engineering students, this study provides beneficial insights into specific aspects of these experiences.

Assumptions of the Study

Social and cultural capital theories assume fundamentally that contemporary society operates based on socio-historically established, stratified social structures. The three pivotal pieces—or social structures—that create societal stratification include power, wealth, and status (Bowles, 2013). These social structures (e.g., rich–poor; majority–underrepresented minority; lower, middle, and upper class; urban, rural, suburban; working versus professional class) reflect relative levels of social advantage and privation determined by power relationships that allocate resources and privileges determined by well-defined and societally embedded norms, values, beliefs, and myths. The notion that American society places a premium on economic capital underlies this assumption, privileging individuals who have attained the highest levels of financial wealth. Financial wealth, social mobility, and information that steer younger generations toward opportunities for success are, in large part, functions of family income, the quality of local information networks, and individual educational attainment (Anderberg & Andersson, 2007). Attaining wealth, and hence status, in American society seems to depend on gaining access to competitive universities and sought-after academic credentials that provide the potential leverage, or transaction value, that is a precondition for either social mobility or securing one's existing social status.

The selective admissions process utilized by the engineering program in the present study manifests this structure; candidates for admission compete with one another in what is often perceived as a zero-sum game for admission to a limited number of annually available seats within the college's first-year class. Admission to the engineering college, and attaining an engineering degree, are seen as significant steps towards retaining, or gaining, status and power within the broader social structure; the most powerful corporations and organizations, not only in the United States but across the globe, hire the program's graduates. They can expect a starting salary of over $72,000 per year, which is the highest starting salary associated with any major across the university by an average of approximately $15,000 (Sparrow, 2013). A graduate's engineering credential licenses access to exclusive and privileged social networks involving some 36,000 living college alums scattered around the world, providing enhanced possibilities for professional growth and promotion. And all of these elements represent the domino effects of economic, social, and cultural capital that are an extension of the capital to which many students attending this particular engineering college were exposed throughout their lives.

In some ways, the benefits derived from entering and graduating from this engineering college reinforce existing societal structures and barriers. Absent the assumption that such social structures exist, the explanatory power of social and cultural capital theories as explanatory referents for TT experience within engineering becomes otiose; reinforcement of engineering-specific social and cultural capital via high school TT experiences is an operative component of this research project.

Purpose and Objective of the Study

The purpose of this dissertation is to understand whether individuals participating on a TT in high school are better prepared to withstand the rigors of the first year of undergraduate engineering education; I am particularly interested in understanding how engineering-specific social capital may interact with success in undergraduate engineering. This study compared TT participants and non-TT participants as they moved through the first year of the engineering curriculum at a highly selective engineering college. Relative levels of social capital and confidence and varying perceptions of engineering-related socialization between the two groups (TT participants and non-TT participants) were measured via a series of surveys and interviews. Comparisons between groups were also made based on gender, ethnicity, and socio-economic status.

Hypotheses and Research Questions

Central Study Hypothesis:

Undergraduate engineering students who participated on an extracurricular TT in high school are more likely to be better prepared for success in undergraduate engineering education than students who did not participate on such a team.

The central research question is addressed by four related hypotheses:

Hypothesis 1A: First-year engineering students who have participated on a high school TT will have *stronger self-efficacy* skills than their engineering classmates who did not participate on a high school TT.

Hypothesis 1B: First-year engineering students who have participated on a high school TT will achieve *higher cumulative GPAs* than their engineering classmates who did not participate on a high school TT.

Hypothesis 1C: First-year engineering students who have participated on a high school TT will be *more confident* in their abilities to succeed in an undergraduate engineering program than their engineering classmates who did not participate on a high school TT.

Hypothesis 2: Participation on an extracurricular TT in high school provides participants with increased engineering-specific social capital resources relative to engineering classmates who did not participate on a high school TT.

Chapter 2 – Review of the Literature

Introduction

My objective in this chapter is twofold. First, I seek to develop a theoretical framework that underpins the study, premising the work on pre-existing research and providing a theoretical basis that informs the research problem. Second, adhering to Krathwohl's (1998) conception of theory as "an explanation of behavior that makes good logical sense and either is consistent with the research and explanations that preceded it or convincingly negates or modifies them," in this chapter I seek to combine aspects of several theories to develop a robust theoretical lens through which to examine the potential effects that participation on a high school technical team (TT) may have on undergraduate engineering student success.

I used several criteria to define the boundaries of the literature review. For social capital theory, I used only references focusing on individual (as opposed to group or community) social capital. As a result, techniques for measuring social capital were also confined to references that illustrated, or discussed, the measurement of individual social capital. For socialization theory, I reviewed seminal socialization references and then focused primarily on socialization theory within the field of organizational behavior. The rationale for this approach is that students joining undergraduate engineering programs move through a process similar to what individuals joining organizations experience: socialization trajectories and processes in the two contexts may exhibit similar patterns and features. As a consequence, organizational socialization offers a well-established framework for understanding how first-year engineers are initiated into their new organizations: engineering colleges. Finally, much of this project involves understanding problems related to access to engineering and retention within engineering. *Does participation on a high school TT help students find, enter, and persist in an engineering program?* More to the point, does TT participation in high school provide valuable social capital information networks and insight into the socialization process that becoming an engineer entails? Much research has focused on factors that lead college students to drop out of college. This body of literature is vast and provides a nuanced look into the issues of college persistence and attrition. I restricted the literature review to studies that are considered seminal within this field and studies whose content is relevant to attrition from undergraduate engineering in particular.

Social Capital Theory

Figure 1. Theoretical Diagram 1: Possible benefits of TT participation.

Two elements form the heart of this diagram:

1. The notion that TT participation leads to the construction of an engineering identity (Situated Learning Theory)
2. The possibility that social networks, developed through TT participation, may be exploited to various forms of advantage by individuals in (a) the admissions process and (b) once they enter an engineering community of practice, including the transaction of an engineering identity to obtain various benefits (Cultural *and* Social Capital Theories).

PRE - HIGH SCHOOL TECHNICAL TEAM PARTICIPATION

Cultural capital as a catalyst for joining a technical team. . .

HIGH SCHOOL TECHNICAL TEAM PARTICIPATION:

Adult Experts:
Engineer(s)
Business people
Parent(s)
Teacher(s)
Peer Experts:
Fellow students
Students from other technical teams encountered through the Internet, competition, demonstrations

Technical team as an **incubator** of engineering culture, norms, language, and behavior . . . learning what it means to *be* an engineer.

"Engineering Identity" constructed through situated learning—specifically, Legitimate Peripheral Participation—within a technical team.

Use of social capital derived from social networks and developed within a technical team in strategic ways to gain various tactical advantages.

Benefits of cultivating an engineering identity activated by cultural capital and realized by social capital.

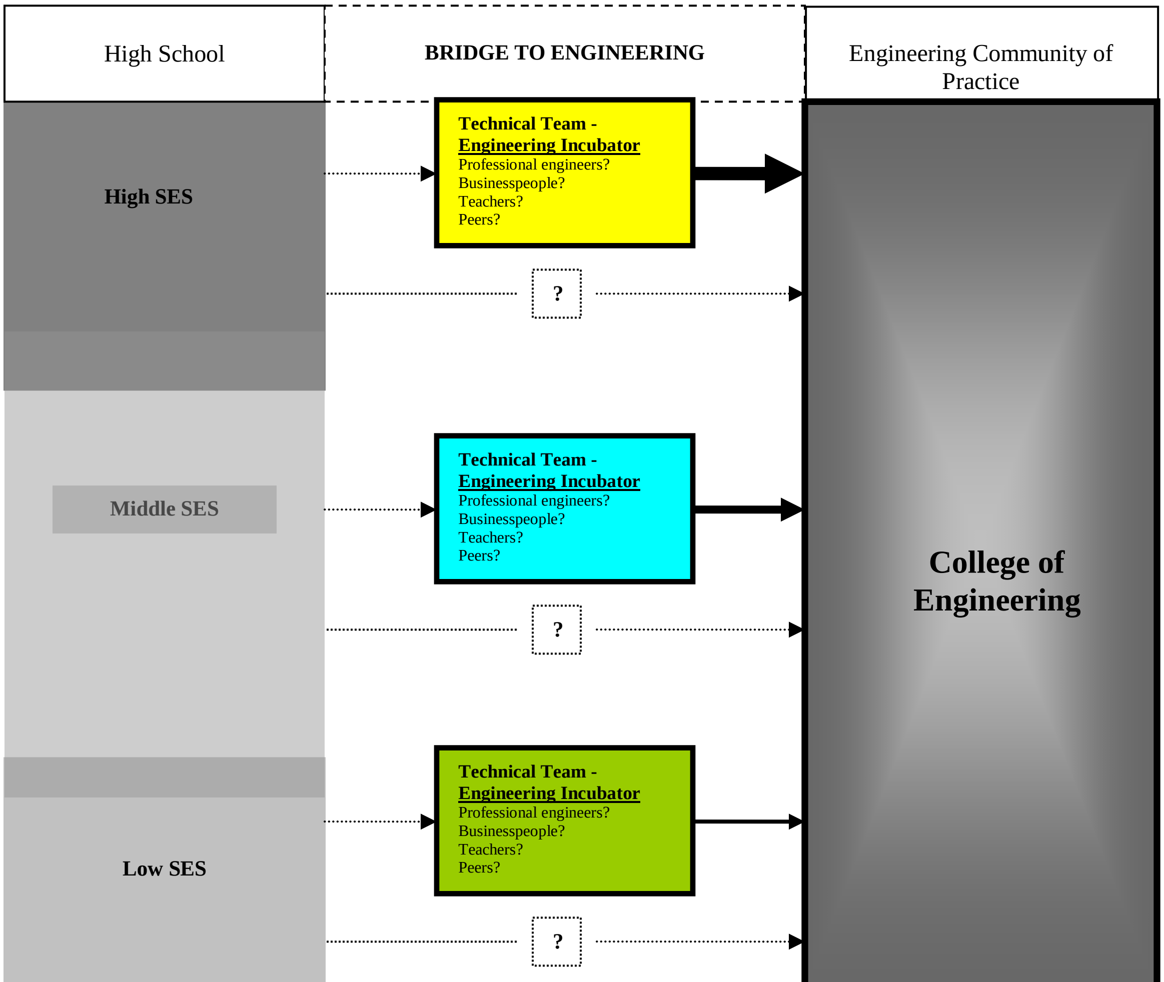
COLLEGE OF ENGINEERING AS A COMMUNITY OF PRACTICE

Potential benefits of a well-developed engineering identity, realized, in large part, through the activation of social capital:

1. **Admissions process** - Being spotlighted by admissions officers because you know *what engineering is* and have demonstrated commitment to engineering prior to entering the application process.
2. **Perceptions of success** – Feeling confident and/or feeling happy as a consequence of congruence between pre-application expectations of engineering and the reality of experiencing engineering as a novice member of an engineering community of practice (i.e., being a first-year engineering student). Being able to say "Engineering is what I thought it was going to be *and* I like engineering!"
3. **Actual success** – GPA, high participation rate in clubs and organizations that provide rewards (e.g., research teams, student projects, engineering student organizations).
4. **Increased Retention** – Enhanced ability to persist *through the course of the first year and through graduation with a BS from engineering* in the face of obstacles and failures; essentially to remain in the engineering community of practice as a consequence of understanding the culture of the engineering community.
5. **Feeling part of the engineering community of practice** – Knowing *how* (knowing culturally appropriate ways) to participate in the engineering community of practice—engineering-specific norms, language, culture, practice.

Figure 2. Theoretical Diagram 2: Qualitative differences in TT experience and SES.

Salient ideas include: (a) TTs potentially serve as bridges between high school and engineering and (b) the caliber of TT experience is likely to vary from team to team (and perhaps even within teams) and *may* be a function of the net Socio-Economic Status (SES) of individual teams and their respective communities. For example, High and Middle band SES TTs *may* include professional engineers who are part of the student participants' residential communities or part of the students' familial and/or social networks. Low SES TTs *may* include a high school physics or math teacher as the only "adult expert."



<u>Notes on the theory:</u> The diagram shows the potentially varying quality of TT experiences that are available to students based on relative SES structural location. With whom *students have the opportunity to interact in their TTs determines the instrumentality of the TT as a bridge from high school to undergraduate engineering. The dotted lines in the central section that include question marks indicate students who never participated on a TT—because they were unaware of the availability of these experiences, chose not to participate, or were excluded; issues pertaining to these students include (a) the criteria they use to choose engineering, (b) how they* know *that engineering is a good match for them, and (c) how confident they are in the decision to pursue engineering.*

The varying widths of the solid lines/arrows pointing from TTs to engineering indicates my hypothesis that more affluent TTs may provide richer sources of social capital and a firmer sense of engineering identity for participants—the wider and more solid the line, the higher the caliber of information available to participants.

Introduction to Social Capital Theory

In this section I review studies that inform my view that social capital theory is a good model for understanding the interaction between TT experience as well as access to, and success in, undergraduate engineering. Nan Lin conceives of social capital as

> *investment in social relations with expected returns in the marketplace*. . . . In this approach, capital is seen as a social asset by virtue of actors' connections and access to resources in the network or group of which they are members. (Lin, 2001)

Ricardo Stanton-Salazar complements Lin's definition by viewing social capital as

> social relationships from which an individual is potentially able to derive institutional support, particularly support that includes the *delivery of knowledge-based resources*, for example, guidance for college admission or job advancement. Working class youths have vastly less social capital than do middle-class youths. (Stanton-Salazar & Dornbusch, 1995: underline added)

As Lin suggests, social capital is a deceptively simple concept—people use their social relationships tactically as they attempt to gain advantaged positions within some social structure (a neighborhood, a school, a country, a community, an applicant pool for a job or for college admission). The word 'deceptive' applies because the concept of social capital rests on a complex set of overlapping assumptions; it presupposes that individuals—at least part of the time—calculate how to serve their own best interests, compete against other individuals or groups for scarce resources, and have differential access to information and power networks that vary in terms of the numbers of people within the networks and the quality of information and resources those people are able to provide (Bourdieu, 1989). Agents—individual people—also meet with varying degrees of success in their attempts to activate these networks; some are quite skillful at manipulating and utilizing them, while others are not. Perhaps most critically, the concept of social capital presupposes that individuals operate within socially structured hierarchies, and one's location within any given social structure relative to others either limits or facilitates exploitation of the network resources—the social capital—at one's disposal (DiMaggio, 1979; Lin, 1981; Stanton-Salazar, 1997). As a consequence the relative utility and quality of one's social capital might either propel or curtail movement within the hierarchy, particularly if the desired movement is either upward or lateral. While it is conceptually straightforward, the application of social capital theory can actually be quite complex.

My interpretation of social capital rests on the notion that it is indeed instrumental and can be consciously and tactically deployed by individuals via relationships with other individuals, or groups, who hold power, information, resources or access and linkage to other individuals with power, information, or resources. Instrumentality and tactics are essential to establishing a connection between social capital theory and TT participation.

Social capital, then, is a function of social networks and is fundamentally about the development of relationships *in the pursuit of advantage*. As Burt, Hogarth, and Michaud (2000, p. 123) state, "the brokerage principle in network theory says that there is a competitive advantage to building bridge relationships. Resources flow disproportionately to people who provide indirect connections between otherwise disconnected groups." At the heart of contemporary social capital theorists' conceptions are the seminal ideas of Pierre Bourdieu and his neo-capitalist conception of various forms of capital. Social capital theory is premised on using social capital to understand how an individual actor (the ego) operates within social structures (institutions). It is the ego's orientation within the structure and degree of instrumentality relative to others (alters), and the ways in which social capital sheds light on this individual-within-structure dynamic that drives much of the explanatory power of their work (Seibert, Kraimer, & Liden, 2001; Kenis & Knoke, 2002). The fundamental social capital theoretical concepts that shed light on my project include:

a. Social capital is premised on the existence of social structures that necessitate—or promote—competition for scarce spaces at the top that provide some combination of prestige, wealth, or power (Lin, 2001).

b. Based on their positions within an existing social hierarchy, social capital facilitates the actions of certain actors who could not carry out those actions without the presence of social capital (Coleman, 1988). Individual actors can use social capital in strategic ways to attain tactical advantages over their peers (Lin, 1999; 2001). Social capital, in terms of both quantity and quality, is not evenly distributed across social hierarchies (Lin, 1999).

c. Social capital can enforce group social norms and values (Coleman, 1988; Kahne & Bailey, 1990).

d. Social capital is a conduit for information flows (Coleman, 1988b; Lin, 1981). Individuals placed at strategic locations (structural holes) within a social network are better positioned to broker the flow of information and are at a tactical advantage relative to individuals placed less favorably in the social structure (Burt, 1997, 2000; Reagans & McEvily, 2003). Social structure also implies locational placement of specific individuals within a social hierarchy and affects the operational capacities of individual actors—or *groups* of actors (e.g., women and minorities). The potential of social capital within social structures depends crucially on the notion of structural centrality. Theorists have defined four types of centrality: degree, closeness, betweenness, and information centrality (Kenis & Knoke, 2002). "Briefly, degree simply counts the number of direct ties to or from an organization; closeness takes into account both direct and indirect links, representing efficiency or independence from all other network actors; and betweenness calculates the extent to which actors fall between other pairs on the shortest paths connecting them" (Kenis & Knoke, 2002, p. 283).

e. Strong social ties facilitate group solidarity (Teachman, Paasch & Carver, 1996). Social capital can promote the recognition of individuals as members of specific groups; social capital lends individuals identity and recognition in the eyes of influential others (Lin, Cook & Burt, 2001; Podolny & Baron, 1997).

f. Weak social ties have the potential to promote both the quality and quantity of the information that individual actors receive (Granovetter, 1983; Lin, 1991). Individuals with abundant networks of weak ties are at a tactical advantage relative to their peers who have relatively fewer networks of weak ties (Lin, 1981) *if* the goal of an individual is mobilization as opposed to consolidation of power or social position.

g. "Institutional agents"—those placed in positions of power and prestige within a social hierarchy—are key sources of social capital because they control access to both information and opportunities (Stanton-Salazar, 1997; Stanton-Salazar & Dornbusch, 1995). Perhaps more importantly, institutional agents generally recognize and reward individuals whose cultural capital is congruent with the norms and values of the upper echelons of a social hierarchy (DiMaggio, 1979; DeGraaf, Degraaf, and Kraaykamp, 2000; Gonzalez, Stoner, & Jovel, 2003). This dynamic reinforces existing structural biases.

h. Social capital can be used as a source of power to exclude outsiders from vital resources, including critical tactical information (Portes, 1998).

For the purposes of my project, the notion of individual instrumentality is *the* critical element. *Do* individual engineering applicants consciously use the information they cultivate via TT experiences to enhance their positions while other applicants who do not have the benefits of a TT experience cannot? If so, *how* does their social capital provide them with advantages? *Are* individual students cultivating advantages as undergraduate engineers as a consequence of being TT participants in high school? *Are* these experiences differentially allocated across groups (e.g., male majorities, women, affluent students, minorities, rural students, poor students)? I *think* that some, if not all, engineering applicants do perceive these experiences as tactically advantageous and that information that provides actual advantages is embedded within the framework of the TT as a "structural hole" or rich social network—the TT places these students at the intersection of valuable information that makes it easier to access engineering programs and develop an engineering identity.

Cultural Capital

Any discussion of social capital must also discuss cultural capital. For my purposes, cultural capital serves as a catalyst for social capital (although determining which direction the causal arrow between social capital and cultural capital points is difficult if not impossible to discern). According to Bourdieu, cultural capital is more tacit and less instrumental—it is more disposition than tactic, more invisible and subtle than overt and identifiable (Young, 1999). It is the *intangible* cousin of the other forms of capital and can be as imperceptible as body posture and control, accent, choice of sport, or even the abundance or absence of facial wrinkles (Throsby, 1999; Elster, 1981). Bourdieu himself described cultural capital as "the best hidden and socially most determinant educational investment" (Bourdieu, 1986, p. 244). What he likely meant is that cultural capital is less about an individual's innate intelligence and ability and more about the individual's location within a social hierarchy and how closely the cultural training the individual receives at home complements what is culturally valued by institutions, such as schools, that dole out highly prized social rewards. Cultural capital represents the set of socialized expectations that allow individuals to make sense of, and, in the case of societal elites, capitalize on the social structures they encounter in their daily lives (Lareau, 2003).

It is critical to note that the most powerful conception involving social and cultural capital presupposes that they act in concert (Schaefer-McDaniel, 2004). This might mean that either is inert without the presence of the other—to wit, cultural capital may be a trigger for social capital and social capital may be an expression, or outcome, of activated cultural capital. Social capital is a manifestation of the inherent power of social class when the key elements of cultural capital match the appropriate setting *and* an individual *realizes* the power exercised in capitalizing on this match. As Young states, "clearly the forms of capital overlap and interconnect" (Young, 1999, p. 204) and in the case of cultural and social capital, the relationship is reciprocal. It is important to note, however, that not all individuals endowed with tactically rich social networks activate these networks to their advantage.

How *do* some students *know* that their high school TT experiences might offer transaction payoffs at some point down the line in terms of information and resource benefits? Why do some applicants with TT experiences pointedly choose to describe their social interactions with professional engineers in their application essays rather than in their interactions with actors who have less influence over their career trajectories? Lin suggests that, "only when the individual is aware of their (social ties') presence, and what resources they possess or can access, can the individual capitalize on such ties and resources" (Lin, 2001, p. 25). Cultural capital—represented by an individual's "habitus," which can be described in a rudimentary way as "the underlying rules, or 'grammar,' that structure consciousness and, as such, regulate the ways in which we categorize, organize, select, and configure the material and cultural resources we employ in our social behaviour" (Moore, 2004, p. 80; I explain the term "habitus" at greater length later in the chapter)—is the trigger that allows more privileged students to realize the latent advantages of interacting and working with "real" engineers in "real" settings within TTs. Eventually these interactions make up a stock of information and experiences that may be traded in for benefits and advantages in the selective engineering application process as well as later in engineering classrooms and labs.

Because it is not, on its own, instrumental and is not as overt as social capital, cultural capital is of less interest to me. I am much more interested in the social structures, and the networks embedded within those structures, that lead individual students to capitalize on their experiences. That is to say, I want to understand how individuals *use* their TT experiences as "social freeway[s]" (Stanton-Salazar, 1997, p. 6), or social networks, in very overt and consciously tactical ways that enable them to climb the social ladder or reinforce their existing positions in the social hierarchy.

Theorizing Social Capital

Social capital is a multifarious set of ideas with broad applications. Not many theorists agree on its uses, there is no consensus on a conceptual definition (Schaefer-McDaniel, 2004), and its applications have been "proliferating wildly" (Schuller & Bamford, 2000). The concept has been wielded by economists, sociologists, anthropologists, linguists, computer scientists, historians, philosophers, agents of the World Bank, politicians, and so on, with little theoretical congruence (Farr, 2003; Woolcock, 1998). As Sobel suggests, "[n]o one could dispute that social capital is multi-faceted. Authors recognize that if they are going to use the term, then they must define how they will use it"(Sobel, 2002, p. 144).

While some may see the fractured conceptual framework of social capital as a weakness, I see it as quite useful, for two reasons. First, the range of elements that fall under the social capital umbrella allows me to draw from a rich vein of cross-disciplinary resources. I draw from several theorists to combine selected elements of their social capital theories and thereby develop deeper insights into the dynamics of the TT experience than would otherwise be possible.

Second, social capital indeed provides common theoretical footing (most theoreticians agree on what drives social capital, namely the use of social networks in the pursuit of some goal or objective). Although its application has been stretched across a variety of disciplines and it has been utilized in efforts to offer insight into contemporary problems from a range of vantage points, this versatility enhances the theory's overall plausibility (Farr, 2003).

Historical Focus: Hanifan and the Seeds of Social Capital Theory

The lineage of the term *social capital* is worth tracing. Although Pierre Bourdieu and James Coleman are widely recognized as the progenitors of contemporary social capital theory (or neo-capitalist theory), Karl Marx is credited with inventing the term (Farr, 2003; Portes, 1998). The term "social capital" was also used at the turn of the twentieth century. L. J. Hanifan, the State Supervisor of Rural Schools for West Virginia, wrote a book entitled *The Community Center* that was part of the 1920 Teacher Training Series designed to guide rural teachers and superintendents in the use of public schools as a hub for revitalizing stagnating rural communities. Hanifan included a chapter titled "Social Capital—Its Development and Use" to introduce some basic concepts. The main thesis of the chapter captured the initial—and powerful—kernel of social capital theory that theorists such as Coleman, Lin, and Bourdieu were later able to develop more fully. Hanifan defined social capital as follows:

> In the use of the phrase "social capital" no reference is made here to the usual acceptation of the term "capital," except in a figurative sense. We do not refer to real estate or to personal property or to cash, but rather to that in life which tends to make these tangible substances count for most in the daily lives of a people; namely, good will, fellowship, sympathy, and *social intercourse among the individuals and families who make up a social unit*,—the rural community, whose logical center in most cases is the school. In community building, as in business organization, there must be an accumulation of capital before constructive work can be done. . . . *The individual is helpless socially if left to himself*. (Hanifan, 1920, p. 78–79 [emphasis added]).

The book—and Hanifan's conception—was part of a larger American social movement designed to move people away from individualism and toward wider social integration and activity. At the heart of this movement was John Dewey, whose “philosophy was the seedbed for the concept of social capital in this era, one fruit of which was the term itself” (Farr, 2003, p. 9). The “social center movement” began in Rochester in 1907 and spread south from there (Farr, 2003). While it was a broad social movement, representing the optimism of the Progressive Era, it was Hanifan who realized the important role public schools could play in reinforcing local community solidarity. He also recognized the gross inequities rooted in the existing social structures of his time:

> [Hanifan] had by then already sketched an analysis of social conditions that helped explain what he would call “the total lack of social capital in rural districts” when first using the term. This sketch analyzed “deplorable” school conditions, “inequalities of wealth” attending “industrial developments,” segregation and unequal education for “Negro youth,” and “great many foreigners” in rural as well as urban America who could not “become good citizens” without a “helping hand.” (Farr, 2003, p. 7)

For Hanifan, social capital offered a mechanism, or tactic, that could rectify or mitigate the inequities he observed. The critical factor Hanifan identifies, and calls social capital, is the notion that *social interconnectedness* enhances the possibility that a community’s economic—or physical—capital can be improved via the strengthening of collective action and activity. His corollary suggestion is that the process of reinforcing communities by tying individual actions to a centrifugal community organization (such as a school), also provided direct benefits to individual members of the community. The dynamic is, in essence, a two-way street with mutually beneficial exchanges occurring between an individual and the collective to which he or she belongs, whereby both ultimately benefit. While perhaps simplistic, this notion is nevertheless a key foundational concept of contemporary iterations of social capital theories.

Key Theorists' Contemporary Conceptions of Social and Cultural Capital

James S. Coleman

Coleman picks up Hanifan's initial thread in the early 1960's, noting that school social systems generally—and the relative influence of peer status systems particularly—reward the achievements of individual students based on each student's location within school social strata—his survey questionnaire consisting of five concentric circles and the question, "Suppose the circle below represented the activities that go on here at school. How far out from the center of things are you?" draws attention to the notion of location within a social hierarchy or structure, but nonetheless makes the point that social structure was central to his work (Coleman, 1960; Coleman, 1961; McDill & Coleman, 1965). Coleman's seminal work caused national controversy when he found that students' within-school social interactions and peer-group associations, in combination with their families' backgrounds, had dramatic and direct consequences for academic achievement (Coleman, 1966; Coleman, 1968). At the time, this was a revolutionary finding, contradicting accepted notions that the school itself (desks, books, teachers, heating systems, gymnasiums, oak lined walkways—or the lack of these things) rather than peer connections and family background had the most dramatic consequences for student achievement. Thus Coleman's findings implied that federal attempts to pour fiscal resources into schools in an effort to level the educational playing field were viewed as necessarily ineffective. Home socio-economic background and peer group associations took on new explanatory prominence in the wake of Coleman's findings.

"Social Capital in the Creation of Human Capital" is perhaps Coleman's most oft-cited work related to social capital theory (Coleman, 1988b). In this paper Coleman defines social capital by its *function* (what purpose, or purposes, does social capital serve?) stating that social capital is

> a variety of entities with two elements in common: they all consist of some aspect of social structures, and they facilitate certain action of actors—whether persons or corporate actors—within the structure. Like other forms of capital, social capital is productive, making possible the achievement of certain ends that in its absence would not be possible. (Coleman, 1988, p. S98)

While the paper covers a wide swath of theoretical terrain, the cornerstone of Coleman's conception of functional social capital includes the following elements:

1. Social capital is a resource made available *to* individual actors, deriving from relations *between* individual actors. Social structures (read: social relations) either facilitate or constrain the specific actions of individuals within closed social networks.
2. Social capital has the potential to facilitate actions promoting the accomplishments of individual actors.
3. Social capital has the potential to affect the enforcement of social norms and values.

Coleman outlined three manifestations of social capital:

1. Obligations and expectations inherent to social networks form the basis of exchange relationships. Trust is a key element, driving the efficacy of this form of social capital (Coleman, 1988b). High levels of trust promote social capital, while low levels of trust dilute the efficacy of social capital (Sobel, 2002).
2. Social capital is also the rail upon which information rides. Because social relations have the potential to act as strategically important conduits of information, increased levels of social capital increase the potential for

individuals to access information that will allow them to act in ways that improve their odds of being successful (Coleman, 1988b).

3. Finally, knowledge of certain types of subtle—and also not-so-subtle—social norms represents social capital insofar as individual actors recognize that particular behaviors are appropriate *relative* to specific situations. Actors recognizing this can adapt their behavior to social settings in ways that produce specific sanctions *or* rewards. Social capital, in this sense, enforces accepted social norms (Coleman, 1988b; Kahne & Bailey, 1990).

The final, and, perhaps for the purposes of this research project, the most important, element of Coleman's conception of social capital rests on the notion of intergenerational social closure (see Morgan & Todd, 2009 for a detailed discussion of intergenerational social closure). Social closure essentially suggests that dense social networks, with multiple redundant connections, reinforce the effects of social capital, "where closure refers to congruence in one generation's expectations for behavior in the next generation. . . . The accumulation of social capital rests on the fact that a web of social relationships with consistent expectations for behavior is generated" (Teachman, Paasch & Carver, 1996, p. 774). Trust is an important antecedent of social capital and tightly knit social structures promote higher levels of trust, specifically within social groups where obligations and expectations provide the necessity for collective action. Stated quite simply, "the closure of the network gives increased potential for amplifying the returns to the network" (Coleman 1988 a, p. 57).

For my purposes the most salient piece of this argument is Coleman's assertion that social capital provides valuable information to individuals while also enforcing specific community norms and behaviors (Coleman, 1988a). It is conceivable that TT participants "discover" the intricacies of engineering by gathering information via the TT experience and as a consequence of their relationships with engineering experts they encounter as participants. It is also conceivable that they learn engineering norms, behaviors, and vocabularies during TT activities.

I also find the notion of intergenerational closure useful, but not as Coleman describes it. For Coleman, "closure of the social structure is important not only for the existence of effective norms but also for another form of social capital: the trustworthiness of social structures that allows the proliferation of obligations and expectations" (Coleman, 1988b, p. S107). While I see Coleman's point that enforcing norms is more efficient in tidy, tightly knit networks of scale, I also see network closure—and particularly intergenerational closure—as a factor that *limits* access to, and the spread of, valuable information. Morgan (2000) reinforces this point with his finding that social closure actually inhibits learning among high school students because it limits their access to "horizon-expanding environment(s) that could more capably motivate them to learn"(Morgan, 2000, p. 594). For my purposes, intergenerational closure may have a negative influence on the ability of lower-status individuals to tap into social networks that provide beneficial information. Network closure has the potential to insulate individual actors from critical information sources. This may be crucial, particularly in TT settings where, even if lower-status individuals have access to TT experiences, they may not have any sense of the importance of activating the latent social capital these experiences make available because they operate in a closed social network.

This is an important notion because it lays the groundwork for viewing social capital in a tactical light; that is to say, individual actors may consciously choose to use accrued social capital to their advantage. Those who do not know that they can leverage advantage via social capital lose, by definition, the value of their social capital. This also acknowledges that social capital exists in what I refer to as multivalent form—"it exists in the relations among persons" (Coleman, 1988b, p. S101). As such, this makes it difficult to perceive whether a given individual is an outsider. For my purposes, it matters most that (a) social capital can be used tactically for benefit or gain by individual actors, and, perhaps more importantly, that (b) social capital is contextually driven by the potential to serve as a catalyst to success for some while remaining dormant for others.

<u>Coleman In Summary:</u>

- → Social capital is a conduit for valuable information.
- → Social capital enforces community norms and values, particularly in communities with high levels of social closure (such as colleges of engineering)
- → Intergenerational potentially limits opportunities for individuals positioned lower in a social hierarchy to access the cultural and social capital of their friends and friends' parents.

Nan Lin – Part 1

Lin builds on Coleman's nascent social capital conception, pointing out that

> the premise behind the notion of social capital is rather simple and straightforward: *investment in social relations with expected returns in the marketplace*. . . . In this approach, capital is seen as a social asset by virtue of actors' connections and access to resources in the network or group of which they are members. (Lin, 2001, p. 19)

Lin also expands the concept of social capital, unifying the underlying principles posited by various social capital theorists:

> Thus Bourdieu, Coleman, Lin, Flap, Burt, Erickson, Portes and others all share the understanding that social capital consists of resources embedded in social relations and social structure, which can be mobilized when an actor wishes to increase the likelihood of success in a purposive action. (Lin, 2001, p. 24)

To gain a better sense of Lin's observation one must first understand Mark Granovetter's conception of social networks; the two ideas are closely related and inform one another as Lin synthesizes elements of social network theory and social capital theory. Granovetter developed and clarified one of the fundamental tenets supporting Lin's conception of social capital: the strength of weak ties (Granovetter, 1973). According to Granovetter, social ties come in two forms: strong ties (e.g., relationships with close friends), which promote group solidarity, and weak ties (e.g., relationships with acquaintances), which promote access to unique and valuable information (Granovetter, 1983; Lin, 1991). The conception of strong ties is analogous to Coleman's concept of network closure; both describe densely packed social ties, intimately connected with one another with limited or no substantial external contact; such ties are most advantageous if a group seeks solidarity and consolidation, but they are confining if the group seeks social nimbleness, expansion, and competitiveness.

It is worth bearing in mind that the critical difference between Coleman and Granovetter is that Coleman viewed strong ties (social closure) as fundamentally beneficial to a community *because* network closure promotes the essential ingredient of trust within social relations. For Coleman, trust, or trustworthiness, is the electricity that turns on the lights of social capital; no trust, no reciprocity, no real information exchange . . . no social capital.

Granovetter, on the other hand, argues that strong ties are less potent than weak ties—strong ties serve to isolate individuals within a network while also stranding the network as a whole within the greater social milieu (Granovetter, 1973; Granovetter, 1983). As a result, strong ties limit individual access to valuable information, influential others, and, finally, social mobility. The concept of homophily as described by Mouw (2006) is conceptually analogous. Homophily, as it relates to social capital, suggests that individuals select—or choose—people they see as similar to themselves to include in their social networks and, as a consequence, their social networks reflect insular characteristics that inhibit the flow of valuable information. Homophily is particularly pronounced along lines of race and gender, localizing information and, as a result, restricting opportunities (McPherson, Smith-Lovin, & Cook, 2001). After all, how does one learn of unique opportunities if one interacts only with those in one's immediate family, neighborhood, community, or class?

Granovetter (1983) adds that the advantage of *weak* ties is that they serve as "bridges" connecting separate networks consisting of strong ties. Bridges are commonly used by those with better, or higher, positions in a hierarchy and are tactically useful in information transfer and attaining insider assistance that reinforces or elevates an actor's social status. This suggests that perhaps TTs bridge high school networks with engineering networks. Bonding, on the other hand, is the process of reinforcing existing strong ties, and is used primarily by those with relatively low status positions in a social hierarchy—more on this point below (Granovetter, 1983).

The bridging function of weak ties makes them valuable to individuals as they move upward through social hierarchies (Sobel, 2002; Reagans & Zuckerman, 2001). By using weak ties as bridges, an individual (the ego) can access information that is more diverse and robust than what is available in a network consisting merely of strong ties with paralytic rigid social closure, punctuated by imperfect and limited information; in short, bridges lead to enriched information for those who know how to cultivate and capitalize on them. The corollary argument can also be made that the *more* weak ties there are in the ego's network (in terms of quantity), especially weak ties that reach *upwards* to individuals occupying positions with higher social status (higher quality), the richer the information resources the ego can access and utilize. The notion of utility is important for it suggests both purposeful action and strategic social tactics (Lin, 1999). This implies that individuals with relatively rich sets of weak ties will more efficiently attain status, prestige, and social mobility, all of which represent the inherent rewards of a highly structured society (Granovetter, 1983).

Lin places Granovetter's account of weak ties within a broader conceptual framework, tying social network theory to social capital theory. Two foundational ideas of social network theory, social resources and social structure, are pivotal to Lin's social capital argument: "In this conceptualization, social capital may be defined operationally as the *resources embedded in social networks accessed and used by actors for actions*" (Lin, 2001, p. 25; my emphasis).

Social resources are defined as the "wealth, status, power as well as social ties of those persons who are directly or indirectly linked to the individual" (Lin 1981, p. 395). Social resources represent not only the *quantity* of people on whom an individual can call for information, but also the collective *quality* of the position each contact holds in the social hierarchy; in essence, this means that contacts can provide resources that matter. The quantity and quality of the ego's social resources also provides insight into *where* he or she ego lies in the social hierarchy. In some sense, the ego's status can be defined by the quantity and quality of his or her ties *and* the efficacy with which these ties are wielded (or utilized) by him or her.

Social structure is conceived "as comprising a network of persons whose positions are ranked according to certain normative honors and rewards, such as wealth status and power" (Lin, 1981, P. 395). Social structure *is* the social hierarchy in its entirety from top to bottom. Individuals who know what constitutes social structure can locate themselves in the social hierarchy and then take action to solidify a position of privilege or move upwards.

The notion of social structure is critical to Lin's thesis; he suggests that society is based on a macrostructure that rests on the following three assumptions:

Assumption 1: Social structure is pyramidal, consisting of "a set of positions that are rank-ordered according to certain *normatively valued resources* such as class, authority, and status" (Lin, 2001, p. 56).

Assumption 2: Hierarchical positions tend towards congruence and transferability. To put it crudely, those with wealth likely also wield power—or have access to other people occupying levels of power that match their wealth status.

Assumption 3: The structure of society is pyramidal, with relatively fewer people occupying the most selective positions at the top. Those occupying these select positions have the greatest access to resources and information (Lin, 2001). Positions at the top are, then, analogous to scarce resources and this promotes competition within the structure.

I stress the relevance of social structure as a basis for Lin's concept of social resources, for two reasons. First, if one accepts the premise that American society consists of hierarchically tiered structures, with highly sought positions at the top of each structure, then this premise inextricably ties the concept of social resource accessibility to the concept of social structure. Strathdee makes the point that this dynamic is particularly applicable to young people seeking employment:

> The development of mass schooling freed young people from their social origins and led to an erosion in the significance of social class. Status is achieved rather than ascribed and young people become the authors of their individual destinies. Based on this view, the role of social networks in the recruitment process has declined through the creation of open labour markets.[1] This position is challenged here in that the demise of the significance of social networks in the process of obtaining employment and the credentials needed to obtain employment has not taken place. Rather, in some segments of the labour market credentials do not function in the manner predicted and in other segments the relationship between credentials, networks and employment has become more complex. Work-bound school-leavers attempting to make the transition into work but lacking access to valuable networks can be seen to experience disadvantage compared to those with access to such networks. By the same token, young people who have access to valuable knowledge concerning which qualifications are in demand and the best institutions in which to obtain these are advantaged relative to those who do not. (Strathdee, 2005, p. 16).

With differential access to social resources available to individuals in the social structure (e.g., information about gaining admission to a selective engineering school), it stands to reason that the higher an individual ranks the more social resources he or she commands and the more tactically he or she can behave. For Lin this is the case; the efficacy of the ego's social network and resources is a function of his or her position in the hierarchy. Those with high positions in the hierarchy can reach down into the social structure as well as laterally and possibly even upwards to access valuable information and resources that reinforce positions of privilege (Lin, 1981; Granovetter, 1983). Such individuals can exercise what one might call social versatility in using their advantaged positions. This may be truer true today, in the "information age," than at any time in history; information not only drives economic capital, but is also seen as necessary for

[1] Strathdee suggests that this was the ideal of the open-access mass education proposed by post-World War II social reformers.

successful navigation of everyday life. Those with enhanced access to information are at a particular advantage.

The second reason social structure is important takes us directly back to Granovetter and the concept of homophily—“the tendency to choose as friends those similar to oneself—it follows that the lower one’s social stratum, the greater the relative frequency of strong ties” (Granovetter, 1983). The consequence of homophily is that individuals occupying lower positions in the social pyramid experience exponentially negative social resource constraints; not only are their existing social ties likely to be strong, or dense (which in this case limits their ability to reach up through the social hierarchy to higher-quality information sources and resources), but they tend to strengthen their existing strong ties to family, close friends, and their insular communities—to focus inwards instead of outwards for information and important resources as a matter of day-to-day survival.

It is therefore worth noting that, if the social networks of people occupying lower social echelons are composed primarily of strong ties and dense social networks, and individuals in these positions tend to rely more on immediate family and close kinship relations as their primary social contacts, then their social capital is more likely to be static, which in turn may lead to restricted social mobility (Lin, 2000).

Nan Lin – Part 2: Lin and the Utilization of Social Capital at the Individual Level

The most important element of Lin’s approach for my work is the instrumental conceptualization of actors’ use of social resources, which occurs within bounded social structures, to provide advantages over an individual’s less well-connected peers:

> The second component of social capital, therefore, must reflect that Ego is cognitively aware of the presence of such resources in her or his relations and networks and *makes a choice in evoking the particular resource.* There may be ties and relationships that do not appear in Ego's cognitive map and thus not in her or his awareness of their existence. (Lin, 2001, p. 25; my emphasis)

Lin also states that that are two types of status attainment, the "process by which individuals mobilize and invest resources for returns in socioeconomic standings" (Lin, 1999, p. 467), namely personal resources and social resources. Lin defines social resources as those that are available to individuals through direct and indirect social ties, adding that individuals undertake actions and strategies to maximize their own self-interest (Lin, 1999). For Lin, the best strategy for any individual to employ to climb the social hierarchy is to utilize weak ties. Capitalizing on weak ties allows Ego to access information across a range of fronts, enhancing the ego's ability to formulate tactical decisions (Lin et al., 1981). He posits three propositions in support of this claim:

Proposition 1 – The social resources proposition: social resources (e.g., resources accessed in social networks) affect the outcome of an instrumental action (e.g., an attained status).

Proposition 2 – The strength-of-position proposition: social resources are, in turn, affected by the original position of the ego (as represented by parental resources or previous resources).

Proposition 3 – The strength-of-ties proposition: social resources are also affected by the use of weaker rather than stronger ties.

A subsequent variation of the last proposition is the extensity of the proposition: social resources are affected by the extensity of direct and indirect ties (i.e., the range of an individual's ties is related to efficacy—a wider range equals greater efficacy; Lin, 1999, p. 470).

The differential mobilization of social capital by individual actors implies that social capital is not evenly distributed across the social hierarchy. Lin's research confirms this as he cites studies that have consistently found that inequality in social capital limits social mobility for both women and minorities (Lin, 1999).

The question remains: what do individuals gain from utilizing social capital? Lin outlines four distinct benefits that social capital provides individuals (Lin, Cook & Burt, 2001):

1. Strategically located social ties facilitate access to strategic information. Such information has the potential to allow organizations to *find* individuals with desired skills or cultural knowledge (i.e., people who *fit* with the organization).
2. Social ties have the potential to *influenc*e key agents with the power to open up opportunities. Lin suggests that these key agents may be recruiters or supervisors. With regard to my project it is conceivable that such key agents might be admissions officers or engineering faculty, either of whom can be seen as gatekeepers of desired resources (i.e., offers of admission, crucial information, good grades, faculty mentoring, initiation into research and project teams, etc.).
3. Social ties may be seen as equivalent to "*credentials*" by individuals or organizations that the ego is trying to enter or access. In other words, the social capital of the ego may serve as a stamp of approval that signals to the organization that the ego "can provide 'added' resources beyond his/her personal capital" (Lin, Cook & Burt, 2001, p. 7).

4. Lastly, social capital reinforces what Lin refers to as "identity and recognition." The ego's social networks assure him or her of his or her "worthiness as an individual and a member of a social group sharing similar interests and resources" (Lin, Cook and Burt, 2001, p. 7). This in turn leads to a sense of identity recognition that may go so far as to serve as "public acknowledgement of one's claim to certain resources" (Lin, Cook and Burt, 2001, p. 7). Thus point 4 relates to point 1, which suggests that social capital enables organizations to identify individuals with traits and behaviors that are recognizable—and desirable—to them.

<u>Lin In Summary:</u>

- → Social capital is a function of social networks embedded within hierarchical societal structures.
- → Weak social ties enhance the possibility that individual actors can access richer sources of information and resources.
- → Bridging weak ties enhances the value of information that individuals are able to access.
- → Social capital can be consciously mobilized by individual actors in attempts to attain social advantages.
- → Activated social capital may serve four essential purposes for individual agents:
    - o Information collection and organizational recognition
    - o Access to influential others
    - o Certification of social credentials
    - o Identity reinforcement
- → As a product of homophily, strong ties restrict access to social networks and limit opportunities for increasing social capital.

Ronald Burt – Social Capital and Structural Holes

Burt conceives of social capital in much the same way as Lin. Burt builds his conception of "structural holes" based on Granovetter's proposition regarding the strength of weak ties (Burt, 2000). Like Lin, Burt premises the theory of structural holes on interaction between individuals in social networks; Burt is an unabashed structuralist. Social capital is framed as a metaphor for advantage in competitive markets where individuals pursue their own interests (Burt, 2000). Burt defines a structural hole in terms of

> missing relationships that inhibit information flow between people. A hole "is a buffer, like an insulator in an electric circuit" (Burt, 1992: 18). . . . Numerous studies have shown that managers whose social networks bridge structural holes have a competitive advantage over peers confined to a single group of interconnected people. Information, opinion, and practice are more homogeneous within than between groups, so a manager whose network spans structural holes (call him a network broker, connector, or entrepreneur) has a vision advantage in early exposure to diverse information and a general political advantage as a hub in the information flow. (Burt, 2007, p. 119)

Again, the key to understanding the instrumentality of social capital lies in understanding the interactions and exchanges that occur between an individual and the various social structures within which he or she operates. The tactically important element social capital provides acts as a mechanism that individuals can use to tap into valuable information lying dormant in their social connections. The information garnered from these connections to disconnected networks allows individuals to act in strategic ways that provide them with advantages that reward both status and competitive dispositions. Burt refers to individuals who consciously capitalize on structural holes as "network brokers" who negotiate the passing of information between networks (Burt, 2012). The key element is that specific points, or locations, in the structure of the network promote the utility and efficacy of social capital:

> nonredundant contacts offer information benefits that are additive rather than redundant. Structural holes are the gaps between nonredundant contacts. The hole is the buffer, like an insulator in an electric circuit. . . . A structural hole indicates that the people on either side of the hole circulate in different flows of information. A manager who spans the structural hole, by having strong contacts on both sides of the hole, has access to both information flows. The more holes spanned, the richer the information benefits of the network. (Burt, 1997, p. 341)

The person who locates and then positions himself or herself *at* the structural hole (the network broker) reaps three forms of benefits: access benefits (broader social networks and therefore enhanced chances of receiving information about impending disasters or opportunities), timing benefits (being the first to receive information allows an individual to get a jump on competitors), and referral benefits (because bridging the structural hole creates access to more diverse networks, an individual's chances of being included in new opportunities are increased; Burt, 1997; Reagans & McEvily, 2003). Burt also describes individuals who utilize structural holes as "entrepreneurs" because of their ability to capitalize on information spanning separate networks (Burt, 2000).

Podolny and Baron (1997) build on Burt's work, suggesting that structural holes serve two functions (Burt lists one—that of information access and flow). The first function is as Burt suggests: structural holes serve as rich sources of resource-based information. The second function is that of identity construction. Podolny and Baron (1997) contend that structural holes also enable organizations or groups to provide normative structures for their members. The informal networks that constitute structural holes provide and enforce a bracketed identity for individuals who have access to them (Podolny & Baron, 1997). Individuals accessing information through structural holes may be seeking, and receiving, an understanding of the essential norms, values, rules and accepted behaviors of a specific community:

> Moreover, individuals seek not only resources and information through social networks, but also a sense of belonging and an understanding of what is expected of them, and sometimes the very same tie (e.g., to a mentor or supervisor) can be a source of both resource-based and identity-based flows. (Podolny & Baron, 1997)

When I first read about structural holes, I envisioned the TT as a structural hole and TT participants as individuals who are lucky—or clever—enough to be positioned on the cusp of the structural hole. A TT brings people from non-redundant social networks together: professional engineers, parents, and peers—all with varying levels of knowledge, skills, and abilities. If the team succeeds and moves on to regional, national, and perhaps even international competitions, the structural hole becomes portable, bridging increasingly diverse and higher-quality TTs containing even richer veins of information and more tightly defined exposure to identity formation. It is entirely feasible that students within a TT, when it functions as structural hole, reap all the advantages of access to information, timely reception of information, referral, and development of engineering "identities."

Burt In Summary:

- → Social capital is used to attain advantages in "markets" where there are scarce resources.
- → The concept of the "structural hole" as an information-rich crossroads. Individuals positioned at these crossroads have tactical advantages over competitors.
- → The notion that structural holes may provide the information necessary for individuals to form engineering identities.

Ricardo Stanton-Salazar

Ricardo Stanton-Salazar uses social capital theory to understand how social networks either promote or inhibit the ability of marginalized minority students to gain access to key institutional resources (Stanton-Salazar & Dornbusch, 1995). But while social capital plays a pivotal role in his theoretical framework, Stanton-Salazar, like Lin, turns first to network theory to develop the basis for using the principles of social capital. Describing middle-class social networks as "social freeways" providing middle-class students with rapid and virtually unobstructed access to multiple levels of valuable information, Stanton-Salazar suggests that these social networks are (a) not generally accessible to students occupying lower positions within the status hierarchy and (b) serve as channels to “privilege and power” (Stanton-Salazar, 1997). He goes on to suggest:

> A major vehicle that allows for use of such freeways is an educational experience that is strategic, empowering, and network enhancing. . . . Empowering educational experiences can broaden young people’s social frame of reference, expand their access to a large number and variety of potential network members and develop the necessary skills for both initiating and maintaining network relations (Stanton-Salazar, 1997, p. 3).

Stanton-Salazar’s argument centers on understanding the role that “institutional agents” play in controlling information sources and opportunities that minority students can access. He defines institutional agents as

> individuals who have the capacity and commitment to transmit directly or negotiate the transmission of institutional resources and opportunities (such as information about school programs, academic tutoring and mentoring, college admission, and assistance with career decision making). . . . We argue that supportive ties with institutional agents represent a necessary condition for engagement and advancement in the educational system and, ultimately, for success in the occupational structure. For working-class and minority youths, however, these supportive ties are mainly found outside the family, in school settings and community organizations. (Stanton-Salazar & Dornbusch, 1995, p. 117).

Perhaps more importantly, dominant social structures dictate both subtly and overtly that institutional agents reward majority students with information and opportunities in higher proportions than minority students; in short, “hierarchies depend on the social arrangements that sustain and reproduce them” (DiMaggio, 1979, p. 1462). Teachers, it is argued, communicate more easily with students who participate in elite status cultures, give them more attention and special assistance, and perceive them as more intelligent and gifted than students who lack cultural capital (DiMaggio, 1982; De Graaf et al., 2000). This reward differential may be seen as a result of the cultural capital that majority students have at their disposal, reflecting the alignment of their cultural capital with dominant social structures to a greater extent than the cultural capital of minority students

(Stanton-Salazar, 1997). “Homespun” attitudes, abilities, and behaviors that are congruent with “institutional standards” are rewarded by both teachers and academically oriented peers (Stanton-Salazar, 1997). Institutional agents use students’ behavior, performance, acculturation style, and status expectations “to decide which low status students are attractive and worthy candidates for institutional mentorship and promotion” (Stanton-Salazar & Dornbusch, 1995, p. 118). Institutional agents can be seen as gatekeepers of existing social structures, controlling access to information and resources that lead to valued opportunities and rewards (e.g., participation on high-profile technical teams).

The result of this incongruence between institutional structures and minority students’ socialization (and, consequently, cultural capital) *may* result first in corrosive distrust of institutional social structures and agents (e.g., schools and teachers) and then to increased potential for self-elimination and withdrawal (Perna, 2000). While it is both understandable and logical, this withdrawal is also antithetical to success in a system that *rewards* students who capitalize on institutional networks. Stanton-Salazar points to the experiences of majority students to support this claim:

> Among Whites, the support of significant others usually goes beyond encouraging and modeling to include more class-based and network-oriented forms of support, such as coaching, providing privileged information, and institutional “pull.” . . . For Whites, membership in resource-rich social networks in schools corresponds to embeddedness in middle-class and privileged networks in their families and communities. For Blacks and other minority groups, participation in such school networks may instead correspond to regular displays of conformity and accommodation. (Stanton-Salazar & Dornbusch, 1995, p. 118)

Stanton-Salazar explicitly ties network theory to social capital theory via three propositions (Stanton-Salazar & Dornbusch, 1995). The first proposition suggests that individuals who have access to, and use of, social networks (social freeways) that are rich in social capital can acquire institutional resources and advocacy that they would otherwise be unable to receive; social networks *are* the conduits of social capital. The second proposition states that an individual's structural opportunities to develop relationships with people who control institutional resources (again, institutional agents) is inversely proportional to the individual's position in the social hierarchy; those low in the hierarchy have relatively few ties to institutional agents. Even when minority students have access to institutional agents, the corresponding relationship is often permeated with mistrust and antipathy. Finally, the third proposition states that, for working-class youth who *are* able to access and utilize these types of ties, weak ties offer substantial competitive advantages over ties to their working-class peers who do not capitalize on their own weak ties. This is because so few of their peers have access to networks with weak ties and *because* weak ties are instrumental in attaining the resources needed for upward social mobility (Stanton-Salazar & Dornbusch, 1995).

All three of Stanton-Salazar's propositions are premised on the possibility that individuals develop relationships with institutional agents and are then able to cultivate these relationships so that they yield valuable information. Essentially, such relationships span structural holes between socio-economic and ethnic networks. In Stanton-Salazar's model, institutional agents play hinge roles by providing scarce resources and tactically valuable information. Social capital, then, lies in the activation of social networks wherein individuals pinpoint specific institutional agents and then use these agents to access information and opportunities; social capital may also be a function of minority students' relative unwillingness to work within a social structure that traditionally has excluded, suppressed, and even exploited them. In this light, Stanton-Salazar defines social capital as

> social relationships from which an individual is potentially able to derive institutional support, particularly support that includes the *delivery of knowledge-based resources*, for example, guidance for college admission or job advancement. Working class youths have vastly less social capital than do middle-class youths. (Stanton-Salazar & Dornbusch, 1995, p. 119; my emphasis)

Stanton-Salazar discusses social capital in light of culturally derived contexts, explicitly connecting social capital and cultural capital. While he hints at the idea that cultural capital is the nest-bed for social capital, he confesses being uncertain of the direction the causal arrow points between social capital and cultural capital—the argument raises a basic question about which is the catalyst and which is the outcome. In his mind, however, there is no doubt that the two are inextricably connected, regardless of which causes the other to occur.

For minority children, performing in dominant institutional structures such as schools necessitates decoding dominant, middle-class cultural norms, language, styles and behaviors (Bernstein, 2003; Stanton-Salazar, 1997). For minority students, being successful in these institutions means being successful across two planes: satisfactorily performing technical tasks (e.g., being able to understand that 2 + 2 = 4) and decoding the rules, norms, and behaviors of the dominant culture:

> For members of subordinate groups to fully access [institutional] funds of knowledge and to use them productively for instrumental purposes requires no less than tapping into the cultural logic of the dominant group—however arbitrary it may be. Decoding the system begins with 'making sense' of this cultural logic; it entails knowing how to role-play using the institution's 'identity kit.'. . . The strict adherence to cultural rules, the display of appropriate cultural and linguistic capital, and the enactment of prescribed cultural competencies within schools' domains is critical precisely because such instances of decoding behavior activate crucial exchanges with institutional agents who respond to the display of mainstream cultural and linguistic capital by providing not only enriched academic subject

> knowledge, but also the forms of institutional support viewed here as crucial to school success. (Stanton-Salazar, 1997, p. 8)

Stanton-Salazar proposes that "the process of inclusion in mainstream institutions is aided when cultural and linguistic capital are converted into instrumental relations with institutional agents who actively transmit valued resources, special privileges, and personal assurances of future institutional support" (Stanton-Salazar, 1995, p. 120). Cultural capital, then, is tied directly to the activation of social capital.

Alejandro Portes and Kenneth Gonzalez.

Portes reviews the contemporary literature on social capital, unifying several definitions under one umbrella and defining social capital simply as

> the ability of actors to secure benefits by virtue of membership in social networks or other social structures . . . social capital inheres in the structure of [an individual's] relationships. To possess social capital, a person must be related to others, and it is those others, not himself, who are the actual source of his or her advantage. (Portes, 1998, p. 7)

For Portes, social capital serves three functions: as a form of social control by establishing norms and sanctions—reminiscent of the norm-enforcing behavior Coleman found in the Brooklyn diamond merchants (Coleman, 1988); as a form of family support for individual members; and as a conduit for accruing benefits via extra-familial networks (Portes 1996; 1998). Portes suggests that the most common function associated with social capital is as a source of network-mediated benefits extending beyond the immediate family (Portes, 1998). He argues that this perception of social capital provides a powerful explanatory tool for understanding social stratification, particularly in terms of access to employment and subsequent social mobility opportunities for individuals living in impoverished communities.

Portes suggests—while supporting this notion with evidence from his own study of the assimilation of immigrant groups into the dominant American culture—that some poorer communities suffer from extremely limited network resources that do not reach beyond their immediate communities (Portes, 1996). The social networks of these communities are cut off from external information sources. This level of isolation denies people residing in these communities access to mainstream information that may lead to mainstream mobility—they are unable to bridge disparate social networks. Network limitations include both poor quality and insufficient quantity of social networks that limit access to critical information with the potential to promote social mobility.

Portes's ideas are particularly trenchant when applied to the issue of college attendance on the part of impoverished or minority children. Gonzalez et al. (2003) found that relative levels of social capital that are accessible to social groups comprising underrepresented minority students can be directly related to opportunities to enroll in college. The critical factor for minority students, many of whom are limited in their ability to attend college in part because their parents lacked the social networks necessary to provide key college access information, was the role played by both "informal and formal social networks that may serve as conduits for college opportunities" (Gonzalez, et al., 2003, p. 148).

Gonzalez builds on the notion of "institutional agents" of social capital developed by Stanton-Salazar, re-defining institutional agents as "agents of social capital" (Gonzalez et al., 2003). Agents of social capital have played crucial roles in determining *which* minority students have received information necessary for applying to colleges and universities, providing emotional support, access to privileged information and knowledge, and access to opportunities for college admittance (Gonzalez et al., 2003). Minority students receiving rich levels of information from agents of social capital have enjoyed greater opportunities to attend college. Those receiving relatively poor information, and those ignored or shortchanged by institutional agents of social capital, have been much less likely to attend college (Gonzalez et al., 2003).

It is important to note here that Gonzalez does not discuss social capital as an individual-to-social-structure dynamic. Rather, he suggests that social capital is a function of accessing and utilizing specific individuals within social hierarchies who have the power to provide information and benefits that students with low levels of social capital need desperately. This reinforces the notion that social capital is predicated on tactics, rooted in relationships of power, and is, in the end, a function of social stratification and structure.

Portes's and Gonzalez's work applies to TT participation in three areas. First, poorer communities (in which Portes explicitly includes minority groups) lack the social capital necessary for social mobility. This may be a consequence, in part, of a lack of adults within poorer communities who can provide links between young people and information that will help them succeed in both school and areas of the job market that make socio-economic advancement possible. In terms of TT participation, the composition of a TT may expose students from backgrounds with relatively limited social networks to peers, parents, and professional engineers with relatively rich sources of social capital. By contrast, TTs consisting mainly of poorer students or students from marginalized communities may serve as dense social networks and actually inhibit access to social capital that would provide members with tactical and valuable information. If the only adult mentor on a team is a high school physics teacher, say, then the network advantages enjoyed by more affluent TTs, with multiple professional adult mentors participating, may be eliminated. For poorer TTs, participation might provide little or no social capital advantage, and may even serve to reinforce existing structural inequalities. (See my discussion of situated learning for a more detailed discussion of this phenomenon.)

The second way in which Portes's and Gonzalez's work applies to TT participation is in terms of Portes's definition of what he calls "negative social capital." Portes discusses four negative consequences of social capital (Portes, 1998). First, social capital can be used to exclude outsiders from many advantages, from information to participation. This idea aligns with Coleman's social closure; in order to attain or retain high levels of social status—or merely for purposes of protection—groups with high levels of bounded solidarity and trust will close ranks around their privileged networks and implicitly restrict outsiders (Portes, 1998). Portes ties this idea directly to economic theory and the notion of a zero-sum game wherein groups *compete* with one another for scarce resources:

> Two centuries ago, Adam Smith complained that meetings of merchants inevitably ended up as a conspiracy against the public. The public, of course, are all those excluded from the networks and mutual knowledge linking the colluding groups. Substitute for "merchants" white building contractors, ethnic union bosses, or immigrant entrepreneurs, and the contemporary relevance of Smith's point becomes evident. (Portes, 1998, p.16)

I am curious about the motives behind an individual student's use of the TT. In particular, I would like to know whether students use the information they cultivate from their TT experience as a source of power with the potential to *exclude* "outsiders," those of other ethnicities, or those hailing from elsewhere on the social hierarchy.

Finally, Gonzalez, et al. (2003) tie social capital directly to college attendance opportunities for minority students and describe the varying and important roles agents of social capital play in this process. It is conceivable that adults and peers within high school TTs act, in some capacity, as institutional agents of social capital. They may provide information about everything from applying to colleges to understanding what engineering is to personally advocating for students in the college application process.

Heavy Lifting: Bourdieu's Concept of Social and Cultural Capital

Bourdieu – Part 1 – Some Initial Ideas

Bourdieu's conception of capital, and the way he describes how capital operates within a broader social structure, bear directly on my research. Before discussing Bourdieu's conceptions of capital, however, I must briefly discuss two important ideas:

1. Bourdieu's models are based on the premises that (a) society is hierarchically structured to sustain and reproduce existing class differences, (b) children are socialized into particular positions in the social hierarchy based on family background, and (c) social life entails a constant struggle for advantage and position within the social hierarchy (DiMaggio, 1979; Young, 1999). For Bourdieu, *class conflict* lies at the heart of human social interactions (Siisiainen, 2000). The various forms of capital serve as arsenals in the competition for social position and stature within the social hierarchy (Sabatini, 2005).

2. Bourdieu's notion of *habitus* is a defining element of his concept of capital. Delamont, et al.'s (1993) description of habitus traces the word to its Latin translation of Aristotle's Greek concept of "hexis," meaning "state" or "disposition." They characterize habitus as

> a system of embodied dispositions which generate practice, but—and here Bourdieu introduces a specifically sociological element—in accordance with the structural principles of the social and cultural world. . . . The term 'habitus'. . . operates merely as a label for a certain constellation of embodied dispositions of various kinds acquired as a result of socialization. . . . The theory of habitus is Bourdieu's theory of socialization . . . in which we are provided with a story about how society must be seen as an organised set of relations which get into the head . . . and into the very constitution of the muscular body itself, and so generate practices that will—other things being equal—ensure the continued existence of the society and the maintenance of its relations with others. (Delamont, Nash & Apple, 1993, p. 319)

Social structure, in a sense that resembles Burt's and Lin's conceptions of social structure, is the domain where individuals exercise their varying arsenals of capital, while habitus defines both the types and quality of capital they have at their disposal. More importantly, habitus defines how individual actors respond—both consciously and subconsciously—within certain structural settings or fields. Lareau and Horvat liken this to a game of cards in which each player has "a different set of cards (capital), [and] each player relies on a different set of skills (habitus) to play the cards (activate the capital)" (Lareau & Horvat, 1999, p. 39). While this certainly oversimplifies that case, the point is made nonetheless. For DiMaggio (1979), habitus is related directly to, and a reflection of, social class:

> a product of early childhood experience, particularly of unconscious family socialization, it is continually modified by the individual's encounters with the world. To the extent that members of different social classes differ in the nature of their primary socialization—and Bourdieu believes that they do—each class has its own characteristic habitus, with individual variations (DiMaggio, 1979, p. 1464).

Finally, Thorsen (2000) offers clarification, suggesting that habitus is embodied socialization that both consciously and unconsciously directs individual actions:

> Habitus can be interpreted as an unconscious system of values, and it contains elements which cannot be expressed verbally. In some situations habitus is 'home,' while in other situations, e.g. unfamiliar situations, frictions can arise. . . . The action schemes which are part of habitus make a set of strategies possible, i.e.

> possibilities to master social situations. Individuals are defined as agents, i.e. agents in social relations. Habitus gives an incorporation of objective future possibilities for each individual . . . the notion has to be understood as intersubjective. It is in the relation between individuals that habitus is both created and expressed. This means that habitus for groups is important. (Thorsen, 2000, p. 1)

Bourdieu states quite simply that habitus implies a sense of one's place as well as a sense of the place of others (Bourdieu, 1989) and that is quite a good working definition. It is a class-based way for individuals to locate themselves within the social hierarchy while also serving as a guiding mechanism for appropriate responses to specific social settings and circumstances. Habitus interacts with various forms of capital (cultural, human, social, and symbolic) and both are operationalized based on the immediate social structure, or what Bourdieu refers to as the "field" (Bourdieu, 1984). "Fields are spaces in which dominant and subordinate groups struggle for control over resources; each field is related to one or more types of capital" (Dumais, 2002, p. 46).

Bourdieu – Part 2 – Cultural Capital

Bourdieu's *The Forms of Capital* (1986) states that capital has the potential to produce profits, takes time to accumulate, and represents the structure of the social world in such a way that it determines the chances of success or failure as well as the relative access to strength and power of individuals (Bourdieu, 1985; Bourdieu, 1986). Capital, in whatever form it assumes, takes its value from its scarcity and unequal distribution across social hierarchies. Three forms of capital are defined: economic, social, and cultural.

Although Willis (1977) is ultimately critical of Bourdieu's theories of capital, he nonetheless provides an excellent baseline definition of cultural capital and a solid point of departure for understanding the key concept:

> Bourdieu and Paseron argue that it is the exclusive ‘cultural capital’—knowledge and skill in the symbolic manipulation of language and figures—of the dominant groups in society which ensures the success of their offspring and thus the reproduction of class position and privilege. This is because educational advancement is controlled through ‘fair’ meritocratic testing of precisely those skills which cultural capital provides. (Willis, 1977, p. 128)

TTs may provide the nest in which the “knowledge” and the “skill” of the dominant class are incubated and reinforced in non-school settings where a select cadre of students have access to these experiences.

Bourdieu’s (1986) description of cultural capital provides a more nuanced perspective, identifying three forms of cultural capital: the embodied state, the objectified state, and the institutionalized state. Embodied cultural capital occurs over time as a process of unconscious inculcation whereby an individual incorporates the “habits” of a specific class or community. The primary transmitters of cultural capital are a child’s parents, especially his or her mother (Dumais, 2002). Cultural capital cannot be purchased in an economic sense and it must be developed within an individual over time—it also cannot be bestowed as an instantaneous attribute (Bourdieu, 1986).

Embodied cultural capital functions as symbolic capital, legitimizing the holder as competent or as an authority on specific activities and in specific settings. The value of this form of capital lies in a sort of recognition in specific settings that provides distinction for its owner (Bourdieu, 1986). Embodied cultural capital is the most interesting form of cultural capital and the one most closely associated with social capital for this study.

Institutionalized cultural capital is, quite literally, the certification of forms of the more nebulous cultural capital. Bourdieu suggests that it is symbolic capital, “an official definition of an official identity” (Bourdieu, 1989). It is, for example, the degree from an

Ivy League institution that physically hangs on your wall and provides you, with respect to any group, with the cultural capital necessary to realize your social status and societal worth with a

> conventional, constant legally guaranteed value with respect to culture. . . . It institutes cultural capital by collective magic. . . . By conferring institutional recognition on the cultural capital possessed by any given agent, the academic qualification also makes it possible to compare qualification holders and even to exchange them. (Bourdieu, 1986, p. 248)

Importantly, cultural capital is often mistaken for natural ability. An individual's success is ascribed to innate ability or talent when in reality the individual may be merely receiving the intrinsic benefits of membership in a class whose cultural capital is, de facto, valued and rewarded by dominant social structures, and thereby is ushered onward and upward by virtue of membership in such a privileged caste. All educational systems provide excellent examples of this type of cultural transmission (Bourdieu, 1986).

Bourdieu – Part 3 – Social Capital

Bourdieu (1986) defines social capital as:

> The aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition—or in other words, to membership in a group—which provides each of its members with the backing of the collectivity-owned capital, a "credential" which entitles them to credit, in the various senses of the word . . . the network of relationships is the product of investment strategies, individual or collective, consciously or unconsciously aimed at establishing or reproducing social relationships. (Bourdieu, 1986, p. 249)

The quality and amount of social capital held by individuals is determined by the size of their social networks, the amount of cultural capital they possess, and the people they can access via durable social networks (Dika and Singh, 2002). Social capital, in the form of *social networks*, represents either actual or potential membership in a group; by virtue of an individual's social capital, he or she can attain membership by recognizing, adhering to, and enforcing the norms and expectations of the group while simultaneously leveraging advantages accrued through group membership (Song, 2011). This dynamic represents an exchange relationship whereby membership rewards (likely based on habitus-congruence between group members) are exchanged for group solidarity (Bourdieu, 1986). If you are a member of a group, you are obligated to protect the integrity of the group, whatever that may mean.

Two aspects of this definition of social capital are critically important. The first is that social capital—in the form of the benefits derived from group membership—enhances other forms of capital. Second, social capital can be exchanged for material or symbolic profits. The crucial idea here is that an exchange takes place and the

> [e]xchange transforms the things exchanged into signs of recognition and, through the mutual recognition and the recognition of group membership which it implies, reproduces the group. By the same token, it reaffirms the limits of the group, i.e., the limits beyond which the constitutive exchange . . . cannot take place. Each member of the group is thus instituted as a custodian of the limits of the group: because the definition of the criteria of entry is at stake in each new entry, he can modify the group by modifying the limits of legitimate exchange through some form of misalliance. (Bourdieu, 1986, p. 250)

At its heart, then, Bourdieu's notion of social capital is about group solidarity, social reproduction of privilege, and guarding the boundaries of a group through social networks of mutual membership recognition (Bourdieu, 1986). Social capital is, in short, about the maintenance of structures that provide privilege to some while depriving others of opportunity.

Situated Learning Theory

Like the concept of social capital, situated learning was introduced in the early twentieth century:

> Passing now to the scientific and logical side of education, we remember that here also ideas which are not utilized are positively harmful. By utilizing an idea, I mean relating it to that stream, compounded of sense perceptions, feelings, hopes, desires, and of mental activities adjusting thought to thought, which forms our life. I can imagine a set of beings which might fortify their souls by passively reviewing disconnected ideas. Humanity is not built that way. . . . The solution which I am urging, is to eradicate the fatal disconnection of subjects which kills the vitality of our modern curriculum. There is only one subject-matter for education, and that is Life in all its manifestations. (Whitehead, 1916, p. 112)

The seminal ideas of situated learning are not novel; Alfred North Whitehead made his appeal for English schools to replace a curriculum rife with "inert ideas" with a curriculum placing students within contextual settings in 1916, long before Lave and Wenger's book outlining their definition of situated learning.

Situated learning represents contemporary thinking about contextualized learning. The basic ingredients of situated learning include:

1. Learning occurs for individuals "as progress along trajectories of participation" (Anderson et al., 2000, p. 6). Situated learning considers learning as a *social act* by definition.
2. Participation and, hence, learning are initially peripheral, but, as individuals become more adept they attain full membership in a community of practice. A significant part of learning involves enculturation whereby the individual develops behavioral codes that govern group members' activities. (Ben-Ari, 2004).
3. Learning—or action—can be maximized if it is contextualized in real settings (Anderson, Reder, & Simon, 1996). Contextualizing learning in authentic settings

increases the chances that learning will be transferable from setting to setting (Ben-Ari, 2004; Brown et al, 1989b).

Situated settings not only help students master technical skills, they also help them learn "to be members of a situated, rhetorical discourse community. Students learn not only content knowledge but also disciplinary norms, expectations, and standards in that particular area of expertise. . . . Students move from novice toward expert through coparticipation with members of the disciplinary community" (Dannels, 2000, p. 7).

Legitimate Peripheral Participation

At the core of situated learning is Lave and Wenger's concept of *legitimate peripheral participation* (LPP), which they define as "the point [at which] . . . learners inevitably participate in communities of practitioners and [at which] . . . mastery of knowledge and skill requires newcomers to move toward full participation in the sociocultural practices of a community" (Lave & Wenger, 2002, p. 29). In this sense, learning is both part of, and defined by, structured social interactions:

> Learning is a process that takes place in a participation framework, not in an individual mind. This means, among other things, that it is mediated by the differences of perspectives among the coparticipants. . . . Learning is, as it were, distributed among coparticipants, not a one-person act. (Lave & Wenger, 2002, p. 15)

The process of learning becomes located in social interaction rather than purely in abstract cognition (or what Lave and Wenger would call "the head"). For the non-TT children, the concept of "engineering" may be much more abstract. For TT participants, the concept of engineering is *real* because of the proto-engineering context in which they have been involved and the interaction with engineers they encounter; the social construction of an engineering identity is reinforced by practicing an engineering activity which grounds principles of identity and uncovers distinct guidelines of behavior and practice. Indeed, social practice, as it occurs in the "lived-in world," is the phenomenon that generates learning as an outcome (Lave & Wenger, 2002). LPP describes this social process where learning is the primary focus.

Understanding the component parts of LPP is critical to understanding Lave and Wenger's overall theory—and its direct application to the role TT experiences play as students transition from high school to engineering. Each of the words comprising LPP makes a unique contribution to the overall structure of the theory. The word "legitimate" connotes a sense of belonging and emphasizes that belonging to a community is an essential component of learning. "Peripheral" suggests that individuals encounter "multiple, varied, more-or less-engaged-and-inclusive ways of being located in the fields of participation defined by a community; it is a way of moving into, or interacting with, a community of practice" (Lave & Wenger, 2003, p. 36). Finally, "participation" perhaps reflects the most important element of LPP, suggesting that

> peripheral participation is about being located in the social world. *Changing* locations and perspectives are part of actors' learning trajectories, developing identities and forms of membership. Furthermore, legitimate peripherality is a complex notion, implicated in social structures involving relations of power. As a place in which one moves toward more-intensive participation, peripherality is an empowering position. As a place in which one is kept from participating more fully . . . it is a disempowering position. Beyond that, legitimate peripherality can be a position at the articulation of related communities. In this sense, it can itself be a source of power or powerlessness, in affording or preventing articulation and interchange among communities of practice. *The ambiguous potentialities of legitimate peripherality reflect the concept's pivotal role in providing access to a nexus of relations otherwise not perceived as connected. . . . Peripherality, when it is enabled, suggests an opening, a way of gaining access to sources for understanding through growing involvement*. (Lave and Wenger, 2003, p.36 [emphasis added])

Conceptually, LPP shares elements common to social capital. The main ingredients of LPP (Lave and Wenger, 2002) are as follows:

a. Learning occurs in a structured, purposeful way. It is not a random occurrence, but rather a thoughtful, considered process.

b. Novices—or apprentices—move from positions of relatively low levels of skill and ability toward increased levels of proficiency and skill; ultimately, they become experts or masters within the specific framework of the communities in which they are learning. These communities are called “communities of practice.”

c. Learning becomes less about abstract concepts divorced from their broader context and more about encountering multiple concepts with relational components remaining within view of the learner. Concepts are integrated with one another so the learner gains a sense of the whole as well as the sum of each of the parts. Meaning is derived from understanding how distinct pieces of knowledge fit together. In this sense, the learner is not a passive receptacle of knowledge, but instead *participates* in the formation of knowledge.

d. LPP—the use of the word “legitimate” connotes a power relationship whereby agents move from positions of limited power within a social structure to positions of increasing power. The agent is *legitimated* as he or she moves more securely into the community of practice (Lave & Wenger, 2002).

e. A critical element of LPP is that it combines “social” elements with “cultural” elements of a community of practice. This is important because it allows the learner to attain increasing levels of legitimacy as he or she moves toward full participation. For example, involvement in LPP is inherently a social process, making the development of social capital possible and perhaps even likely. Also, through social interactions, the norms, behaviors, vernacular, and rules of a community of practice—the culture governing that group—are revealed to the initiate a little at a time; in essence, this promulgates cultural capital.

f. LPP has no center—an agent cannot move through concentric zones of expertise and finally occupy the center spot. Instead, agents move towards *full participation* via the LPP process. Expertise, then, is less about knowing all there is to know—it is not the process of reaching a finite point—than it is about securing membership within a community. In this sense, membership encompasses knowledge acquisition; attaining knowledge occurs, in part, through membership. Legitimate membership in a community is the critical factor suggesting "an opening, a way of gaining access to sources for understanding through growing involvement" (Lave & Wenger, 2003, P. 37).

g. Lave and Wenger confess to offering a definition of "communities of practice" that lacks precision and clarity. They suggest that "[h]egemony over resources for learning and alienation from full participation are inherent in the shaping of the legitimacy and peripherality of participation in its historical realizations. It would be useful to understand better how these relations generate characteristically interstitial communities of practice and truncate possibilities for identities of mastery" (Lave &Wenger, 2003, p. 42).

h. Identity formation is one of the most important parts of the concept of LPP (Billett, 2002). Indeed, LPP describes a process whereby the practices of communities are structured in such a way as to control and regulate the entrance of novices or outsiders (Wenger, 2004).

Tying Together Social Capital and Situated Learning

There are (at least) two areas where social capital theory and situated learning theory complement each other; the *use of social networks* for individual benefit is at the heart of each theory and *identity* construction is also an important element common to both.

I discuss the relevance of social networks and relations first. Both theories are based on the instrumentality of social networks and social interactions, particularly for individual agents. For social capital, the key piece of the puzzle involves the development and manipulation of social networks, providing the ego with access to people in positions of strategic importance in the social structure or network, while bridging structural holes to attain advantages of controlling information flows existing in distinct networks. For situated learning theory, multiple social dynamics exist, but the factor that is most analogous to the development of social capital involves the interaction between an individual and expert others, or masters, who are in position to assist as the individual learns within a socio-cultural context.

For my purposes I emphasize the novice-to-expert relationship and the promotion of learning that is a consequence of that interaction, with the additional realization that "learning" entails enculturation, or the transmission of cultural capital. Significant connective tissue between the two theories is, I believe, this *relationship* between the individual and expert or strategically important others, and how that relationship is used, what it produces, and what social structures it reinforces. Social connections can conceivably be utilized to strategically access information that provides advantages over other people. The same network relationships can provide the opportunity for identity construction, bringing the individual more fully towards membership in a community of practice.

Wenger (2004) poignantly illustrates the importance of this relationship:

> The standing of the master in the community is therefore crucial. Today, doctoral students have professors who give them entry into academic communities. Granting the newcomers legitimacy is important because they are likely to come short of what the community regards as competent engagement. Only with enough legitimacy can all their inevitable stumblings and violations become opportunities for learning rather than cause for dismissal, neglect, or exclusion. (p. 101)

I interpret this to mean that the agent uses the relationship with the expert to attain fuller participation (attain expertise), while securing membership within a learning community. This relationship can also be perceived, in a very real sense, as a form of social capital, securing the agent's position within that community relative to others.

Perhaps a simple example related to my project will further illustrate this point, while also tying it to identity construction. A student on a TT gets to know the professional engineers that are members of the team. The student, via his or her regular interactions with the engineers involved with the TT, begins to understand how engineers speak, how they tackle problems, and how they handle tools and other technical apparatus specific to the engineering community of practice. Over a period of time, the student, slowly but surely, develops and masters the skills and technologies, including use of the vernacular, that are recognizable to the engineering community of practice. This is the process of identity construction playing out as a function of LPP.

Suppose one of these engineers is also connected to his or her alma mater's admissions office and, *after prompting by the student*, is willing to advocate for the student in the admissions process in a way that provides the student with an advantage over candidates not receiving this level of endorsement. This would constitute applying social capital; social relations are transacted for tactical advantages in the competitive admissions process. By participating with engineers in a real engineering context, the student enjoys the opportunity to reap several types of benefits by virtue of network membership. The student may be inspired to pursue engineering as a consequence of understanding the engineering identity, may trade the engineering identity for admissions advantages (again, unifying social capital and situated learning), may be more "in tune" with the culture of the engineering college (cultural capital), or may trade the recognition of this identity for other advantages once enrolled as an undergraduate engineer (again, unifying social capital and situated learning).

I am particularly interested in the notion of identity construction. I view the engineering world as a gated community with its own peculiar mores, norms, rules, vocabulary, and culture. McIlwee and Robinson (1992), as discussed in Leonardi (2001), state that engineering culture

> consists of three main components that are recognized by most engineers: (1) An ideology that stresses the centrality of technology, and of engineers as producers of technology; (2) the acquisition of organizational power as the base of engineering success; and (3) a self-centered "macho" belief in the value of engineers. . . . The idea of engineering culture is important because most engineers orient their identities and careers to their occupation rather than to their organizational communities. (McIlwee & Robinson, 1992, p. 19)

The notion of a specific engineering culture is central to my project because such a culture implies a sense of membership—that people who understand the nuances of a community's culture likely have greater access to membership privileges. Those lacking the cultural knowledge are likely to be ostracized or to have a more difficult time gaining entrance to the community:

> Everyone participates in multiple cultures, each of which frames its own culturally appropriate activity. . . . Without the culture, the practice fails to make much sense. Entering the culture, however, enables someone to pick up its skills, for the culture provides scaffolding for learning the content or subject matter . . . all [cultures] have implicit goals, legitimate activities, and patterns of interaction that people accommodate, if they are enculturated, and often violate, if they are not. (Brown et al, 1989a, pp. 283–284)

Students do not enter engineering undergraduate programs and automatically become engineers with full membership in the engineering communities they have just joined. I believe the process of gaining membership in an engineering community takes time, requiring students to peel back the layers of what it means to be an engineer. Indeed, for first-year students admitted to the College of Engineering where data was collected for the present study, it is not until the fall semester of their sophomore year that student undergo a process called "affiliation" through which they secure membership in one of the institution's ten engineering departments. Until that time they are not truly considered "engineers." Those who fail to secure membership in one of the departments are officially referred to as "unaffiliated" students and are seen to be in a state of limbo—not quite engineers but also not members of any other part of the university academic community.

The relationship between identity construction and membership is important and worth emphasizing:

> To talk about academic disciplines, professions, or even manual trades as communities or cultures will perhaps seem strange. Yet communities of practitioners are connected by more than their ostensible tasks. They are bound by intricate, socially constructed webs of belief, which are essential to understanding

> what they do. The activities of many communities are unfathomable, unless they are viewed from within the culture. . . . Unfortunately, students are too often asked to use the tools of a discipline without being able to adopt its culture. To learn to use tools as practitioners use them, a student, like an apprentice, must enter that community and its culture. Thus, in a significant way, learning is, we believe, a process of enculturation. (Brown et al., 1989a, p. 213)

The use of the word 'enculturation' is important and linked specifically to identity formation. Rosch and Reich (1996) identify four stages of enculturation that occur when a new member of a community moves toward membership:

> (1) the prearrival stage, dealing primarily with an individual's predispositions prior to entering a new setting; (2) the encounter stage, dealing with an individual's preconceptions formed during recruitment and selection; (3) the adaptation stage, dealing with the external socialization processes and the initiate's identification with the organization; and (4) the commitment stage, dealing with the extent to which the norms and values of the local culture are assimilated by new organization members. (p. 116)

Brown, et al., (1989b) go on to emphasize the importance of enculturation via *learning* as a form of linking identity formation to membership:

> From a very early age and throughout their lives, people, consciously or unconsciously, adopt the behavior and belief systems of new social groups. Given the chance to observe and practice in situ the behavior of members of a culture, people pick up relevant jargon, imitate behavior, and gradually start to act in accordance with its norms. . . . *The activities of a domain are framed by its culture. Their meaning and purpose are socially constructed through negotiations among present and past members. Activities thus cohere in a way that is, in theory, if not always in practice, accessible to members who move within a social framework. These coherent, meaningful, and purposeful activities are authentic, according to the definition we use here. Authentic activities, then, are most simply defined as the ordinary practices of the culture*. (p. 213 [emphasis added])

The authentic activity, then, is the key to making culture accessible and identity construction possible. For example, in the case of the FIRST Robotics competition, organizers are encouraged to format team work spaces to simulate real engineering settings. Professional engineers are brought in to work with the students and are referred to as "the nucleus of the project team" (The ASME Guide to Starting A FIRST Team, 2005). Engineering-related companies sponsor teams and participants receive “pep talks” and listen to speeches from company CEOs. Participants are encouraged to work long days for many weeks under rigorous time constraints as they develop their robots and prepare for competition; a situation that closely simulates “real” engineering project work. Local, regional, and national competitions promote both a competitive culture and a collaborative spirit (teams are often asked to collaborate with other teams during competitions). They use the same tools engineers use, and begin using them with the help of their engineering mentors. Novice teams are mentored by veteran teams and students are taught to compete. The result is exactly as Brown, et al. (1989b) suggest: participants eventually become part of the engineering culture and cultivate an engineering identity via the crucible of FIRST participation. A FIRST participant described it this way:

> FIRST has literally changed my life. . . . I never had a strong interest in math or science until my eleventh grade year when I joined a FIRST team. FIRST made me see that science and math are something that I am not only interested in, but truly enjoy doing every day. FIRST opened a door to a whole new world, a world I wanted to stay in. I would have to say that FIRST is the reason why I will be an engineer someday. (Melchior et al., 2005, p. 28)

As Ben-Ari (2004, p. 87) suggests, apprentices—like the one cited above—“undergo a process of enculturation in order to learn both the technical content and the codes of behavior that govern the activities of members of the group.” FIRST provides this socially constructed enculturation and identity formation process and—perhaps—the effects of this resonate well into the novice engineer’s college tenure.

Social capital also offers insight into identity construction because, as Lin points out, one of the functions of social capital may well be the reinforcement of congruence between the identity of the individual attempting to gain membership and that of the group or organization (Lin, Cook & Burt, 2001; Podolny & Baron, 1997). Social capital offers individuals elements of identity recognition through social relations and trust. This may also be activated in the college engineering admissions process, as applicants purposefully describe in the applications for admission their relationships with the world of engineering and engineers. Subsequently, admissions officers often translate this as "knowing what engineering really is" (as opposed to non–TT members, who admissions officers *may* feel do *not* know what engineering really is). TT interactions with engineers may allow some forms of engineering identity to rub off on candidates. Displaying these experiences in the admissions process may make that relationship pay off in terms of admissions advantages; even if the benefits ascribed to such relationships are based on conjecture on the part of admissions committees, it nonetheless plays a definitive role in a number of admissions decisions.

Finally, the benefit of meshing social capital theory and situated learning theory is that, together, they provide a more robust explanation of what *might* be happening in groups such as high school TTs. The instance I described above capitalizes on social interaction as social capital; the relationship provides the student with benefits he or she would not have been able to develop *without* the relationships available within the bounds of the TT. For purposes of both social capital and situated learning, the hinge piece *is* the relationship between a novice and an engineer. This relationship has the potential to serve as a source of both social capital and master–apprentice learning—and identity construction—while also possibly yielding cascading benefits for novices that extend beyond the boundaries of the TT itself.

Measuring Individual Social Capital

Introduction

Because there is a lack of consensus regarding the conceptual definition of social capital, researchers coalesce around several distinct measures. Typically, measurement techniques depend on the parameters representing the phenomena researchers are trying to understand and the strictures of the academic communities from which they hail (Fukuyama, 2002; Schuller and Bamford, 2000). Researchers studying macro-social capital (social capital resources that inhere in communities or nations or other aggregates) will use measurement techniques designed for application to *groups*. Researchers studying micro-social capital (the social capital resources available to individuals) will use measurement techniques that attempt to uncover social capital resources accessed and mobilized by *individuals*. As a consequence, precisely defining social capital, and the units of analysis (group versus individual) under study, is a critically important precursor of any social capital measurement scheme.

At the micro-social capital level, three measurement techniques have been tested and accepted by social capital researchers:

1. The name generator
2. The position generator
3. The resource generator

Units of Analysis

The unit of analysis for my project is the individual student. While I ultimately want to analyze small groupings, my fundamental interest resides in understanding the effects of social capital that is accessed and mobilized via TT participation on individual engineering students. For the purposes of my project, I define social capital at the micro level primarily as an *individual good* rather than as a *collective good*. To a large degree, this drives the range of measurement options available to me. Two goals of my project will be to (a) measure the social capital of individual students and then (b) use these individual measurements to compare the aggregated social capital of specific groupings based on the following classifications:

a. Gender
b. Socio-economic status
c. Region of origin—urban, rural, suburban, international
d. Ethnicity

Toward a Precise Definition of Social Capital

I base my definition of social capital on the work of three researchers: Alejandro Portes, Nan Lin, and Ricardo Stanton-Salazar. Each of these individuals' research focuses on social capital at the individual level.

Portes's statement that "social capital stands for the ability of actors to secure benefits by virtue of membership in social networks or other social structures" (Portes, 1998, p. 6) offers a solid baseline foundation for conceptually understanding social capital theory while simultaneously setting the stage for Lin's equally parsimonious, but more operational, notion of social capital: "The investment in social relations by individuals through which they gain access to embedded resources to enhance expected returns of instrumental or expressive actions" (Lin, Cook & Burt, 2001, pp. 17, 19).

Finally, Stanton-Salazar complements Lin's definition by conceptualizing social capital as the

> social relationships from which an individual is potentially able to derive institutional support, particularly support that includes the *delivery of knowledge-based resources*, for example, guidance for college admission or job advancement. Working class youths have vastly less social capital than do middle-class youths. (Stanton-Salazar & Dornbusch, 1995, p. 119 [emphasis added])

Three important assumptions underpin these definitions of social capital:

1. Resources that may be used for individual benefit are embedded in pyramidal social structures with the most prestigious—and scarcest—positions residing at the top of the structure.
2. Individuals have varying abilities to access embedded social resources based upon each individual's position or location within the social structure.
3. Certain individuals with access to embedded social resources mobilize social resources in purposive actions (Lin, 1999).

Lin suggests that the notion of *homophily*—again, the idea that people band together with other people with whom they share similar characteristics and, as a result, are familiar—unifies these three elements and has the potential to explain unequal access to social capital resources across social structures (Lin, 2000). For example, homophily implies that an aspiring engineering student from a low SES background (inferior position within the social structure) will likely spend the majority of his or her time with other students from similar backgrounds. The student's position in the social structure, combined with the tendency to seek out "like" alters, results in relatively limited access to rich and diverse sources of social capital. Lin refers to this phenomenon as *"capital deficit,"* which he frames as:

> the consequence of a process by which differential investment or opportunities produce the relative shortage (in quantity or quality) of capital for one group as compared with another . . . different social groups may be embedded in different social hierarchies or social networks that facilitate or constrain their members' capital acquisition. . . . Capital deficit, in this formulation, is expected to account for the differential placement and rewards received by different social groups. (Lin, 2000, p. 37)

Lin also states that capital deficit has a disproportionately negative affect on women and certain ethnic minority groups (Lin, 2000). This point is critical for my work because both women and minorities are underrepresented in engineering.

Finally, two types of potential outcomes may result from the mobilization of social capital by an individual:

1. Returns on *instrumental* action
2. Returns on *expressive* action (Lin, Cook & Burt, 2001)

Lin's conception of social capital focuses on ways in which *individuals* (not groups) derive benefits by taking advantage of their social networks—returns on micro-social capital investments accrue first and foremost to *individuals*. Bearing this in mind, Lin states that "instrumental action is taken to obtain resources not possessed by the actor, whereas expressive action is taken to maintain resources already possessed by the actor" (Lin, Cook & Burt, 2001, p. 19).

For definitional clarity I use Borgatti, Jones, and Everett's (1998) labels for measuring the social capital of individuals within a network; "ego" refers to the person whose social capital is being measured while "alter" refers to the person(s) the ego is connected to via the social network.

Instrumental returns provide the ego with benefits he or she did not possess prior to mobilizing his or her social capital. As such, they are the consequence of tactical actions the ego takes to realize some form of personal gain. Expressive returns involve the reinforcement of the ego's existing resources, suggesting that the ego is entrenching and consolidating existing resources. These outcome variations, along with the focus on individual behavior, have implications for the range, and quality, of social capital measurement tools.

The Heart of the Matter – Measuring Social Capital

Van Der Gaag and Snijders suggest that there are two purposes for measuring social capital: to determine an individual's access to social capital and to determine how an individual uses mobilized social capital to yield returns (Van Der Gaag and Snijders, 2005). They also suggest that social capital measures should measure not only the ego's access to network resources but also alters' willingness to aid the ego.

A substantial portion of my project entails understanding how individual engineering students use social capital derived from TT experiences to realize *both* expressive *and* instrumental returns on the social resources they access and mobilize through their networks while in high school. Examples of *expressive* returns that fall within the scope of my project include:

- increased levels of self-confidence
- emotional support from TT peers and mentors
- a sense of belonging within the engineering community
- perceiving and solidifying a position of advantage within the social structure
- the development of an engineering identity

Examples of *instrumental* returns that fall within the scope of my project include:

- developing a deeper understanding of what it means to be an engineer
- advantages in the engineering admissions process
- developing the skills to more fluidly work in settings where group-work is emphasized
- cultivating the engineering vernacular
- comprehending—and becoming comfortable with—the engineering culture
- learning important technical skills that are relevant to engineering
- building bridges to selective and prized undergraduate engineering activities such as research and project teams

My research strategy, then, must focus on developing survey questions that elicit answers to the following core social capital questions that outline the relationship between the ego, his or her alters, and the returns derived from these ties:

1. Did the ego's network resources provide his or her with access to alters who are engineers or who have knowledge of engineering?
2. Were the ego's engineering-related ties a product of TT participation?
3. If the ego had access to alters with engineering knowledge, then how many of these ties did he or she have? Additionally, what were the strengths of these ties (strong versus weak)?
4. Did the ego consciously mobilize the advantages inherent to these resource ties?
5. What specific returns did the ego hope to derive from mobilizing engineering-specific network resources? In other words, assuming that the ego mobilized these ties consciously in seeking returns, how did he or she benefit from the relationship?

Three Micro-Social Capital Measurement Techniques

Three methods for measuring individual (or micro) level social capital are well established and widely recognized. Each is summarized in the grid below:

Micro-Social Capital Measurement Methods	
1. Name Generator	
Technique and Advantages	The ego is asked to list all individual contacts. Provides an extremely detailed map of the ego's social network.
Disadvantages	Highly labor intensive, has the potential to overstate the ego's social capital, connections to alters can often be redundant given that access to one alter is typically enough social capital to solve a problem, researchers using the name generator have not provided consistent social capital measures
Key References	McCallister & Fischer, 1978; Marsden, 1987

2. Position Generator	
Technique and Advantages	Quite simple to execute, the position generator measures social capital based on the ego's access to alters who occupy prestigious occupations or positions of occupational authority. This measurement tool rests on the assumption that society is tiered hierarchically. People located higher in the hierarchy are positioned to help those below them reach upward. Provides simple and effective social capital measures.
Disadvantages	Social capital measures provide little indication of the ego's social resources, particularly of the diversity of his or her social resources. Also, the assumption that occupational prestige is a key theoretical element may not be accurate for all populations.
Key References	Lin & Dumin, 1986; Lin et al., 2001

3. Resource Generator	
Technique and Advantages	Asks the ego about access to a fixed list of resources. Each resource represents a sub-collection of social capital. Availability of each resource indicated by the ego is checked for tie strength (weak versus strong ties—family member, friend, or acquaintance). This measurement system can be administered quickly and efficiently and measures the ego's goals for mobilizing social capital.
Disadvantages	May provide results that are incomparable across populations because relevant resources may vary across populations—a resource that is relevant to one population may not be relevant to another.
Key References	Van Der Gaag & Snijders, 2005

1. **Name Generator Technique**

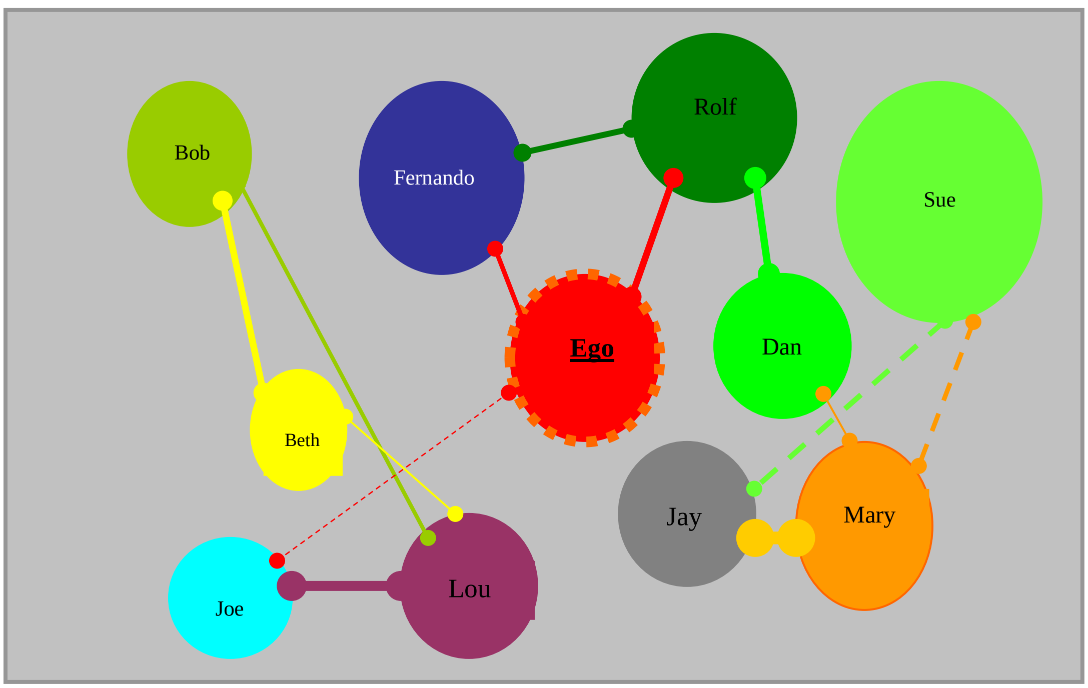
Based on network theory, the name generator uses survey methods to list the ego's contacts across specific aspects of his or her daily life. For example, Lin (2001) suggests combining the following elements when using the name generator technique:

a. Attain a list of each alter that exists in role *relationships* within the ego's neighborhood or work.
b. Attain a list of alters existing in *content areas* that are relevant to the ego—for instance, work matters or household chores.
c. Attain a list of each alter's relative level of intimacy with the ego—the ego rates the level of intimacy with various alters spanning the areas listed in (a) and (b). For example, the ego rates relations in role relationships and content areas based on his or her level of intimacy with each contact: confidential, most intimate, friendly, or formal (doing this provides information pertaining to the strength of the tie).
d. Finally, trace the relationships not only from the ego to all his or her alters, but also between alters (Lin, 2001).

The goal of the name generator is to compile an extremely detailed network map—or set—of relationship ties between the ego and his or her network of alters (see Figure 3 below). A second goal is to identify the points within the ego's network where alters are also connected. Uncovering each alter's social ties should shed light on the *diversity* and *range* of the ego's ties—how far can the ego's social ties propagate upwards or across the structural hierarchy? According to this technique, mobilized social capital is defined by the ego's ability to use a primary alter as a conduit through which to access the resources of a secondary alter who is not within the ego's immediate network range.

From the name generator list, a second set of questions—focusing on determining the social capital aspects of the ego's network—are designed to describe the diversity, strength, range of resources (education and occupation), and characteristics (gender, race, age, SES, positional authority) of the ego's network (Lin, 2001). It is worth remembering that the name generator technique focuses primarily on indexing the names of alters connected to the ego. While such a list is sufficiently detailed and complex, it may lack a certain focus on specific populations or research questions.

Figure 3. Name Generator Example.



Reasons for **discarding** the name generator technique:

a. While the technique is exhaustive, it is also, well, exhausting. Proponents of the technique suggest that it is excellent for measuring the social capital of small groups of individuals (small office groups, teams, etc.). For large groups the technique is cumbersome and exponentially complex because the name generator requires interviewing all individuals within the bounds of the group in question and then constructing extremely detailed maps of their social contacts and networks.

b. Researchers using this technique have not defined social capital measures consistently. This makes it difficult to compare social capital findings across studies using this technique.

2. **Position Generator Technique**

The position generator is designed to measure the ego's ties to people in valued *occupational positions* within specific social hierarchies (Song and Lin, 2009). An overly simplistic example may clarify this concept. In Figures 4 and 5 below, Ego A and Ego B are asked about their ties to (a) professional engineers, (b) engineering professors, (c) engineering graduate students (d) engineering undergraduate students and (e) engineering admissions officers. In this example, engineers are considered prestigious, occupying positions of importance within the social hierarchy—having access to them represents social capital. Figure 4 indicates that Ego A has ties to positions (a) through (e), suggesting that, within this particular social structure, Ego A has access to significant social capital. Figure 5 indicates that Ego B has ties only to an undergraduate engineering student and an engineering admissions officer, indicating that Ego B is more limited in the social capital he or she can access compared with Ego A. Both have weak ties (denoted by the dotted line) with the engineering admissions officer.

Figure 4. Position Generator Example 1.

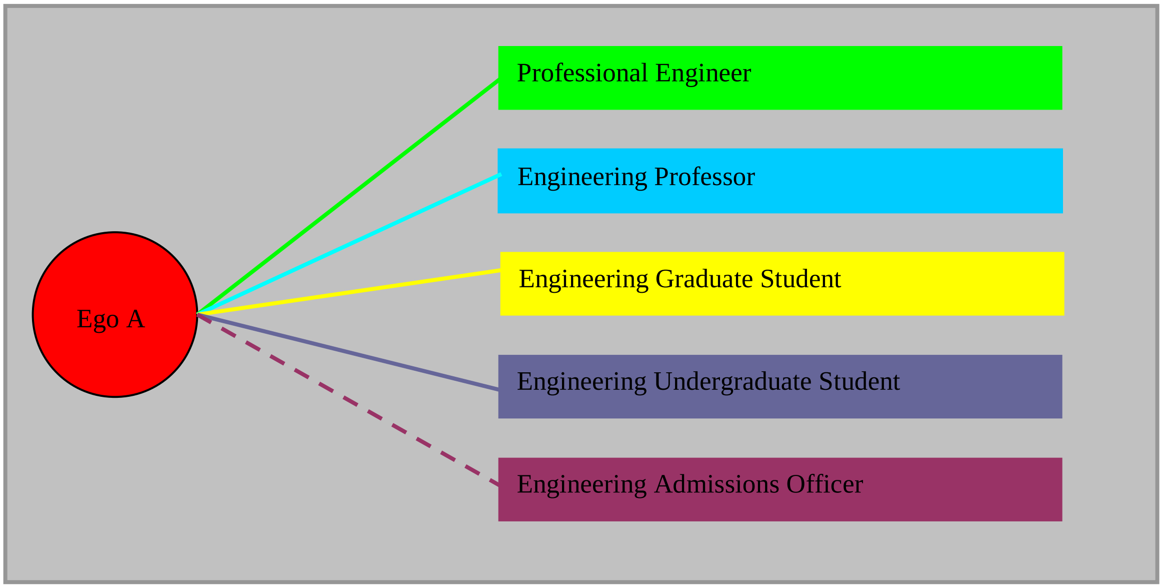
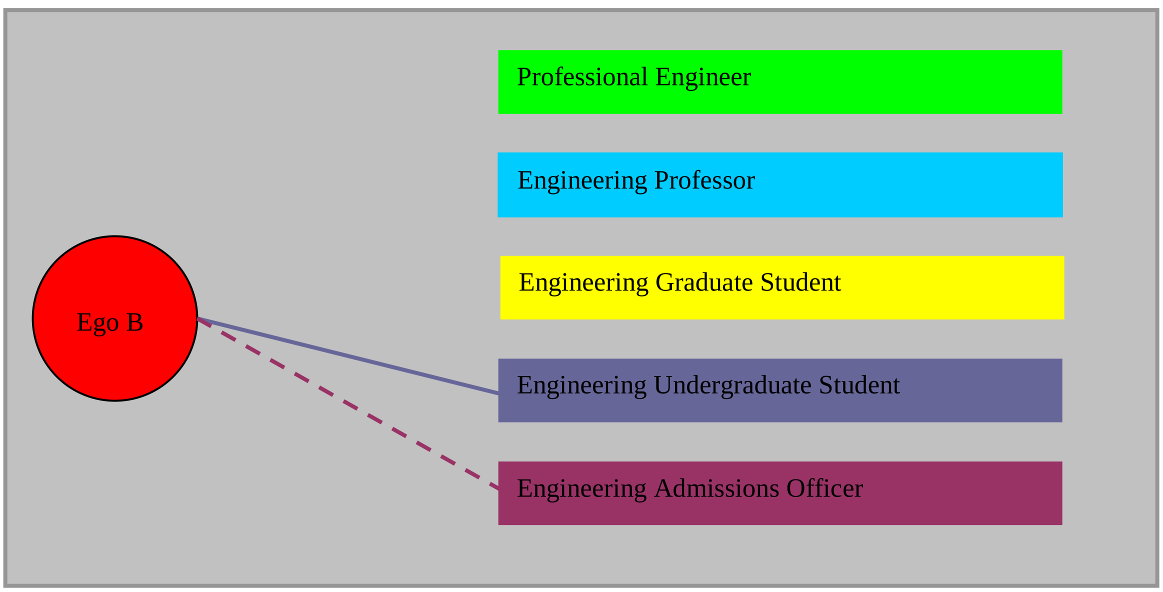


Figure 5. Position Generator Example 2.



These diagrams are, of course, oversimplifications, but they illustrate the basic premises behind the name generator and the position generator.

Figure 6 adapts a survey question from Nan Lin's (2001) position generator and demonstrates the measurement range the position generator technique affords relative to that of the name generator. Bear in mind that the major limitation of this technique is the assumption that social capital lies primarily in positions of *occupational status*; the technique does not measure far beyond this. In some ways, the technique is too narrowly focused:

Figure 6. Sample Position Generator Survey Questions.

Question: Here is a list of engineering positions and occupations. Would you please tell me if you happen to know someone holding each position?							
Position	**When you were in high school, did you know anyone in this position?**	**How long did you known this person? (Number of months)**	**What was your relationship with this person?**	**How close were you with this person? (Long-term friend, friend, acquaintance)**	**His/her gender?**	**When you were in high school would you have been able to find such a person through someone you knew? (Person M)**	**Repeat #2 – 6 for Person M.**
Professional Engineer							
Engineering Professor							
Engineering Graduate Student							
Engineering Undergraduate Student							
Engineering Admissions Officer							

The operative component of the position generator is determining whether or not the ego's network has access to alters that are populating prestigious occupational positions. The position generator provides a way to measure the ego's ability to access alters residing in various positions of occupational influence within the social hierarchy (Lin, 2001). Here the social capital exists in the tie between the ego and these individuals of influence; these are the people the ego can use to scale the social hierarchy. It is important to note here that the existence of only *one* tie between the ego and an influential alter is all it takes to qualify as social capital. The goal, then, is not to measure the number of engineers to whom the ego is tied, but to determine *if* the ego has at least one tie to an engineer residing in each category of interest. Determining the strength of that tie is also important (weak versus strong).

I wonder about the validity of applying this assumption to engineering, given the range of sub-disciplines under the engineering umbrella. Having a tie to an electrical engineer is likely qualitatively different from having a tie to a civil engineer. While the engineers from each engineering sub-discipline would surely classify themselves as "engineers," the cultures found in each sub-discipline differ considerably. As a result, it is conceivable that the *range* of engineering alters to which the ego has access might be an important indication of the quality and utility of the ego's social capital.

Reasons for being *cautious* about using the position generator technique:

a. While the position generator is easy to execute and has a history of providing accurate social capital measures (range of accessed prestige, highest accessed prestige, and number of different positions accessed), it relies on the assumption that mere access to alters in specific *jobs* is in itself a representation of social capital.

b. The position generator also provides little information about the ego's intentions for mobilizing social capital and is limited to contextually specific social capital—i.e., the position generator may be too uni-dimensional in what it measures (Van Der Gaag & Snijders, 2005).

3. **Resource Generator Technique**

Unifying elements of both the name generator and the position generator, the resource generator is designed to capture the depth and complexity of social capital as measured by the name generator with the economy and internal validity of the position generator (Van Der Gaag & Snijders, 2005; Song, 2011). It is a hybrid of the other micro-social capital measurement techniques (see Figure 7 for a sample survey question using the resource generator).

The resource generator focuses on the *resources* the ego can access and capitalize on through a network of alters (Moore et al., 2005). The technique is less about the people the ego can access and more about what those people can offer the ego. At its heart the resource generator is a technique designed to measure the potentially *productive* social resources derived through the ego's contact network (Van Der Gaag and Snijders, 2005).

The resource generator works by listing a set of resources representing social capital and then asking the ego (a) if he or she has access to these resources and (b) which broad categories of individuals (family members, friends, acquaintances) provide access to each resource (Van Der Gaag &Snijders, 2005). Asking the ego to list his or her relationship to each alter providing access to each resource provides information on the *tie strength* at the ego's disposal for accessing social capital: Family member = strong tie, friend = semi-strong tie, acquaintance = weak tie (remember that strong ties are useful in some circumstances while weak ties are useful in others). Asking the ego initially about resources rather than the names or occupations of specific individuals allows the researcher much greater flexibility to uncover the diversity, range, and quality of social capital resources across multiple domains available to each ego involved in the study.

The developers of this technique argue that measures of social capital built into the resource generator should be rooted in theory that conceptually precedes social capital theory. They suggest two types of theoretical frameworks that accomplish this:

1. Each social capital measure should be rooted in the assumption that individuals pursue universally valued resources such as *power*, *wealth*, and *status* (Van Der Gaag & Snijders, 2005).
2. Each social capital measure should reflect five universal goals—or aspirations—that people seek over the course of their lives:
    a. Private productive activities
    b. Personal relationships
    c. Private discretional or recreational activities
    d. Public productive activities
    e. Public relationships (Van Der Gaag & Snijders, 2005)

These factors provide the theoretical framework for examining social capital in unique contexts.

Van Der Gaag and Snijders (2005) and Flap, et al. (2003) offer three additional factors necessary for the construction of surveys with accurate social capital measures:

a. Volume – the more social ties and resources the ego can access, the more tenable the ego's position becomes within the social hierarchy.
b. Diversity – increased differentiation of social resources available to the ego improves the quality of the ego's social capital because it enriches both the range of opportunities and the diversity of information available to the ego.

c. High upward reach – social resources with the capacity to reach higher in the social structure, representing better-quality social capital. The higher the reach, the better it is for the ego!

To fully appreciate how the resource generator measures social capital it is important also to consider what Van Der Gaag and Snijders (2005) suggest are precursors to the mobilization of social capital. The three determinants of social capital are:

a. Opportunity structure – Social structures that place the ego in a position to interact with other people of influence provide the opportunity for cultivating social capital. Opportunity structures may be found in the ego's neighborhood, community, family . . . or an engineering TT.
b. Homophily – Discussed earlier but emphasized here as "investment in relationships with persons who are similar with respect to demography, education, and lifestyle" (Van Der Gaag & Snijders, 2005, p. 6).
c. Personality characteristics – some individuals are more socially inclined than others, which may affect their capacity to construct ties and cultivate resources that will be beneficial to them.

Finally, Van Der Gaag and Snijders (2005) state that the resource generator is designed to identify each individual's unique and "personal collection of social capital" (Van Der Gaag & Snijders, 2005, p. 6). Also of importance is their note that domains of social capital are *population-specific*. This may be interpreted to mean that social capital measures for engineering students, and conceivably even the specific engineering students participating in this study, have their own unique attributes. Social capital measures that correspond to the population under study must be developed.

Figure 7. Resource Generator Sample Question.

A	When you were in high school, did you know anyone who…	No	Family member	Friend	Acquaintance
1	…had completed an engineering degree?	(0)	(1)	(2)	(3)
2	…could teach you robotics?	(0)	(1)	(2)	(3)
3	…worked for an engineering company?	(0)	(1)	(2)	(3)
4	…could help you get admitted to an engineering school?	(0)	(1)	(2)	(3)
5	…told you what it's like to be an engineer?	(0)	(1)	(2)	(3)

Conclusion

For my project I will discard the name generator as a technique for measuring social capital. Instead, I intend to use a hybrid of the position generator and the resource generator. Doing so will allow me to collect social capital data efficiently and accurately while also adapting survey instruments and social capital measures to the unique attributes and characteristics of the engineering population involved in this study.

CHAPTER 3

DATA AND METHODS

General Overview of Data Collection Procedures

This study employs a quasi-experimental design with posttest-only analysis involving non-equivalent groups, as described in Shadish, Cook and Campbell (2002). The treatment—high school technical team (TT) participation—occurred prior to the research project, although both the treatment group—high school TT participants—and the control group—subjects without high school TT experience—exist. Diagrammatically, the research design can be illustrated as follows:

NR	X	O_1
NR		O_2

NR = Non-Random, indicating the sample was not randomly drawn.

X = Treatment – TT participation in high school

O_1 = Posttest – data collection from the treatment group.

O_2 = Posttest – data collection from the control group.

Central Study Question(s)

The study's central question involves understanding whether and to what extent participation on a high school TT influences the experience of undergraduate engineering in terms of students' self-efficacy, grades, confidence that they belong in engineering and can succeed academically within the engineering curricula, and social capital resources relative to engineering. This question is formalized in the study's four sub-hypotheses.

Hypotheses

The central research question is addressed by four related hypotheses:

Hypothesis 1A: First-year engineering students who have participated on a high school TT will have *stronger self-efficacy* skills than their engineering classmates who did not participate on a high school TT (*measured via the General Perceived Self-Efficacy scales)*.

Hypothesis 1B: First-year engineering students who have participated on a high school TT will achieve *higher cumulative GPAs* than their engineering classmates who did not participate on a high school TT.

Hypothesis 1C: First-year engineering students who have participated on a high school TT will be *more confident* in their abilities to succeed in an undergraduate engineering program than their engineering classmates who did not participate on a high school TT *(measured via Pittsburgh Freshman Engineering Attitudes Survey [PFEAS]; see Table 3 for a description).*

Besterfield-Sacre, et al. (1998) describe a set of variables that measure engineering students' perceptions of engineering, their reasons for enrolling in engineering undergraduate programs, and their confidence in being able to succeed in engineering. The study utilizes the Pittsburgh Freshman Engineering Student Attitude Survey to analyze if and how high school TT experience influences engineering students' confidence as they enter engineering.

Hypothesis 2: Participation on a TT in high school provides participants with increased engineering-specific social capital resources relative to engineering classmates who did not participate on a high school TT (Theory tie = social capital theory).

Lin conceives of social capital as

> *investment in social relations with expected returns in the marketplace*. . . . In this approach, capital is seen as a social asset by virtue of actors' connections and access to resources in the network or group of which they are members. (Lin, 2001)

Stanton-Salazar complements Lin's definition by viewing social capital as the

> social relationships from which an individual is potentially able to derive institutional support, particularly support that includes the *delivery of knowledge-based resources*, for example, guidance for college admission or job advancement. Working class youths have vastly less social capital than do middle-class youths. (Stanton-Salazar & Dornbusch, 1995: emphasis added)

Within the framework of this study, social capital is defined from an individual perspective and includes the capacity of individuals to attain knowledge that provides specific advantages. Of particular interest is understanding whether high school TT participation inherently provides social capital resources in the form of information about engineering to which non-TT participants do not have access. Data describing social capital resources relative to engineering were collected from study participants using an adaptation of an existing instrument, the Resource Generator (Van Der Gaag & Snijders, 2005). The instrument was adapted to reflect individual social capital resources related to engineering.

Two discrete studies, described below, were conducted to explore the hypotheses.

Contributions of the two studies

The studies contribute to the existing body of knowledge in the following three ways:

1. Study 1 builds on prior studies analyzing the relationship between student self-efficacy, success (GPA), and confidence in undergraduate engineering by introducing high school TT participation as an independent variable to understand whether TT experiences influence self-efficacy, GPA, and confidence in undergraduate engineering.
2. Study 2 builds on Study 1 by introducing the theoretical constructs of social capital into the analysis to more fully understand potential relationships between high school TT participation and success in undergraduate engineering. Currently, high school TT participation is lauded for providing beneficial technical previews of engineering. This study introduces non-technical elements (confidence, social capital, and self-efficacy) into the conversation about the effects TT participation may have on individual students relative to these factors.
3. Study 1 and Study 2 add to existing theoretical research by providing a novel basis, specifically through the “lens” of high school TT participation, for understanding the relevance of confidence, social capital resources, and self-efficacy to engineering students’ ability to succeed and persist in undergraduate engineering programs.

The study sample

To conduct the two studies, I collected data on first-year engineering students via surveys (paper-and-pencil as well as web-based) and archival admissions and registrar records. As a former admissions staff member in the focal engineering program, I enjoyed a high level of access to the student population under study. Access was facilitated by a formal letter from the university's Vice President for Student Academic Services granting me permission to perform research on the student population. The letter, dated August 5, 2004, was delivered to the University Committee on Human Subjects (Appendix 2). The University Committee on Human Subjects approved the research proposal on successive dates beginning in August 2004 and extending through the length of the project.

Participants were enrolled as full-time, undergraduate, first-year engineering students at one university. The setting for the study was a highly selective engineering college (with an admission rate of under 30% for first-year applicants) that operates within a broader research and teaching-intensive university located in the northeastern United States. Data utilized in Study 1 and Study 2 were collected over the course of one academic year, beginning in August 2006 and concluding in May 2007. Additional attrition data were collected in the fall of 2007 to record students in the sample who left engineering during their initial year. In the spring of 2010, a final dataset was provided by the engineering college's registrar that included GPA information for the initial cohort of subjects. As a consequence, GPA data across four years for the initial study sample were included in the Study 1 analysis.

The survey instrument utilized in Study 1, titled "Entry Survey," was piloted in August of 2005. The survey was delivered for paper-and-pencil completion and all entering first-year engineers were invited to participate (749 students were invited to complete the survey and 734 students submitted completed surveys, for a response rate of 98%). Based on the pilot of the Entry Survey, the General Perceived Self-Efficacy Scales were added to the survey as well as demographic and socio-economic questions and questions related to TT participation in high school (questions B1 through B6 on the pilot Entry Survey were moved from the front of the survey to the back of the survey; questions 110 through 147 were included on the final Entry Survey).

The second survey, which was designed to collect social capital data, was titled "Engineering Resource Generator" and piloted in November 2006. The pilot survey was delivered to 80 sophomore, junior, and senior undergraduate engineering students via e-mail. First-year engineering students were excluded because they comprised the population under study. Participants were invited to complete the survey online and print their results. All participants were invited to attend an instrument de-briefing meeting and bring their printed results to that meeting. Thirteen participants attended the meeting. The attending participants were asked to complete an eight-question evaluation of the survey instrument. Printed survey instruments and the evaluation were used as the basis for a conversation with the thirteen students that sought to ensure that the participants understood the survey questions and understood what information the instrument was seeking to collect, and to determine how much time was required to complete the survey. Based on the Engineering Resource Generator pilot, question clarity was determined to be good (questions 50A and 50B were adjusted to improve clarity), the purpose of the survey was clear, and the average completion time was approximately ten minutes.

Timeline for data collection

The timeline for data collection, from the pilot to final survey data collection, extended from August 2005 into June 2007, excepting the final graduation dataset provided by the Engineering Registrar in 2010. Table 1 describes the *full* data collection schedule and timeline.

Table 1. Full Data Collection Procedures.

Table 1: Full Data Collection Schedule and Timeline

	August 2005	*July 2006*	*August 2006*	*November 2006*	*November 2006 – March 2007*	*January – March 2007*	*March – May 2007*	*May – June 2007*	*July 2010*
Data Collection Technique	Survey	Archival Data	Survey	Survey	Survey	Survey	Interview	Survey	Archival Data
Instrument	Entry Survey *Pilot*		Entry Survey *Actual*	Engineering Resource Generator *Pilot*	Engineering Resource Generator *Actual*	Organizational Socialization	Standardized Interview Questionnaire	Year 1 Exit Survey	
Instrument Type	Paper and Pencil Survey		Paper and Pencil Survey	Online Survey, printed with comments, small focus group	Online Survey	Online Survey		Online Survey	
Constructs Measured	Pittsburgh Freshman Engineering Attitude Survey		Pittsburgh Freshman Engineering Attitude Survey	Individual Social Capital	Individual Social Capital		High School FIRST Team experience.		
	Index of Learning Styles		General Perceived Self-Efficacy Scales	One question focusing upon "belonging" in the Engineering College	One question focusing upon "belonging" in the Engineering College		People in high school providing information relevant to engineering.		
			Index of Learning Styles				Rationale for studying engineering.		
Other		Archival Dataset 1, Engineering Registrar.							Archival Dataset 2, Engineering Registrar 7/1/2007
Participants	First-Year Engineering Students (2005 Entry)	First-Year Engineering Students (2006 Entry)	First-Year Engineering Students (2006 Entry)	Sophomore, Junior, and Senior Engineering Students (2006 First-Year Engineering Students Excluded)	First-Year Engineering Students (2006 Entry)	First-Year Engineering Students (2006 Entry)	Ten undergraduate engineering students: 2 Frosh, 4 Sophomores, 4 Juniors, 0 Seniors.	First-Year Engineering Students (2006 Entry)	First-Year Engineering Students (2006 Entry)

Table 2 describes the abbreviated data collection schedule and timeline that were functionally utilized in Study 1 and Study 2.

Table 2. Abbreviated Data Collection Procedures.

	July 2006	***August 2006***	***November 2006 – March 2007***	***July 2010***
Data Collection Technique	Archival Data	Survey	Survey	Archival Data
Instrument		Entry Survey *Actual*	Engineering Resource Generator *Actual*	
Instrument Type		Paper and Pencil Survey	Online Survey	
Constructs Measured		Pittsburgh Freshman Engineering Attitude Survey	Individual Social Capital	
		General Perceived Self-Efficacy Scales	One question focusing on "belonging" in the Engineering College	
Other	Archival Dataset 1, Engineering Registrar.			Archival Dataset 2, Engineering Registrar 7/1/2007.
Participants	First-Year Engineering Students (2006 Entry)	First-Year Engineering Students (2006 Entry)	First-Year Engineering Students (2006 Entry)	First-Year Engineering Students (2006 Entry)

Study 1: Self-efficacy, GPA performance, and confidence relative to high school TT participation

Hypotheses Addressed by Study 1

Three hypotheses were addressed in Study 1:

Hypothesis 1A: First year engineering students who have participated on a high school technical team will have *stronger self-efficacy* skills than their engineering classmates who did not participate on a technical team in high school.

Hypothesis 1B: First year engineering students who have participated on a high school technical team will achieve *higher cumulative GPA's* than their engineering classmates who did not participate on a technical team in high school.

Hypothesis 1C: First year engineering students who have participated on a high school technical team will be *more confident* in their abilities to succeed in an undergraduate engineering program than their engineering classmates who did not participate on a technical team in high school.

Study 1 data collection procedures and timeline

For Study 1, I collected data in August 2006 from entering first-year undergraduate engineering students. Paper-and-pencil surveys were administered during orientation week on August 19, 2006. The survey consisted of 148 questions. All surveys were delivered simultaneously in three separate classrooms. All entering first-year engineers (N=781) were invited to complete the Entry Survey during the first-year engineering orientation advising session. The Engineering Advising Office agreed to assist in the administration and delivery of the survey, with each of the three classrooms where the survey was being delivered containing two professional Engineering Student Services staff members as proctors. Instructions were read aloud by the proctors and participants completed the survey "on site" in the classroom following the delivery of instructions. The Entry Survey required, on average, 45 minutes to complete.

Questions were formatted as four- and five-point Likert scales and open-ended text responses. The Entry Survey was a compilation of the following existing instruments:

1. The Pittsburgh Freshman Engineering Attitude Survey © (PFEAS), which was developed by researchers at the University of Pittsburgh. The instrument was developed with three objectives in mind (Besterfield Sacre et al., 1998):
    a. Identify initial student attitudes about engineering and themselves.

a. Capture how these attitudes change over the course of the first year as a result of their experiences.

b. Correlate these attitudes with retention in the freshman engineering program.

Question responses were measured on a five-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree.” Thirteen attitudinal factors and confidence measures constitute the survey. I included an additional factor (F14), which was not included in the original survey. The fourteen attitudinal factors and confidence measures are described in Table 3.

Table 3. PFEAS Student attitude and self-assessment measures

Student Attitude and Self-Assessment and their Code		**Definition**	**Rating Value**
Career Impressions	General Impressions of Engineering Factor 1 Questions: 4, 5, 6, 7, 8, 9, 10, 11, 12.	How much student likes engineering	1 – does not strongly like engineering 5 – strongly likes engineering
Jobs – Salary	Financial Influences for Studying Engineering Factor 2 Questions: 13, 17, 24, 26.	Belief that engineers are well paid and that having an engineering degree helps assure security	1 – does not hold this belief 5 – strongly holds this belief
Society Contribution	Perception of How Engineers Contribute to Society Factor 3 Questions: 14, 23	Belief that engineers contribute to improving the welfare of society	1 – does not strongly hold this belief 5 – strongly holds this belief
Perception of work	Perception of the Work Engineers Do and the Engineering Profession Factor 4 Questions:15, 20, 21, 25, 28, 30, 31	Considers engineering a respectable field and the work engineers do has a positive impact on solving the world’s problems	1 – does not hold this belief 5 – strongly holds this belief
Math enjoyment	Enjoyment of Math and Science Courses Factor 5 Questions: 16, 22	Preference for math and science courses over liberal arts courses	1 – does not strongly hold this preference 5 – strongly holds this preference
Exact Science	Engineering Perceived as Being an “Exact” Science	Belief that engineering is an exact science	1 – does not hold this

	Factor 6 Questions: 18, 29		belief 5 – strongly holds this belief
Family Influence	Family Influences to Studying Engineering Factor 7 Questions: 19, 27	Belief that parents are influencing student to study engineering	1 – does not hold this belief 5 – strongly holds this belief
Basic Knowledge	Confidence in Basic Engineering Knowledge and Skills Factor 8 Questions: 32, 33, 34, 35, 38	Self-assessed confidence in knowledge of calculus and physics, chemistry and computer skills	1 – has low confidence 5 – has high confidence
Communication Skills	Confidence in Communication and Computer Skills Factor 9 Questions: 36, 37, 38	Self-assessed confidence in writing, speaking and computer skills	1 – has low confidence 5 – has high confidence
Study Habits	Adequate Study Habits Factor 10 Questions: 42, 49	Beliefs about the adequacy of current study habits	1 – not comfortable with study habits 5 – comfortable with study habits
Group Work	Working in Groups Factor 11 Questions: 40, 46, 48	Preference for working in groups	1 – prefer working alone 5 – prefer working in groups
Problem Solving Ability	Problem Solving Abilities Factor 12 Questions: 41, 43, 45, 52, 53	Belief that one has the creative thinking and problem solving abilities required for engineering	1 – does not strongly hold this belief 5 – strongly holds this belief
Engineering Ability	Engineering Abilities Factor 13 Questions: 39, 47, 50, 51	Belief that one has the capability traits of engineers	1 – does not strongly hold this belief 5 – strongly holds this belief
Engineering preview	Confidence in understanding what engineering is Factor 14 Questions: 44, 54, 55	Belief that one understands what engineering is prior to beginning engineering	1 – does not strongly hold this belief 5 – strongly holds this belief

2. The General Perceived Self Efficacy scale adapted from Schwarzer and Jerusalem (1993) was used to measure the self-efficacy of participants. Responses were measured on a four-point Likert scale with responses ranging from "Not at all true" to "Exactly true." The ten-question scale is designed to measure individual competencies that enable students to manage various stressful situations (Schwarzer, 1993). Response results are added to compute a composite total score ranging from 10 to 40 points. While no thresholds defining self-efficacy in categorical terms exist, prior studies indicate that, for high school students (N=3,494 students ranging in age from 12 to 17 years old), the population most similar to this study's population, mean scores are 29.6 with a 4.0 standard deviation (Schwartzer, 2014).
3. The Index of Learning Styles contains 44 items designed to provide information on participants' preferred learning styles. Participants select one of two response options that complete a sentence. For example, "I understand something better after I . . . (a) try it out, or (b) think it through." Composite responses categorize participants into one of four general learning preference categories: Active and Reflective Learners, Sensing and Intuitive Learners, Visual and Verbal Learners, and Sequential and Global Learners. While responses to the Index of Learning Styles survey were recorded, the results are not included in the analysis because the researcher determined that they are beyond the scope of the current study.

The response rate for the Entry Survey was XX%. Data from the paper-and-pencil surveys were loaded into an Access database, transferred to an Excel spreadsheet, and then imported into an SPSS dataset for analysis.

Study 1 variables and analysis

The variables involved in Study 1 vary by hypotheses and are listed as follows:

Hypotheses 1A – Self-Efficacy – variables:

Dependent variable (interval variable):

1. The General Self-Efficacy Scale (GSE)

Independent (predictor) variables that are categorical:

1. Self-identified TT experience
2. Self-identified TT leader
3. Admissions committee–identified TT experience
4. Admissions committee–identified TT leadership

Control variables:

1. Gender (categorical variable, women are classified as 1, men are classified as 0)
2. Under-represented minority (URM) status as measured by a binary dummy (categorical) variable that defines under-represented minority status as 1 and majority status as 0.
3. Socio-economic status as measured by (a) combined parental education via a categorical questionnaire scale (interval variable) and (b) the number of bookshelves in the family home as measured by a categorical questionnaire scale (interval variable) that records the number of bookshelves in each subject's home as a proxy for socio-economic status.

Hypothesis 1A – analysis

The analysis carried out to test hypothesis 1A includes descriptive statistics, bivariate correlations, and simple linear regression.

Hypothesis 1B – Grade Point Average (GPA) – variables:

Two dependent variables (both are interval variables):

1. Cumulative Grade Point Average after the completion of the first year of engineering (GPA 1).
2. Cumulative Grade Point Average after the completion of the fourth year of engineering (GPA 4).

Independent (predictor) variables that are categorical:

5. Self-identified TT experience
6. Self-identified TT leader
7. Admissions committee–identified TT experience
8. Admissions committee–identified TT leadership

Control variables:

4. Gender (categorical variable, women are classified as 1, men are classified as 0)
5. Under-represented minority (URM) status as measured by a binary dummy (categorical) variable that defines under-represented minority status as 1 and majority status as 0.
6. Socio-economic status as measured by (a) combined parental education via a categorical questionnaire scale (interval variable) and (b) the number of bookshelves in the family home as measured by a categorical questionnaire scale (interval variable) that records the number of bookshelves in each subject's home as a proxy for socio-economic status.

Hypothesis 1B – analysis

The analysis includes descriptive statistics, bivariate correlations, and simple linear regression.

Hypothesis 1C – Confidence – variables:

Fourteen PFEAS dependent variables were initially included in the Study 1 analysis. Two variables were dropped from the full analysis after Cronbach's Alpha analysis: "Exact Science" and "Family Influence" were removed based on low Cronbach's Alpha values. The remaining twelve dependent variables include:

1. Career Expectations
2. Jobs/Salary
3. Society Contribution
4. Perception of Work
5. Math Enjoyment
6. Basic Knowledge
7. Communication Skills
8. Study Habits
9. Group Work
10. Problem Solving Ability
11. Engineering Abilities
12. Engineering Preview

Independent (predictor) variables that are categorical:

1. Self-identified TT experience
2. Self-identified TT leader
3. Admissions committee–identified TT experience

4. Admissions committee-identified TT leadership

Control variables:

1. Gender (categorical variable, women are classified as 1, men are classified as 0)
2. Under-represented minority (URM) status as measured by a binary dummy (categorical) variable that defines under-represented minority status as 1 and majority status as 0.
3. Socio-economic status as measured by (a) combined parental education via a categorical questionnaire scale (interval variable) and (b) the number of bookshelves in the family home as measured by a categorical questionnaire scale (interval variable) that records the number of bookshelves in each subject's home as a proxy for socio-economic status.

Hypothesis 1C - Analysis

The analysis includes descriptive statistics, confirmatory factor analysis, bivariate correlations, and simple linear regression.

Study 2: Social capital and high school TT participation

Study 2 collected data from a sub-cohort of Study 1. All first-year undergraduate engineering students were invited to complete an online, web-based survey titled the "Engineering Resource Generator" (see Appendix 3 for a copy of the Engineering Resource Generator). This instrument was adapted from an existing instrument, the Resource Generator (Van Der Gaag and Snijders, 2004), which is designed to measure individual social capital. The instrument is designed expressly to measure social resources that individuals purposely access to attain information from their social networks about specific resources of interest.

The survey contained in total fifty questions designed to measure engineering-specific social capital. Of particular interest were individual social capital resources for students' engineering-specific social network resources at two points: high school and during the first year of engineering college. The instrument contained two primary sections. Section 1 asked participants to reflect on, and detail, engineering-specific social capital resources they accessed in high school. Section 2 asked participants to detail engineering-specific social capital resources they were accessing as first-year engineering students.

The survey instrument was coded in ColdFusion so that it could be completed online. Participants were invited via e-mail using a mass e-mail software package, WorldMerge, to complete the survey online. Of particular interest were under-represented minority students and female students. I provided incentives for both under-represented minority students and women in the form of entry into a raffle for two iPods for completing the survey. I also mobilized the assistance of former colleagues in the engineering college's diversity office to encourage students from these two groups to complete the survey. All non-respondents were reminded to complete the survey over the course of three months and, of the 781 students invited to complete the survey, 312 completed it, for a response rate of 39.9%. Data were migrated from a ColdFusion database into an Excel spreadsheet, checked by hand, and then migrated into an Access database for storage. The Access database was loaded into SPSS for analysis.

Hypothesis addressed by Study 2

Study 2 was designed specifically to test the following Hypothesis 2: Participation on an extracurricular technical team in high school provides participants with increased engineering-specific social capital resources relative to engineering classmates who did not participate on a technical team in high school.

Hypothesis 2 – Social Capital - variables

Ten dependent variables were derived from the Engineering Resource Generator survey:

1. High school technical/engineering social capital (interval): HS Tech/EN
2. High school engineering application and admissions social capital (interval): HS Admiss
3. College of Engineering social capital (interval): CoE SC
4. Number of engineering friends (interval): EN Friends
5. Number of engineering friends in homework network (interval): EN Homework Net
6. Number of engineering student services visited since enrolling (interval): EN StdSrvc
7. Participating in research? (Y/N, categorical): Rsrch
8. Socialization placement upon entering engineering (interval): AugOrgSoc
9. Socialization placement at the time of completing the Resource Generator (interval) ENOrgSoc
10. Sum of Socialization placement (AugOrgSoc + ENOrgSoc, interval): OrgSocSum

One additional dependent variable was derived from the 2006 Entry Survey. The variable measures the support of family and individuals within the immediate social domains of respondents. Question 135 asks, “For each of the following people, what is their opinion about your pursuit of an engineering major or career? *Mark whether their opinion is* *strongly supportive, moderately supportive, neutral, moderately opposed, or strongly opposed.*" The response set was as follows:

	Strongly supportive	Moderately Supportive	Neutral	Moderately opposed	Strongly Opposed
Mother					
Father					
Sibling					
Best friend(s)					
Boyfriend/girlfriend					
Most influential high school teacher					
High school guidance counselor					
FIRST Robotics or TT mentor (if not applicable, leave blank)					

The results were summed to produce a dummy variable (Q135) that provides a measure of high school social capital support for studying engineering relative to each respondent's immediate family and social network in high school. It is important to note that, as with the self-efficacy variable, the Q135 variable was also recorded at a particularly important moment for the respondents.

Independent (predictor) variables that are categorical:

1. Self-identified TT experience
2. Self-identified TT leader
3. Admissions committee-identified TT experience
4. Admissions committee–identified TT leadership

Control variables:

1. Gender (categorical variable, women are classified as 1, men are classified as 0)

2. Under-represented minority (URM) status as measured by a binary dummy (categorical) variable that defines under-represented minority status as 1 and majority status as 0.
3. Socio-economic status as measured by (a) combined parental education via a categorical questionnaire scale (interval variable) and (b) the number of bookshelves in the family home as measured by a categorical questionnaire scale (interval variable) that records the number of bookshelves in each subject's home as a proxy for socio-economic status.

Study 2 – Hypothesis 2 - analysis

The analysis includes descriptive statistics, bivariate correlations, and simple linear regression.

Limitations of the overall study

The overall study was subject to several limitations. I discuss each in turn in this section.

1. The study population is drawn from a highly selective engineering college located in the Northeastern United States. The study population has three immediate limiting implications for the results:
    a. Extrapolating the results of either Study 1 or Study 2 to the broader population of undergraduate students studying engineering at other colleges and universities may be problematic. The study population does not represent all undergraduate engineers or their experiences. Because the study population is from a highly selective population of students, the

results of the analysis are also limited in applicability to similar types of students and similarly selective undergraduate engineering programs.

b. Originally, the study was going to draw the sample population from four distinctly different engineering colleges: one institute, or technical college; one public engineering college; one engineering college that did not practice selective admissions; and the current private, highly selective, engineering college that is part of a broader university. Because of limited funding, this model was not feasible and the study population was drawn exclusively from the highly selective engineering college that is part of a broader university. For the purposes of statistical analysis, this limits variability to a minimal level.

c. Within the study population, there is limited diversity in terms of URM students. Sixty-six students, 8% of the total study population, classify as URM within the study's sample population. This has implications in terms of the generalizability of the results and for the power of the statistical analysis when the focus is on URM participants.

2. A final limitation has to do with the scale of the study. The size of the study is ambitious and what is gained in ground covered is lost in depth of coverage. This may be seen as a limitation insofar as several aspects of the study merit closer scrutiny. For instance, within the social capital study (Study 2), differences in social capital resources based on gender and URM/Majority status could have been analyzed more deeply. Because of the scale of the study, however, it was

possible to provide only an initial level of insight into the various social capital resources of the study subpopulations.

CHAPTER 4

STUDY 1 ANALYSIS: TECHNICAL TEAM PARTICIPATION AND LEADERSHIP RELATIVE TO SELF-EFFICACY, GRADE PERFORMANCE, AND CONFIDENCE IN ENGINEERING

Introduction

In this chapter I describe the analysis carried out for Study 1. The chapter includes a description of the Study 1 hypotheses, a description of the study sample, descriptive statistics, and the respective statistical tests used to inform each of the hypotheses. The chapter reports the analysis for each hypothesis in sequence. The report for each hypothesis includes study sample distributions, univariate analysis, correlations, and concludes with bivariate analysis and a statement of the key findings derived. Study 1 specifically addresses the original research question, “Does high school technical team participation influence success in engineering?”

Technical team (TT) experience was recorded by four variables: admissions committee–identified TT experience (CTTEE TT), admissions committee–identified TT leadership experience (CTTEE Leader), self-identified TT experience (Self TT), and self-identified TT leadership experience (Self TT Leader).

Engineering admissions committees are trained to identify high school TT experience and associated leadership within a TT. Prior to the admissions selection process in 2006, I met with the members of the engineering admissions committees, training them to identify TT experiences and to record these occurrences as they reviewed applications for admission to the college. A document (excerpted below) was included in the engineering admissions committees’ selection instruction manuals, which all committee members received. Committees were instructed to identify and note TT participation as they reviewed the applications of individual candidates:

> Eng/Tech team and/or Research Experience: If the applicant has tech-team experience (e.g., Science Olympiad, FIRST Robotics), please note the experience and circle the 'Y' in the "Eng/Tech Team Experience" box. If they have research experience, please also indicate this by circling the 'Y' and then jotting down their research area in the "Research" section. If they held leadership positions within their tech team, please also indicate this by circling the 'Y' and then jotting down their leadership title in the same box. (Source: Cornell University College of Engineering Admissions, 2006)

Admissions committees' identification of TT participation and TT leadership were then recorded in the general admissions database as admissions decisions were logged in. When the admissions selection process was complete, the TT–specific data were extracted into an Access database. The Access database was loaded into an Excel spreadsheet where it was subsequently loaded into an SPSS database for analysis. The resulting data contain two of the four TT variables: admissions committee–identified TT participation and admissions committee–identified TT leadership experience.

Data on self-reported TT participation were collected from the Entry Survey that was completed by first-year engineering students during the first day of new student orientation in August 2006. The data collected reflected responses to the following two questions: *Question 146: During high school did you participate in any of the following types of special programs in math, science, or engineering?* (A list of TT options were provided with a possible response set of "Yes" and "No"). For each of the possible response options, the question *"Team Leader?"* was posed with a response set of "Yes" and "No." The TT–specific data that were recorded via the survey instrument were entered manually into an Access database. The Access database was loaded into an Excel spreadsheet where it was subsequently loaded into an SPSS database for analysis. The resulting data represent the final two variables of the four TT variables: self-identified TT participation and self-reported TT leadership experience.

The four TT variables are included as independent variables in each of the three hypotheses presented in this chapter (Hypotheses 1A, 1B, and 1C).

In the analysis undertaken to test Hypotheses 1A and 1B, the term “success” relative to grade point average (GPA) is defined by year 1 cumulative GPA (GPA 1) *and* the cumulative GPA after the fourth of year of engineering study (GPA 4). The specific definition of GPA success originates in the engineering college’s operational definition of GPA categorization, as described in chapter 3. According to the college’s metric, GPA distributions range from 0 (the letter grade equivalent of an “F”) to 4.3 (the letter grade equivalent of an A+). GPAs equal to or higher than 2.0 are considered in good academic standing, while GPAs below 2.0 are considered in poor academic standing. For the purposes of this study, “success” relative to GPA will be defined as having a 2.0 or above GPA *(see Figure 20 below for the detailed grading scale).*

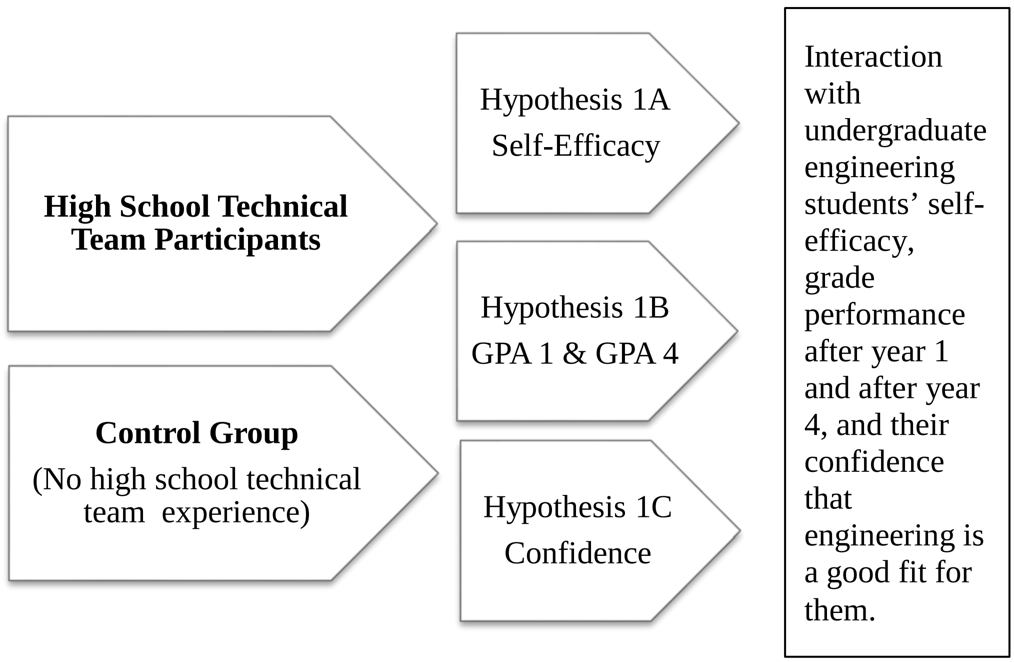
The hypotheses analyzed in Study 1 that will inform the central research question include:

<u>Hypothesis 1A:</u> First year engineering students who have participated on a high school technical team will have *stronger self-efficacy* skills than their engineering classmates who did not participate on a technical team in high school.

<u>Hypothesis 1B:</u> First-year engineering students who have participated on a high school technical team will achieve *higher cumulative GPAs* than their engineering classmates who did not participate on a technical team in high school.

Hypothesis 1C: First-year engineering students who have participated on a high school technical team will be *more confident* in their abilities to succeed in an undergraduate engineering program than their engineering classmates who did not participate on a technical team in high school.

The three hypotheses can be conceptualized in the following diagram:



Overall Sample Description: Distributions of Gender, URM, and Socio-economic Status Relative to TT Participation and Leadership

The sample for Study 1 included all first-year students who completed the Entry Survey in August 2006. A basic description of the study sample, based on the Entry Survey, is described in Table 4. Relative to TT participation, the initial cohort of participants included the following demographic composition by TT variables. The study sample includes an N = 717. Of the 717 participants, 70.2% (503 subjects) were male and 29.8% (214 subjects) were female.

Table 4. Sample Gender Distribution.

	Count	Percent
Male	503	70.2%
Female	214	29.8%

In terms of ethnicity/race, 92.1% (660 subjects) of the participants were Majority (Caucasian, Asian, Other) students, while 7.9% (57 subjects) were URM students (African American, Mexican American, Native American). See Table 5.

Table 5. Sample URM/Majority Distribution.

	Count	Percent
Majority	660	92.1%
URM	57	7.9%

Among the URM students 19% (11 subjects) were female, while 81% (46 subjects) were male (Table 6).

Table 6. Sample Gender by URM Composition.

	Male N	Male %	Female N	Female %	Total
Majority	457	90.8%	203	94.8%	660
URM	46	9.1%	11	5.1%	57
Total	503		214		717

The study sample is further distributed across the four TT variables by gender and URM status. Of the 121 subjects who self-identified as high school TT participants on the August 2006 Entry Survey, 8 (6.6%) were URM students, while 113 (93.3%) were majority students. See Table 7.

Table 7. Self-Identified Technical Team Participation by URM Composition.

	Non-TT	Non-TT %	TT	TT %	Total
Majority	547	91.7%	113	93.3%	660
URM	49	8.2%	8	6.6%	57
Total	596		121		717

Of this group, 19 (15.7%) of the 121 self-identified TT participants indicated that they were leaders on their TTs. Of the 19 leaders, 17 (89.4%) were majority students, while 2 (10.5%) of the leaders were URM students. See Table 8.

Table 8. Self-Identified Technical Team Leaders by URM Composition.

	TT Leader	TT Leader %
Majority	17	89.4%
URM	2	10.5%
Total	19	100%

Of the 215 subjects who were identified by engineering admissions committees as having participated on high school TTs, 12 (5.6%) were URM students, while 203 (94.4%) were majority students (Table 9).

Table 9. Admissions Committee–Identified Technical Team Participation by URM Composition.

	Non-TT	Non-TT %	TT	TT %	Total
Majority	457	91.0%	203	9.4%	660
URM	45	9.0%	12	5.6%	57
Total	502		215		717

Of this group, 83 (38.6%) of the 215 admissions committee–identified TT participants indicated that they were leaders on their TTs. Of the 83 admissions committee–identified leaders, 79 (95.2%) were majority students, while 4 (4.8%) were URM students, See Table 10.

Table 10. Admissions Committee–Identified Technical Team Leaders by URM Composition.

	TT Leader	TT Leader %
Majority	79	95.2%
URM	4	4.8%
Total	83	100%

Of the 121 subjects who self-identified as high school TT participants on the August 2006 Entry Survey, 32 (26.4%) were female, while 89 (73.6%) were males (Table 11).

Table 11. Self-Identified Technical Team Participation by Gender Composition.

	Non-TT	Non-TT %	TT	TT %	Total
Male	414	69.5%	89	73.6%	503
Female	182	30.5%	32	26.4%	214
Total	596		121		717

Of this group, and as stated above, 19 (15.7%) of the 121 self-identified TT participants indicated that they were leaders on their TTs. Of the 19 leaders, 15 (78.9%) were male while 4 (21.1%) were female (Table 12).

Table 12. Self-Identified Technical Team Leaders by Gender Composition.

	TT Leader	TT Leader %
Male	15	78.9%
Female	4	21.1%
Total	19	100%

Of the 215 subjects who were identified by engineering admissions committees as having participated on a high school TT, 60 (27.9%) were female, while 155 (72.1%) were male (Table 13).

Table 13. Admissions Committee Identified Technical Team Participation by Gender Composition.

	Non-TT	Non-TT %	TT	TT %	Total
Male	348	69.3%	155	72.1%	503
Female	154	30.7%	60	27.9%	214
Total	502	100%	215	100%	717

Of this group, as stated above, 83 (38.6%) of the 215 admissions committee–identified TT participants indicated that they were leaders on their technical teams. Of the 83 admissions committee–identified leaders, 58 (69.9%) were male while 25 (30.1%) were female, See Table 14.

Table 14. Admissions Committee–Identified Technical Team Leaders by Gender.

	TT Leader	
Male	58	69.9%
Female	25	30.1%
Total	83	100%

Analysis and Results by Hypotheses

Hypothesis 1A Analysis and Results: TT Participation and Self-Efficacy.

Hypothesis 1A postulates that high school students who participated on a TT during high school will have greater self-efficacy skills than their engineering classmates who did not. Based on the premise that TT participation promotes confidence in individual students that engineering is an appropriate academic pursuit for them, the measure of self-efficacy provides important insight into students' beliefs in their individual capacity to succeed in rigorous engineering programs. Self-efficacy represents each individual student's relative level of a "can-do" attitude.

Bandura (1997) conceptualized self-efficacy as the belief that individuals are able to achieve specific desired outcomes through their own efforts. Of particular relevance to this study, Bandura's theory of self-efficacy states that "(t)he strength of people's convictions in their own effectiveness is likely to affect whether they will even try to cope with given situations. At this initial level, perceived self-efficacy influences choice of behavioral settings" (Bandura, 1977, p. 193). Most importantly, for the purposes of this study, personal self-efficacy is linked directly to individuals' beliefs in their own capacity—or agency—to act in ways that will control outcomes.

> Perceived efficacy plays a key role in human functioning because it affects behavior not only directly, but by its impact on other determinants such as goals and aspirations, outcome expectations, affective proclivities, and perception of impediments and opportunities in the social environment. Efficacy beliefs influence whether people think erratically or strategically, optimistically or pessimistically; what courses of action they choose to pursue; the goals they set for themselves and their commitment to them; how much effort they put forth in given endeavors; the outcomes they expect their efforts to produce; how long they persevere in the face of obstacles; their resilience to adversity; how much stress and depression they experience in coping with taxing environmental demands; and the accomplishments they realize. (Bandura, 2000, p. 75)

An individual's level of self-efficacy plays an important role in determining his or her perceptions of optimism or pessimism and, indeed, whether individuals believe that their actions can improve their circumstances. "Efficacy beliefs play a key role in shaping the courses lives take by influencing the types of activities and environments people choose to get into" (Bandura, 2001, P. 10). More specifically, self-efficacy contributes to determining the energy an individual is willing to expend to overcome obstacles and how resilient he or she will be when encountering adversity (Pajares, 1996). Low self-efficacy amplifies the belief that obstacles are insurmountable while high self-efficacy amplifies the belief that difficult tasks can be completed successfully (Pajares, 1996).

Measuring self-efficacy is important in this study's setting for several reasons. The data were collected on the first day of engineering orientation, following the completion of high school but immediately prior to the beginning of the first semester of engineering. The students involved in the study were perfectly balanced in a transition "bubble" between the conclusion of high school and the beginning of undergraduate engineering when the decision to pursue engineering is becoming a reality but the amorphous perception of being an engineering student is still an abstraction capable of producing indecision and doubt. In a sense, these students had reached a point in time when their beliefs in their own abilities to control what would happen next were at their most precarious and vulnerable. The critical question, then, becomes one of understanding individual students' sense of self-efficacy when they were mere hours away from beginning their time as undergraduate engineering students. Perhaps most importantly, the moment when the data were collected was the perfect time to gain a sense of potential interactions between high school TT experience and students' perceptions of their own self-efficacy. Did participation on a TT enhance students' self-efficacy beliefs relative to engineering? For some, did participation on a TT serve as bulwark against doubt as to whether they had chosen the appropriate field of study?

Measuring self-efficacy

To measure student self-efficacy, I used the General Self-Efficacy Scale (GSE) developed by Schwarzer and Jerusalem (1995). The scale measures *perceived* self-efficacy of individuals to respond to novel or difficult situations. The scale focuses explicitly on personal agency: the notion that an individual can, in fact, control potential positive outcomes. Data were collected via a ten-item questionnaire. Each of the ten items was measured on a four-point Likert scale whereby subjects were asked to respond to a series of ten statements. Response options range from 1, "Not at all true," to 4, "Exactly true." The ten items were aggregated to produce a macro self-efficacy score. The highest possible score is 40, indicating maximum self-efficacy (responding with "4" to all ten questions). The minimum possible score is 10, indicating low self-efficacy (responding with "1" to all ten questions).

The scales have been used in multiple studies and on a variety of populations (adults, children, various nationalities). For the purposes of this study the analogous population consists of high school students. The scale norms for high school students were drawn from a sample of 3,494 high school students (12–17 years of age) with the sample mean equal to 29.60 and a standard deviation of 4.0. Internal consistency was indicated by Cronbach's alphas ranging from .82 to .93 derived from a sample of 991 subjects (Schwartzer, 2014).

For my study, the perceived self-efficacy scales' Cronbach's alphas were .91 with a standard deviation of 5.18. A total of 717 subjects completed the GSE portion of the questionnaire. According to Tavakol and Dennick (2011), Cronbach's alphas >.90 are recommended and items measured by the scale should be internally consistent. Internal consistency obtains when each of the items included in a scale measure a single construct (in this case, perceived self-efficacy).

Variables involved in the analysis of Hypothesis 1A

The variables involved in the analysis of Hypothesis 1A include several independent (predictor) categorical variables: self-identified TT experience, self-identified TT leader, admissions committee–identified TT experience, and admissions committee–identified TT leadership (four variables). There is one dependent variable (an interval variable), each student's score on the GSE. Control variables include gender (a categorical variable; females are classified as 1, males are classified as 0) and URM status as measured by a binary dummy (categorical) variable that defines URM status as 1 and majority status as 0.

The analysis includes two additional variables: socio-economic status as measured by combined parental education via a categorical questionnaire scale (an interval variable) and the number of bookshelves in the family home as measured by a categorical questionnaire scale (an interval variable) that records the number of bookshelves in each subject's home as a proxy for socio-economic status.

The analysis includes descriptive statistics, bivariate correlations, and linear and multiple regressions. The null hypothesis is that no relationship exists between high school TT participation and student self-efficacy as measured by the GSE.

Descriptive Statistics for Hypothesis 1A: General Self-Efficacy Scale

Descriptive statistics provide a framework for understanding the distribution of the results pertaining to the dependent variable (GSE scores). Of particular importance are the skewness and kurtosis of the scores recorded by the composite self-efficacy dependent variable. Parametric statistical analysis requires that the results be normally distributed. In a perfectly normal distribution, the skewness and kurtosis would equal zero. Achieving a score of zero in social science, however, is unlikely and most distributions have some measure of skew and kurtosis. Positive skew indicates scores distributed to the left of the distribution, while negative skew indicates scores distributed to the right of the distribution. Kurtosis is an indication of the pointedness or flatness of the overall distribution of values. Positive kurtosis indicates a pointed distribution, while negative kurtosis indicates a flat distribution. The distributional properties of the GSE dependent variable are presented in Table 15.

Table 15. Distributional Properties of the Dependent Variable: General Self-Efficacy Scale (GSE).

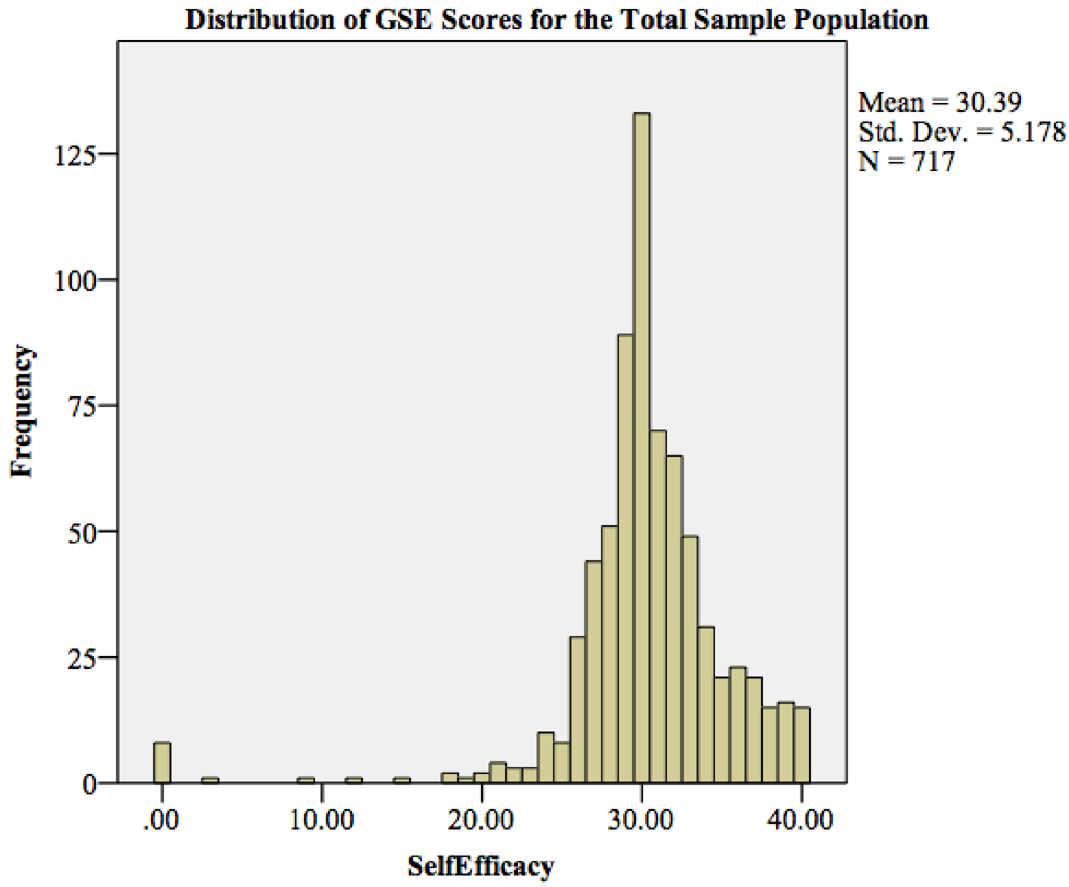
Variable	**N**	**Cases Excluded**	**Mean**	**Standard Deviation**	**Skewness**	**Kurtosis**
GSE	717	-	30.39	5.178	-2.446	13.235

I also calculated the 5% trimmed mean for the GSE variable. The purpose of calculating the 5% trimmed mean is to compare this mean, which removes the top 5% and the bottom 5% of the cases in the response set, with the overall mean of the sample. If the 5% trimmed mean is substantially different from the overall sample mean, this indicates that outliers, or extreme responses, are likely affecting the overall sample mean. The 5% trimmed mean was equal to 30.70, which is not substantially different from the overall sample mean of 30.39. As a result, I have concluded that extreme cases did not substantially affect the overall sample mean.

The Kolmogorov-Smirnov statistic adds an additional check for normality. Non-significant results at the .05 level indicate that the scores are normally distributed. For the GSE variable, the calculated Kolmogorov-Smirnov statistic was .000, which suggests that the scores are *not* normally distributed.

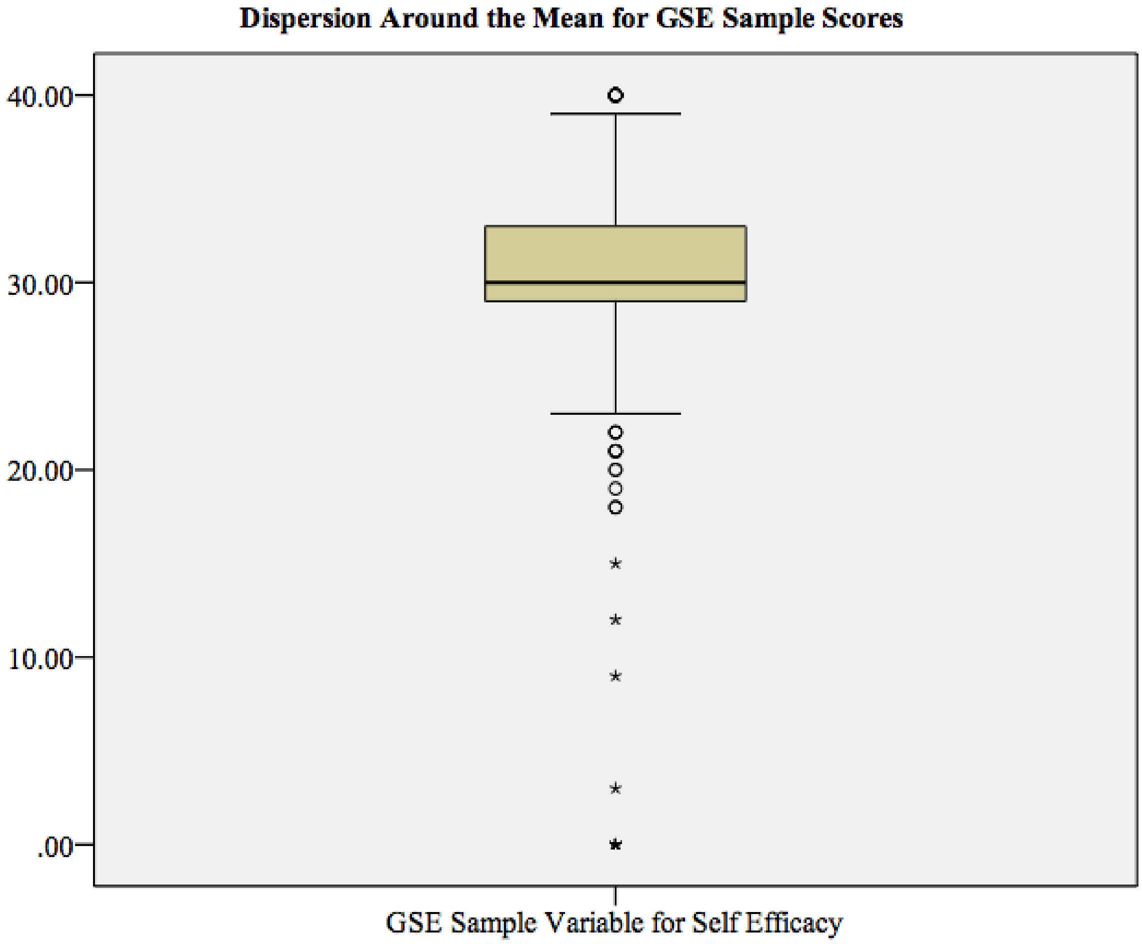
Finally, Figure 8 presents a histogram of the GSE score distribution that confirms that, in fact, the distribution is skewed to the right (skewness = -2.446). The histogram provides a visual sense, however, that the data are approximately normally distributed.

Figure 8. Distribution of GSE Scores for the Total Sample Population.



The dispersion around the mean includes *Md*=30 (*IQR* 29, 33). Figure 9 displays this dispersion.

Figure 9. Dispersion around the Mean for GSE Sample Scores.



Both female and URM students are important populations of interest in the study and are included in the analysis as independent variables. Figures 10 and 11 display the GSE sample scores for females and URM students included in the study sample.

Figure 10. GSE Scores by Gender.

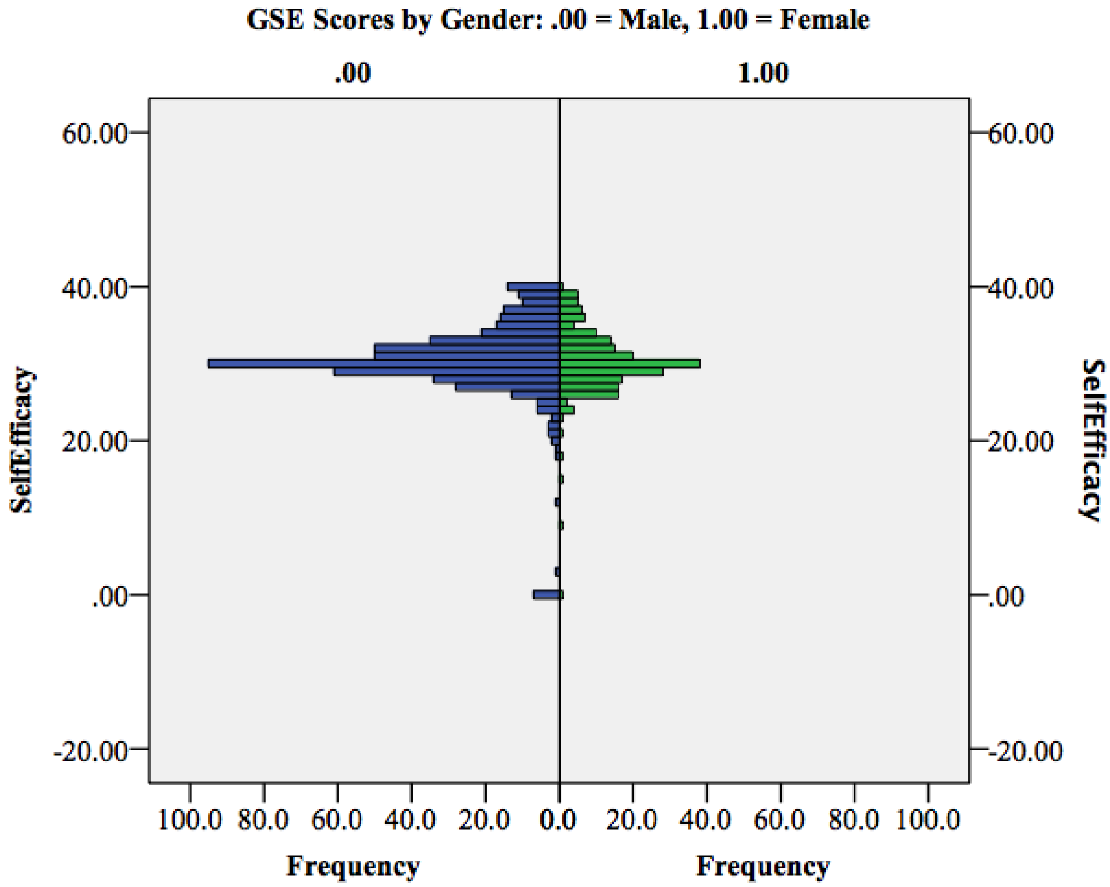
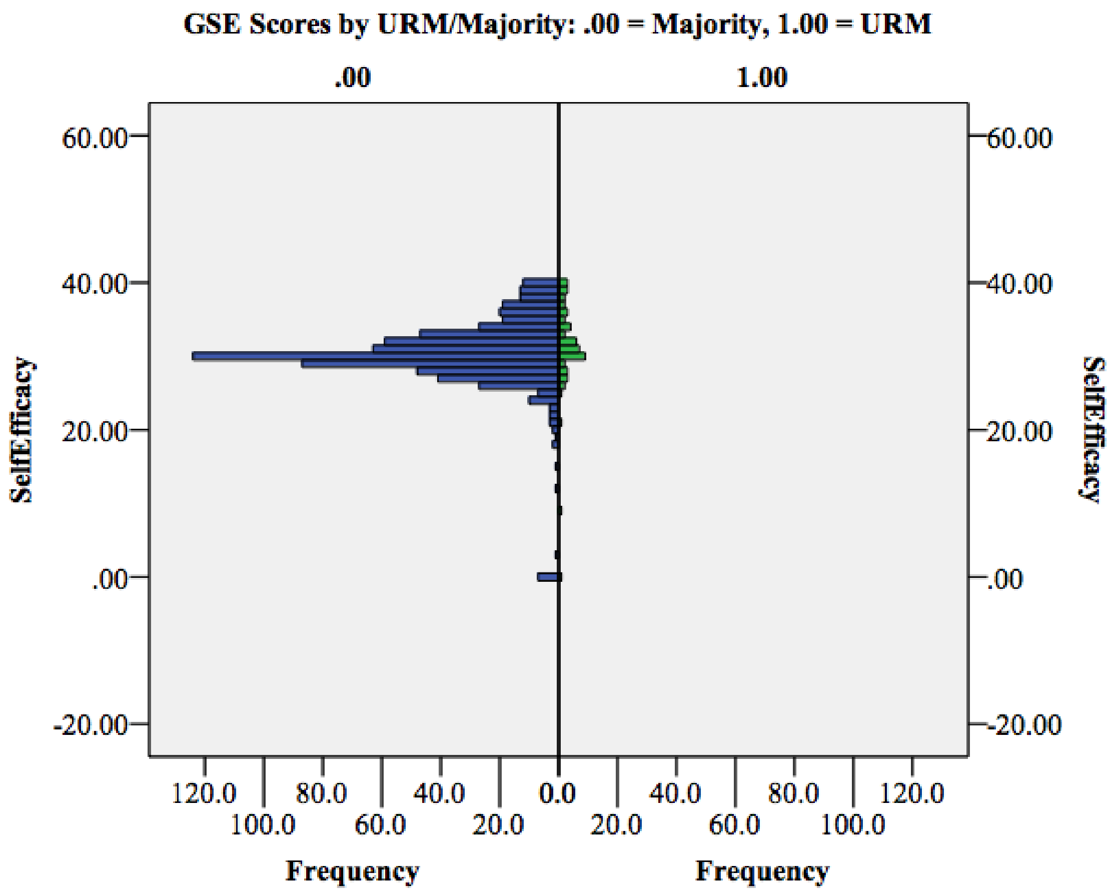


Figure 11. GSE Scores by URM/Majority.



The final two independent variables included in the study are measures of socio-economic status (SES). I created a dummy variable for parental education levels. The data for this variable were collected using the August 2006 Entry Survey. Question 121 asked, “What is the highest level of education obtained by your parents? Mark only one in each column.” The response set included two columns, one for “father” and one for “mother.” Each column included ten response options ranging from “Some high school or less” to “Ph.D./Doctorate” and “Other (please specify)_____”. Question 117 asked, “What is your best estimate of the number of bookshelves your family has in your home? (Check one box).” The response set included five options: None, 1 to 3, 4 to 6, 7 to 9, and

10 or more. Distributions for both SES variables are displayed below. Figure 12 displays the distribution for the parental education dummy variable, while Figure 13 displays the distribution for the bookshelves responses.

Figure 12. Number of Bookshelves in the Home.

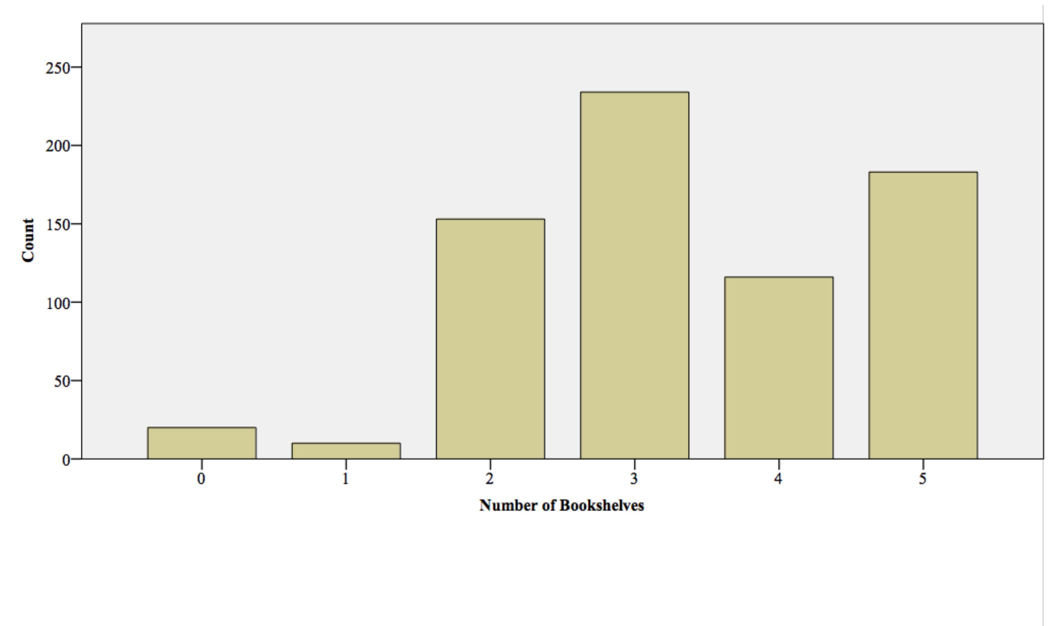
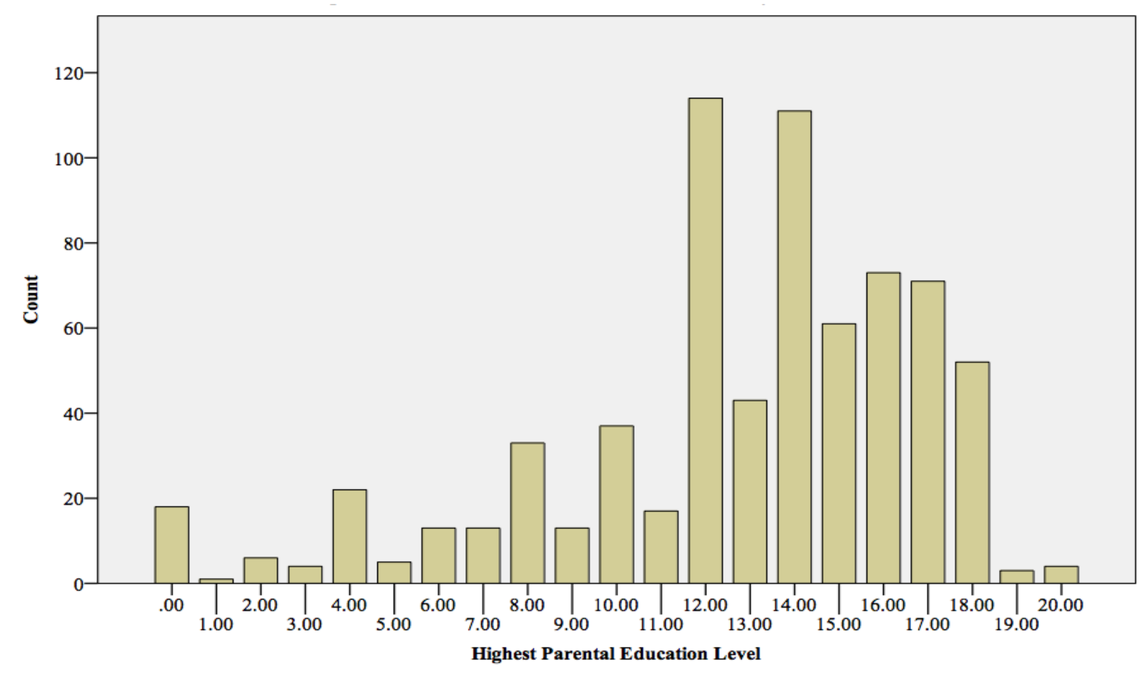


Figure 13. Distribution of Parental Education Dummy Variable.



Having described the data included in the analysis of Hypothesis 1A, I now proceed to the analysis used to determine whether there is a relationship between self-efficacy and high school TT participation.

Correlation Analysis of General Self-Efficacy Scale Scores and TT Variables

Correlation analysis is used to determine whether a linear relationship exists between two variables. The tests can determine if a relationship exists between the variables and also if the relationship is positive or negative. For Hypothesis 1A, I used Pearson's *r* as a parametric measure of association. Pearson's *r* assumes values ranging from -1 to +1, with positive relationships between the two variables denoted by the "+" sign and negative relationships between the variables denoted by the "–" sign. A "+1" Pearson's *r* score would indicate that a perfectly positive relationship exists between the two variables. In other words, as one variable increases, so does the other, in perfect unison. Similarly, a “-1” Pearson’s *r* score indicates a perfectly inverse relationship between the two variables. The size of the absolute value of Pearson’s *r* indicates the strength of the relationship between the two variables. A score of 0 indicates no relationship, while a score of either +1 or -1 indicates a perfect relationship between the variables.

The variables under study in Hypothesis 1A are: GSE score as the dependent variable, self-reported high school TT experience, self-reported high school TT leadership experience, admissions committee–identified TT experience, and admissions committee–identified TT leadership experience. The goal of the study is to determine whether there is a relationship between self-efficacy and TT participation in high school. Table 16 presents the Pearson’s *r* correlations.

Table 16. Pearson’s *r* for GSE.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
GSE Pearson’s *r*	0.033	- 0.066	0.006	-0.011
Sig. (2-tailed)	0.377	0.077	0.871	0.765
R^2 Coefficient of determination	0.11%	0.44%	0.004%	0.01%
N	717	717	717	717

Cohen (1988) suggests interpreting the strength of a relationship as measured by Pearson’s *r* as follows: a small relationship has a Pearson’s r = .10 to .29, a medium relationship has a Pearson’s r = .30 to .49, and a large relationship has a Pearson’s r = .50 to 1.0. Based on this analysis and the small GSE Pearson’s *r* values, the relationships between self-efficacy and all four of the technical team variables fall below the threshold for the “small” category. Additionally, each of the R^2 coefficients of determination suggest that the proportions of the variance in the GSE variable that can be predicted by the four technical team variables are all less than 1%.

Summary of the Correlation Analysis of General Self-Efficacy Scale Scores and Technical Team Variables

Pearson product–moment correlation coefficients were calculated to examine the relationship between individual self-efficacy (as measured by the GSE) and self-reported high school TT experience (as measured by the August 2006 Entry Survey). Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity. There was no correlation between the two variables (r = .033, N = 717). The same analysis was performed to examine the relationship between GSE scores and self-reported high school TT leadership (as measured by the August 2006 Entry Survey). There was no correlation between the two variables (r = -.066, N = 717). The same analysis was performed to examine the relationship between GSE scores and admissions committee–identified TT experience (as identified by engineering admissions committees during the admission review process). There was no correlation between the variables (r = .006, N = 717). Finally, the same analysis was performed to examine the relationship between GSE scores and admissions committee–identified TT leadership experience (as identified by engineering admissions committees during the admission review process). There was no correlation between the variables (r = -.011, N = 717).

Correlation Analysis of General Self-Efficacy Scale Scores and TT Variables Based On Gender and URM Status

I now analyze the correlation between the GSE variable and the four TT variables with gender and the URM variable, disaggregated from the sample population. The gender and URM variables are both of primary interest to the study because both populations of students are under-represented in undergraduate engineering. The goal of this portion of the study is to understand the potential effect high school TT experience may have on students' self-efficacy based on gender and URM status.

Summary of the Correlation Analysis of General Self-Efficacy Scale Scores and TT Variables by Gender

Table 17 presents the Pearson's *r* correlations when the sample is disaggregated by gender.

Table 17. Bivariate correlations: GSE and Technical Team by Gender.

Gender		Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Male	GSE Pearson's r	0.032	-0.072	-0.010	-0.030
	Sig. (2-tailed)	0.468	0.107	0.817	0.507
	R^2 Coefficient of determination	0.10%	0.52%	0.01%	0.09%
	N	503	503	503	503
Female	GSE Pearson's r	0.031	-0.050	0.050	0.041
	Sig. (2-tailed)	0.653	0.467	0.463	0.554
	R^2 Coefficient of determination	0.09%	0.25%	0.25%	0.17%
	N	214	214	214	214

Pearson product–moment correlation coefficients were used to examine the relationship between individual self-efficacy (as measured by the GSE) and self-reported high school TT experience (as measured by the August 2006 Entry Survey) by gender. Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity. There was no correlation between the GSE variable and the self-reported TT participation variable for males or females (males: r = .032, N = 503, females: r = .031, N = 214).

Pearson product–moment correlation coefficients were calculated to examine the relationship between GSE scores and self-reported high school TT leadership (as measured by the August 2006 Entry Survey) for males and females (males: r = -.072, N = 503, females: r = -.050, N = 214). There was no correlation between the GSE variable and high school technical leadership for either males or females.

Pearson product–moment correlation coefficients were calculated to examine the relationship between GSE scores and admissions committee–identified TT experience (as identified by engineering admissions committees during the admission review process) for males and females (males: r = -.010, N = 503, and females: r = .050, N = 214). There was no correlation between the GSE variable and admissions committee–identified high school technical experience for either males or females.

Finally, Pearson product-moment correlation coefficients were calculated to examine the relationship between the GSE and admissions committee–identified TT leadership (as identified by engineering admissions committees during the admission review process) for males and females (males: r = -.030, N = 503, and females: r = .041, *N* = 214). There was no correlation between the GSE variable and admissions committee–identified high school technical-team experience for either males or females.

Summary of the Correlation Analysis of General Self-Efficacy Scale Scores and Technical Team Variables by URM Status

Table 18 presents the Pearson's *r* correlations when the sample is disaggregated by URM status.

Table 18. Bivariate correlations: GSE and Technical Team by URM-Status.

URM Status		Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Majority	GSE Pearson's r	0.069	-0.020	0.027	0.026
	Sig. (2-tailed)	0.076	0.609	0.487	0.497
	R^2 Coefficient of determination	0.48%	0.04%	0.07%	0.07%
	N	660	660	660	660
URM	GSE Pearson's r	-0.300*	-0.423**	-0.175	-0.412**
	Sig. (2-tailed)	0.023	0.001	0.192	0.001
	R^2 Coefficient of determination	9.0%	17.9%	3.1%	17.0%
	N	57	57	57	57

* . Correlation is significant at the 0.05 level (2 tailed).
**. Correlation is significant at the 0.01 level (2-tailed)

Pearson product–moment correlation coefficients were calculated to examine the relationship between individual self-efficacy (as measured by the General Self-Efficacy Scale, GSE) and self-reported high school TT experience (as measured by the August 2006 Entry Survey) by URM status. Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity. There was no correlation between the GSE variable and the self-reported TT participation variable for majority subjects (*r* = .069, *N* = 660). There was a medium, negative correlation between the GSE variable and the self-reported TT leadership variable for URM subjects (r = -.300, N = 57, $p < .05$), with lower levels of self-efficacy associated with high school TT experience.

Pearson product–moment correlation coefficients were calculated to examine the relationship between GSE scores and self-reported high school TT leadership (as measured by the August 2006 Entry Survey) for majority and URM subjects. There was no correlation between the GSE variable and the self-reported TT leadership variable for majority subjects (r = -.020, N = 660). There was a medium, negative correlation between the GSE variable and the self-reported TT leadership variable for URM subjects (r = -.423, N = 57, $p < .01$), with lower levels of self-efficacy associated with high school TT leadership.

Pearson product–moment correlation coefficients were calculated to examine the relationship between GSE scores and admissions committee–identified TT experience (as identified by engineering admissions committees during the admission review process) for majority and URM subjects. There was no correlation between the GSE variable and admissions committee–identified high school TT experience for either majority subjects (r = .027, N = 660), or URM subjects (r = -.175, N = 57).

Finally, Pearson product–moment correlation coefficients were calculated to examine the relationship between GSE scores and admissions committee–identified TT leadership (as identified by engineering admissions committees during the admission review process) for majority and URM subjects. There was no correlation between the GSE variable and admissions committee–identified high school TT experience for majority subjects (r = .026, N = 660). For URM subjects, there was a medium, negative correlation between the GSE variable and the admissions committee–identified TT leadership variable (r = -.412, N = 57, p < .01), with lower levels of self-efficacy associated with admissions committee–identified high school TT leadership.

A further purpose of the study was to determine whether high school TT experiences contributed to perceived self-efficacy when controlling for the effects of gender, URM status, and socio-economic status. Multiple regression was used to accomplish this goal.

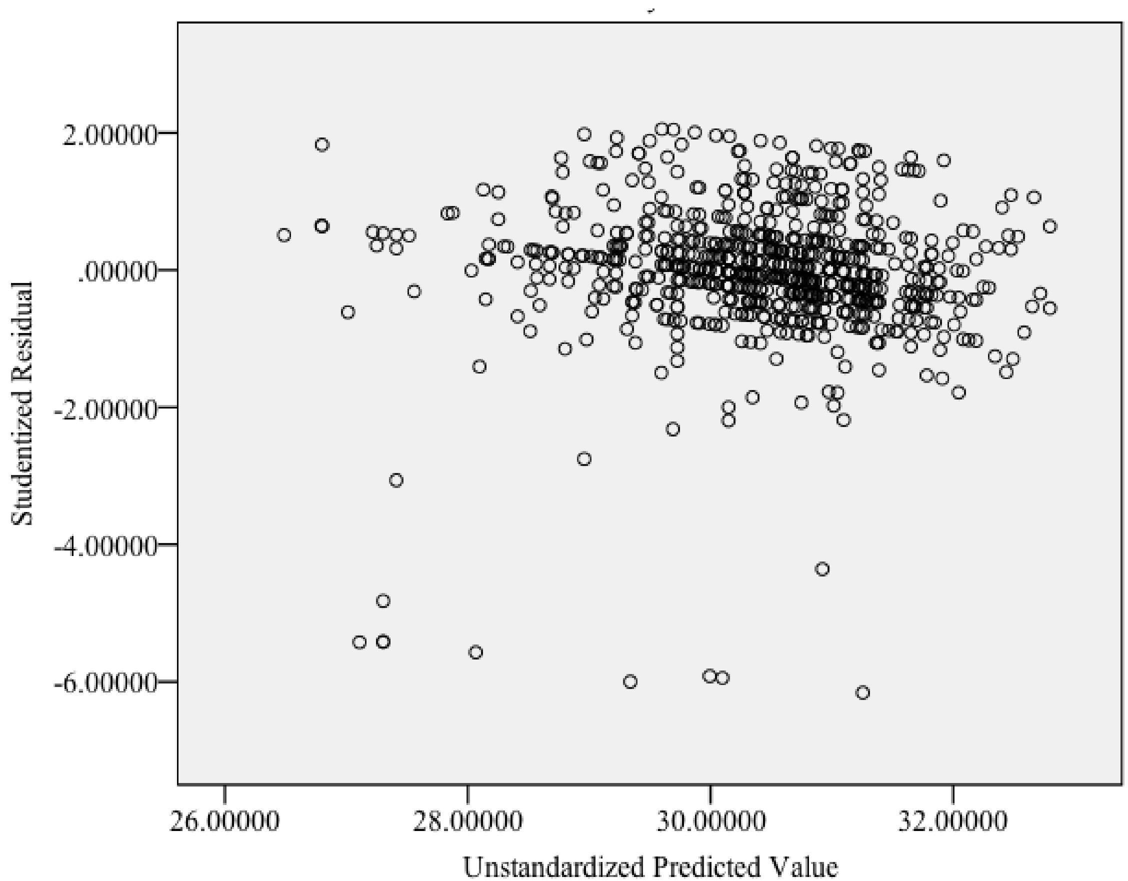
Regression Analysis of General Self Efficacy Scale Scores and Technical Team Variables

Regression is an analytical technique used to determine the relationship between a dependent variable and a number of independent or predictor variables. Regression analysis offers two types of insight into the dependent variable: it predicts new values of the dependent variable based on the independent variables and it determines how much of the variation of the dependent variable may be explained by reference to the dependent variables. In its basic form, the regression equation is $Y = bX_1 + bX_2 + a$, where Y is the dependent variable and X_1 is the value of the first independent variable, X_2 is the value of the second independent variable, and b is the regression weight for that particular variable (Salkind, 2005, p.255). "The calculation for each value of b is made with the degree of correlation between Y and the other variables held constant. As with the bivariate procedure, the value r^2 indicates the percentage variation in Y associated with the variation in the independent variables" (Kent, 2001, p.129). For the purposes of this portion of the study, multiple regression was used as an analytical technique to investigate how much of the variation in self-efficacy (the dependent variable) may be explained by reference to high school TT experience (represented by the independent variables) while holding gender, URM status, and socio-economic status constant.

Multiple regression can be an effective analytical technique if five assumptions about the data are satisfied:

1. Independence of observations suggests that adjacent observations must not be correlated. The Durbin–Watson test determines lack of independence, with test statistics ranging from 0 to 4. A score of 2 is ideal and indicates a lack of auto-correlation between the adjacent observations. The Durbin–Watson statistic for the regression model used in the self-efficacy portion of the study was 1.9. This suggests that the assumption of independence of observations has been met.
2. A linear relationship exists between the dependent variable and the independent variables that are not categorical variables. I checked the linearity of the relationship between the dependent and independent variables by producing a scatterplot of the residuals (Figure 14):

Figure 14. Scatterplot for Studentized Residuals and the Predicted Values: Testing for Linearity and Homoscedasticity.



While the scatterplot does not indicate that a perfect linear relationship between the residuals exists, a linear relationship can be visually discerned. This suggests that the assumption of linearity has been met.

The same scatterplot shown in Figure 14 may also be used to test for homoscedasticity (Princeton University Library, 2007). The assumption of homoscedasticity suggests that the residuals are equal for all values of the dependent variable; practically speaking, this means that the data points dispersed around the mean are evenly distributed. In the scatterplot, the points above *and* below the .00 mark are approximately evenly distributed, suggesting that the assumption of homoscedasticity has been met.

I also created scatterplots to examine the relationship between the dependent variable (self-efficacy) and the two non-categorical dependent variables (unified parental education and number of bookshelves in the home). Both scatterplots (Figures 15 and 16) indicate that approximately linear relationships exist between the dependent variable and the two independent variables.

Figure 15. Partial Regression Plot: Self-Efficacy and Unified Parental Education.

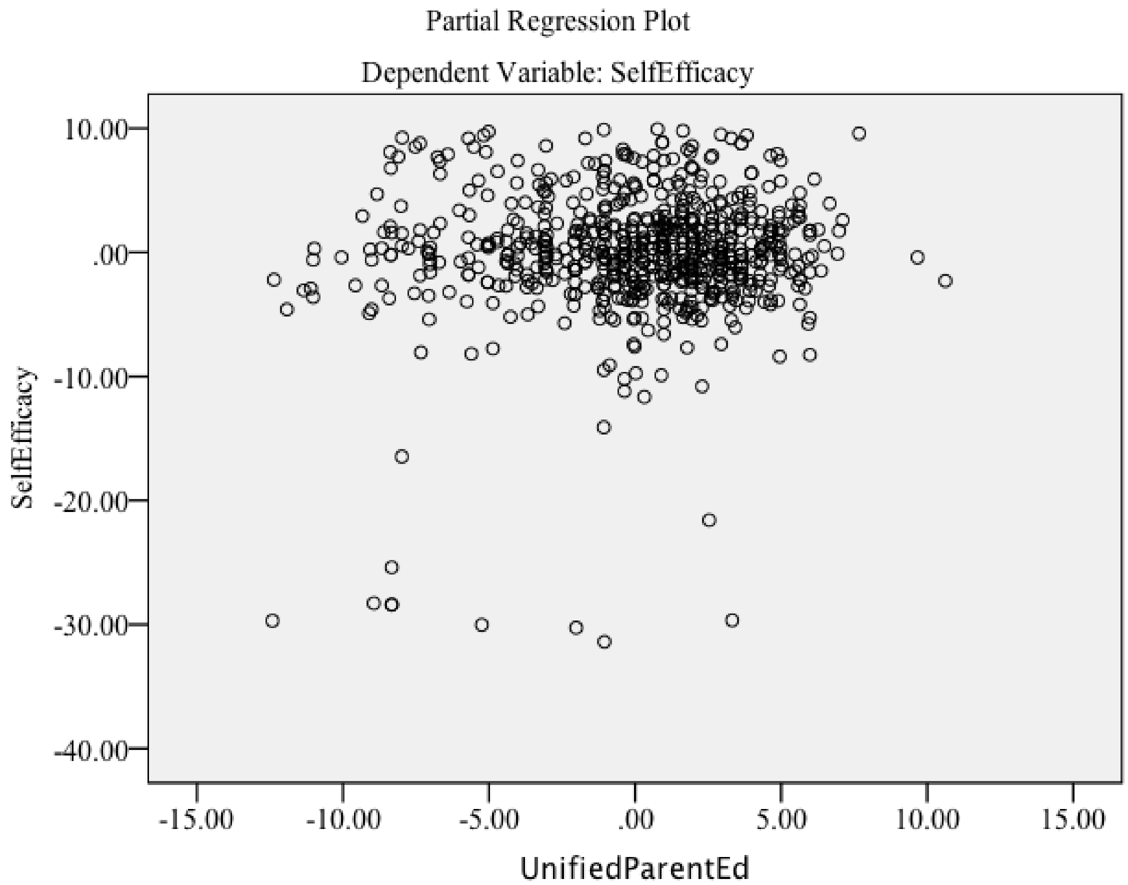
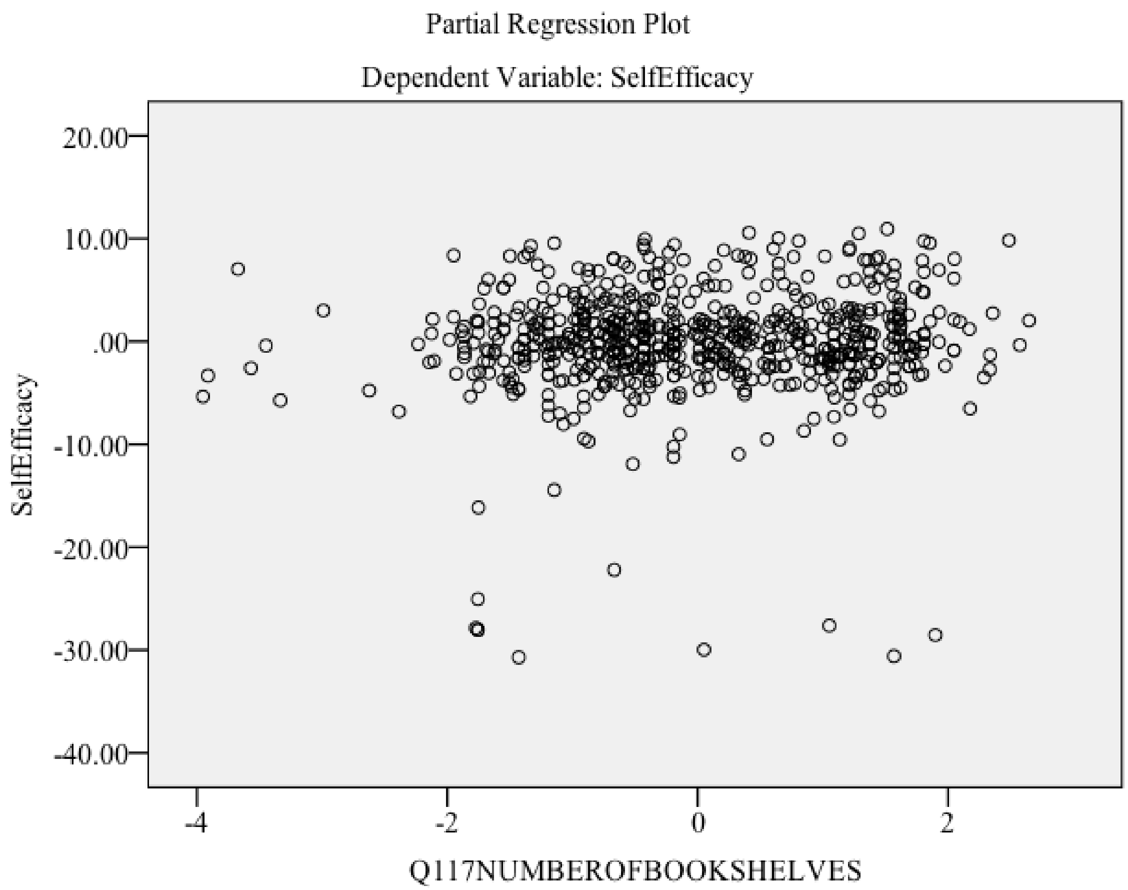


Figure 16. Partial Regression Plot – Self Efficacy and Number of Bookshelves in the Home.



The categorical variables for TT participation, gender, and URM/Majority status were not graphed.

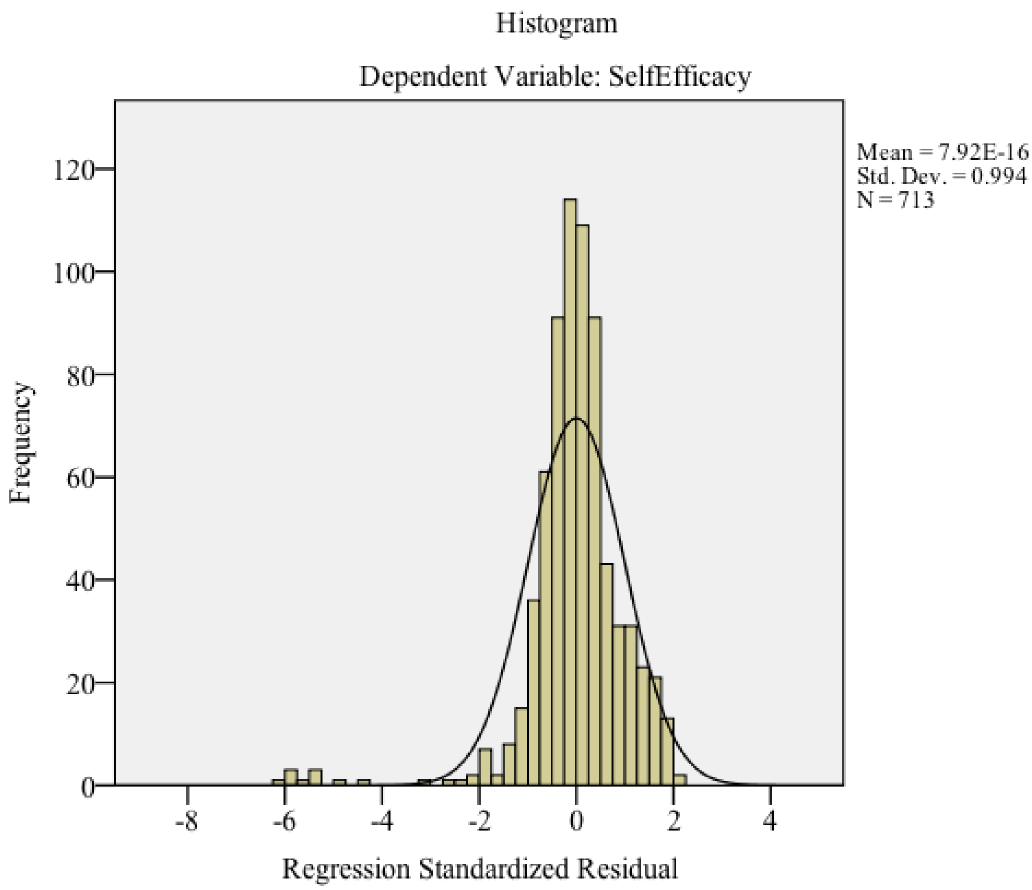
3. The data must not show multicollinearity, a situation in which at least two of the independent variables are correlated with one another. If the independent variables are correlated with each other, it becomes difficult to discern the relationship between the independent variables and the dependent variable. In the current regression model, none of the Pearson's *r* correlation coefficients is

greater than .70. This indicates that the independent variables are not highly correlated, satisfying the assumption that multicollinearity does not confound the regression analysis.

An additional check for multicollinearity involves checking the variation inflation factor (VIF) output for each independent variable in the model. VIFs exceeding a score of 10 indicate multicollinearity (O'Brien, 2007). VIF scores for the model ranged from a low of 1.015 (gender) to a high of 1.223 (parental education). None of the VIF scores exceeded the threshold score of 10, supporting the premise that there is no multicollinearity between the independent variables.

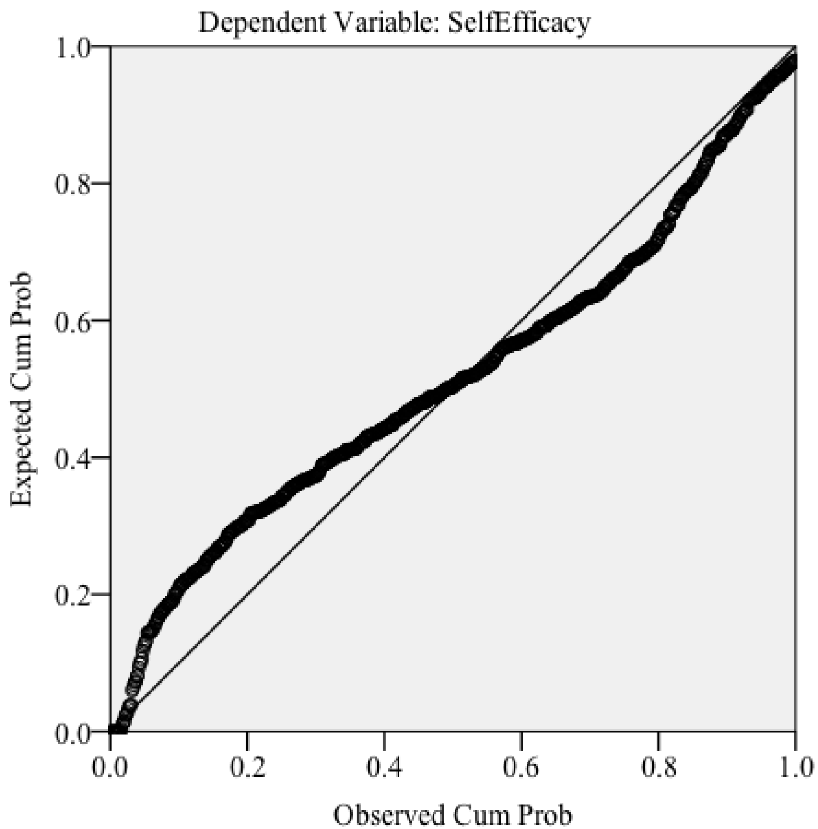
4. The residuals must be normally distributed and, as indicated by the histogram shown in Figure 17, the residuals display an approximately normal distribution.

Figure 17. Histogram of Regression Standardized Residuals for the Variable Self-Efficacy.



The normality of the residuals was also confirmed by checking the P-P Plot (Figure 18) with normality indicated by the residual points approximating the diagonal line. In this instance, the normality is not perfect (if it were, each point would be precisely on the line), but is still approximately normal.

Figure 18. Normal P-P Plot of Regression Standardized Residuals for the Variable Self-Efficacy.



The assumptions needed to make multiple regression effective have been satisfied and the discussion now turns to the regression model I used to examine the interaction between self-efficacy and the independent variables—TT participation, gender, URM-status, and socio-economic status.

The Multiple Regression Model and Associated Outputs

A primary objective of this portion of the Study 1 is to determine whether relationships exist between the dependent variable, perceived self-efficacy, and the four independent TT variables, while holding gender, URM status, and socio-economic status constant. To analyze the relationships between these variables, I conducted standard multiple regression to predict perceived self-efficacy based on high school TT participation. The variables described in Table 19 were included in the regression analysis.

Table 19. Variables included in the GSE multiple regression model.

Dependent Variable	Independent Variables	Control Variables
General Self-Efficacy Scale (GSE)	Self-Identified High School Technical Team Experience	URM
	Self-Identified High School Technical Team Leadership	Gender
	Admissions Committee– Identified High School Technical Team Experience	Unified Parental Education
	Admissions Committee– Identified High School Technical Team Leadership	Number of Family-Owned Bookshelves

Three measures indicate how well the model fits the data: the multiple correlation coefficient (*R*) and the two measures indicating the total variation explained, which are the R^2 and adjusted R^2 results. For the self-efficacy regression model, $R = .204$, indicating a weak level of association between the dependent variable, self-efficacy, and the independent variables.

The R^2 value provides a measure of the proportion of the variance in the dependent variable that is explained by the independent variables. This is an important distinction from the *R* value, which merely measures the linear association between the dependent variable and the independent variables. The R^2 value assesses the fit of the model based on the inclusion of the independent variables in the regression equation. In particular, R^2 measures the variability of the predictive value of the model based on the inclusion of the additional information supplied by the independent variables; it is the proportion of the variance between the variables that is the critical factor. The R^2 equation measures the proportion of the variance *above* what the Pearson correlation coefficient (*R*) mean value measures between self-efficacy, the four TT variables, and the control variables (gender, URM status, and socio-economic status).

It should be noted, however, that R^2 is a measure of the study sample population, not the general population. Because of this, while offering excellent information about the fit of the model for the specific sample population, the R^2 value is a biased estimate of the proportion of the variance accounted for by the model. Adjusted R^2 accounts for the bias of R^2, offering a more conservative value that may be more accurately extrapolated to the total population. The "adjusted" portion refers to the adjustment in the equation indicating degrees of freedom. Unlike R^2, adjusted R^2 may decrease when additional independent variables that offer little explanatory power regarding the variability in the dependent variable are added to the model. An adjusted R^2 guide that may be used to determine how well the model fits the data is as follows:

<0.1: poor fit
0.11–0.3: modest fit
0.31–0.5: moderate fit
>0.5: strong fit

The adjusted R^2 also provides a measure of effect size, which is a standardized way to measure the size of an effect between variables and may be compared as a standardized measure across variables even if the variables under study change. The Pearson correlation coefficient is a useful measure of effect size with scores ranging from 0 (no effect) to 1 (perfect effect).

For the model predicting self-efficacy with the independent variables of self-reported high school TT experience, self-reported high school TT leadership, admissions committee–identified TT experience, admissions committee–identified TT leadership, gender, URM status, unified parental education, and number of bookshelves in the home, Table 20 represents the model summary.

Table 20. Model Summary for Self-Efficacy.

	R	R^2	Adjusted R^2
	0.204	0.042	0.031
Predictors	self-reported high school technical team experience, self-reported high school technical team leadership, admissions committee–identified technical team experience, admissions committee–identified technical team leadership, gender, URM status, unified parental education, and number of bookshelves in the home		
Dependent Variable	Self-Efficacy		

The R^2 value for the self-efficacy regression model is equal to .042. This suggests that adding the independent variables to the regression model explained 4% of the total variability of the self-efficacy measure. The adjusted R^2 value is .031, suggesting that the model explained 3% of the total variability of the self-efficacy measure, based on a more conservative estimate. Based on Muijs’s (2011, p. 145) abovementioned guide, adjusted R^2 values <.10 imply that the model is a poor fit for the data and that the effect size is minimal.

Statistical Significance of the Model

An ANOVA indicates that self-identified high school TT participation, self-identified high school TT leadership, admissions committee–identified TT participation, admissions committee–identified TT leadership, gender, URM status, unified parental education level, and number of bookshelves in the home predict self-efficacy to a statistically significant extent ($F[8,704] = 3.825$, $p < .0005$. Table 21 presents the unstandardized coefficients.

Table 21. Unstandardized Coefficients for Self-Efficacy.

	Unstandardized *B*	Sig.
Constant	27.304	0.000
SELFTTBinary	0.825	0.141
SELFTTLeaderBinary	-3.012	0.020*
CTTEEEXPnew2	0.108	0.810
CTTLDnew2	-0.194	0.762
SexNum	-0.504	0.230
URM_Binary	1.145	0.109
UnifiedParentEd	0.132	0.008*
Q117NUMBEROFBOOKSHELVES	0.422	0.012*

Note. * sig. at the $p < .05$ level.

Summary Report on the Regression Analysis of Self-Efficacy

I ran a multiple regression analysis to predict self-efficacy based on self-reported high school TT participation, self-reported high school TT leadership, admissions committee–identified high school TT participation, admissions committee–identified high school TT leadership, gender, URM status, unified parental education levels, and the number of bookshelves in the home. The relationship between the dependent and independent variables was approximately linear and the assumption of homoscedasticity was met based on a visual assessment of the scatterplots of the studentized residuals and predicted values and the partial regression plots. A Durbin–Watson statistic of 1.9 suggests that the residual observations were independent. The model did not suggest that multicollinearity exists between the variables given that no Pearson's *r* correlation coefficients were higher than .70. The assumption of normality was also met as indicated by a visual inspection of the P-P Plot. Although all assumptions were met, the multiple regression model did not predict self-efficacy to a statistically significant extent (F[8, 704] = 3.825, adj. R^2 = .031). Three of the eight independent variables (SELFTTLeaderBinary, UnifiedParentEd, and Q117NUMBEROFBOOKSHELVES) added statistically significantly to the prediction ($p < .05$). This suggests that, while the regression model is not a good overall fit, some statistically significant interaction occurred between the four independent variables and the dependent variable, self-efficacy. Table 22 presents the regression coefficients and standard errors of the model.

Table 22. Summary of the Multiple Regression Analysis of Self-Efficacy.

Variable	B	SE_B	β
Intercept	27.304	0.708	
SELFTTBinary	0.825	0.560	0.060
SLEFTTLeaderBinary	-3.012	1.295	-0.094*
CTTEXPnew2	0.108	0.452	0.010
CTTLDnew2	-0.194	0.640	-0.012
SexNum	-0.504	0.419	-0.045
URM_Binary	1.145	0.713	0.060
UnifiedParentEd	0.132	0.050	0.108*
Q117NUMBEROFBOOKSHELVES	0.422	0.167	0.102*

Note. * p < .05; B = unstandardized regression coefficient; SE_B = Standard error of the coefficient; β = standardized coefficient

An important corollary note about self-efficacy and ethnicity

Prior research indicates that Asian Americans exhibit self-efficacy behavioral patterns that differ from those of Caucasian students (Yuan, Weiser, & Fischer, 2016) and, based on mediating family influences, may be lower in certain academic circumstances (Shen, Liao, Abraham, & Weng, 2014). This dynamic bears closer scrutiny given that the present study aggregates URM identification as African American, Mexican American, and Native American, and majority identification as Caucasian, Asian, and Other. The rationale for doing so rests on a standard admissions practice that, at times, distinguishes broadly between these two categories. Disaggregating ethnicity and performing bivariate correlation analysis and linear regression relative to self-efficacy will offer insights into the interactions between discrete ethnicities relative to self-efficacy. To explore this idea, I used descriptive statistics, bivariate correlation, and an independent samples t-test.

Summary of the Correlation Analysis of General Self-Efficacy Scale and Ethnicity

Table 23 provides descriptive statistics for the sample population by ethnicity and the GSE variable.

Table 23: Descriptive statistics for GSE by ethnicity.

	N	Mean	Min	Max	Std. Dev	Skewness	Kurtosis
Caucasian	367	31.06	18	40	3.57	0.099	1.18
Asian American	242	30.15	15	40	3.95	0.193	1.12
African American	21	31.57	9	40	6.42	-2.154	7.27
Mexican American	28	31.00	21	40	4.47	0.256	0.129
Native American	4	32.00	31	34	1.41	1.41	1.50
Other	50	31.14	23	40	3.63	0.369	.144

I turn now to bivariate correlation analysis using Pearson's *r*. Table 24 presents the Pearson's *r* correlations when the sample is disaggregated by ethnicity.

Table 24. Bivariate correlations: General Self-Efficacy (GSE) and ethnicity.

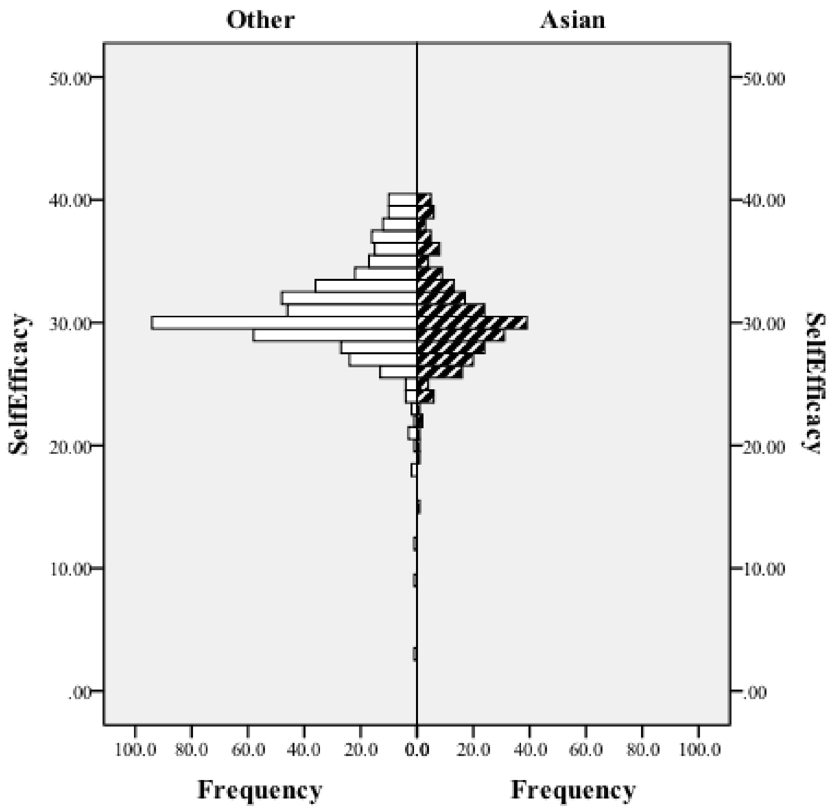
		GSE
Caucasian	Pearson's r	0.083*
	Sig. (2-tailed)	0.028
	R^2 Coefficient of determination	0.69%
	N	709
Asian American	Pearson's r	-0.102**
	Sig. (2-tailed)	0.007
	R^2 Coefficient of determination	1.04%
	N	709
African American	Pearson's r	0.036
	Sig. (2-tailed)	0.338
	R^2 Coefficient of determination	0.13%
	N	709
Mexican American	Pearson's r	0.013
	Sig. (2-tailed)	0.727
	R^2 Coefficient of determination	0.02%
	N	709
Native American	Pearson's r	0.023
	Sig. (2-tailed)	0.532
	R^2 Coefficient of determination	0.05%
	N	709
Other	Pearson's r	0.028
	Sig. (2-tailed)	0.464
	R^2 Coefficient of determination	0.08%
	N	709

* . Correlation is significant at the 0.05 level (2 tailed).
**. Correlation is significant at the 0.01 level (2-tailed)

Pearson product–moment correlation coefficients were calculated to examine the relationship between individual self-efficacy (as measured by GSE) and ethnicity. There was no correlation between the GSE variable and ethnicity for African Americans (r = 0.036, N = 709), Mexican Americans (r = 0.013, N = 709), Native Americans (r = 0.023, N = 709), or Other (r = 0.028, N = 709). There was a small, positive correlation between the GSE variable and Caucasian (r = 0.083, N = 709, $p < .05$). There was also a small, negative correlation between the GSE variable and Asian American (r = -0.102, N = 709, $p < .01$). The analysis provides evidence that there is a statistically significant positive correlation between being Caucasian and self-efficacy. Furthermore, there is a statistically significant negative relationship between being Asian American and self-efficacy. Interestingly, this may affect statistical analysis when ethnicity variables are aggregated. For instance, the majority variable includes Caucasian and Asian American ethnicities. Each ethnicity's respective correlations with self-efficacy may negate the others' in a broader analysis.

A further purpose of the study was to determine whether mean self-efficacy scores for Asian American subjects are statistically different from the scores for all other ethnicities combined. The analytical procedure used to accomplish this is the independent-samples t-test. Figure 19 provides a visual display of the distributions of Asian American self-efficacy scores relative to all other ethnicities combined.

Figure 19. Distribution of Self-Efficacy Values for "Asian" Relative to all Other Ethnicities (Other).



Independent-samples t-tests: Asian American compared with all other ethnicities by self-efficacy

I conducted an independent-samples t-test to determine whether a difference exists between Asian American and all other ethnicities combined in GSE self-efficacy scores. There were 241 Asian American subjects and 468 subjects who were Caucasian, African American, Mexican American, Native American, or Other. The GSE mean score was higher for the combined ethnicity group (M = 31.03, SD = 4.10) than for Asian Americans (M = 30.15, SD = 3.95). The Asian American self-efficacy score was -0.876

(95% CI, -1.51 to -0.25). The difference between the mean self-efficacy scores of the two groups is statistically significant, $t(707) = -2.73$, $p = .007$.

Based on the bivariate correlation and independent-samples t-test, it is clear that Asian American self-efficacy scores are different—and lower—than those of other ethnicities to a statistically significant extent.

Hypothesis 1B Analysis and Results: Technical Team Participation and Year 1 Cumulative GPA and Year 4 GPA

Hypothesis 1B postulates that first-year engineering students who have participated on a high school TT will achieve *higher cumulative GPAs* than their engineering classmates who did not participate on TTs. To test this hypothesis, I used two GPA measures. The first is cumulative GPA after completion of the first year of undergraduate engineering. The second is cumulative GPA after completion of four years of undergraduate engineering. The study sample includes all first-year students who entered undergraduate engineering in the fall of 2016 and who completed the entry survey in August of 2016. The GPA scale is defined by the engineering college under study and adheres to the following grade structure:

Figure 20. Grading Scale.

Letter	Grade Point Value	Description
A+	4.3	Excellent to very good; comprehensive knowledge and understanding of subject matter; marked perception and/or originality.
A	4	
A-	3.7	
B+	3.3	Good: moderately broad knowledge and understanding of subject matter; noticeable perception and/or originality.
B	3	
B-	2.7	
C+	2.3	Satisfactory: reasonable knowledge and understanding of

C	2	subject matter; some perception and/or originality.
C-	1.7	
D+	1.3	Marginal: minimum knowledge and understanding of subject matter; limited perception and/or originality.
D	1	
D-	0.7	
F	0	Failing: unacceptably low knowledge and understanding of subject matter; severely limited perception and/or originality.
S	-	"Satisfactory" equivalent to C– or above
U	-	"Unsatisfactory" equivalent to below C–

Year 1 cumulative GPAs and Year 4 cumulative GPAs for the study sample were provided by the college's registrar in an Excel file. Based on each student's unique identification number, GPAs were connected to each student's 2006 entry survey responses and merged into an overall study SPSS dataset for analysis.

Several studies support the premise that pre-college experiences influence grade success as measured by GPA (Besterfield-Sacre, Atman, & Shuman, 1997, Veenstra, Day, & Herrin, 2008, French, Immekus, & Oakes, 2005, Levin & Wyckoff, 1988, Lotkowski, Robbins, & Noeth, 2004). This study presents a unique perspective on such research by focusing on the effects of pre-college experiences on GPA success in engineering by examining the effects of interactions between high school TT experiences and other variables on undergraduate engineering GPAs.

Variables involved in the analysis of Hypothesis 1B

The variables involved in the analysis of Hypothesis 1B include the following categorical independent (predictor) variables: self-identified TT experience, self-identified technical leader, admissions committee–identified TT experience, and admissions committee–identified TT leadership (four total variables). There are two dependent variables (both are interval variables): cumulative GPA after the completion of the first year of engineering (GPA 1) and cumulative GPA after the completion of the fourth year of engineering (GPA 4). GPA 1 includes the cumulative GPAs of the first two semesters of engineering. GPA 4 includes the cumulative GPAs of eight semesters of engineering. Control variables include gender (a categorical variable with females classified as 1 and males classified as 0) and URM status as measured by a binary dummy (categorical) variable that defines URM status as 1 and majority status as 0.

The analysis includes two additional variables: socio-economic status as measured by combined parental education via a categorical questionnaire scale (an interval variable) and the number of bookshelves in the family home as measured by a categorical questionnaire scale (an interval variable) that records the number of bookshelves in each subject's home as a proxy for socio-economic status.

The analysis includes descriptive statistics, bivariate correlations, and linear and multiple regressions. The null hypothesis is that no relationship exists between high school TT participation and either GPA 1 or GPA 4.

Descriptive Statistics for Hypothesis 1B: GPA

Basic descriptive statistics for GPA 1 and GPA 4 are provided in Table 25.

Table 25. Distributional Properties of the Dependent Variables: GPA 1 and GPA 4.

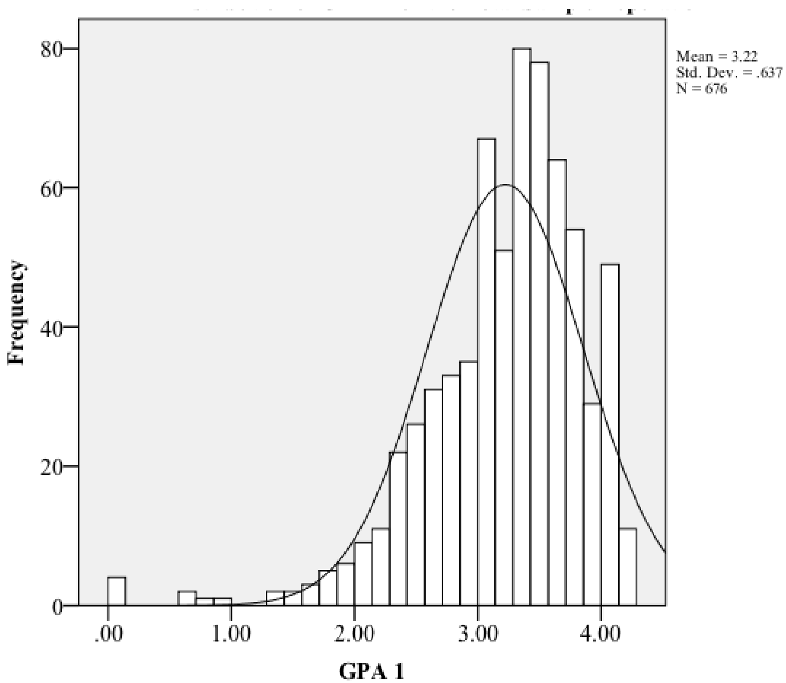
Variable	N	Cases Excluded	Mean	Standard Deviation	Skewness	Kurtosis
GPA 1	676	41	3.22	0.637	-1.424	4.018
GPA 4		27	3.22	0.557	-0.762	0.849

I also calculated the 5% trimmed mean for the GPA 1 and GPA 4 variables. The 5% trimmed mean for GPA 1 was 3.27, which is not substantially different from the overall sample mean of 3.22 for GPA 1. The 5% trimmed mean for GPA 4 was 3.24, which is also not substantially different from the overall sample mean of 3.22 for GPA 4. As a result, I have concluded that extreme cases did not substantially affect the overall sample means for GPA 1 and GPA 4.

The Kolmogorov–Smirnov statistic adds an additional check for normality. Non-significant results at the .05 level indicate that the scores are normally distributed. For both the GPA 1 and GPA 4 variables, the calculated Kolmogorov–Smirnov statistic was .000, which is less than the .05 significance threshold and suggests that the scores for GPA 1 and GPA 4 are *not* normally distributed.

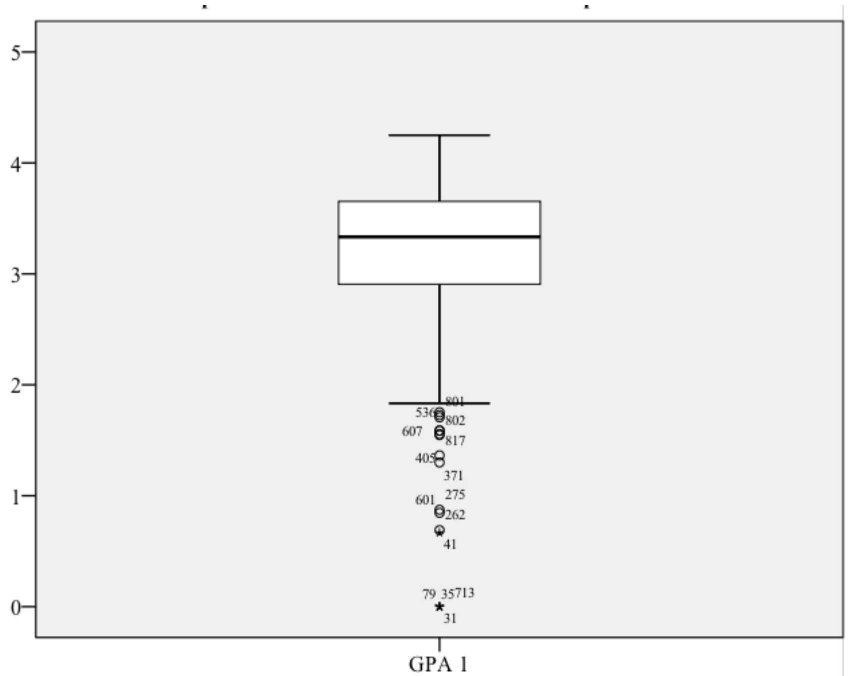
Histograms of both the GPA 1 and GPA 4 dependent variables indicate that the distributions are approximately normally distributed. The variable GPA 1 is skewed slightly to the left with a skewness value of -1.424. Figure 21 displays the distribution of GPA 1.

Figure 21. Distributions of GPA 1 for the Total Sample Population.



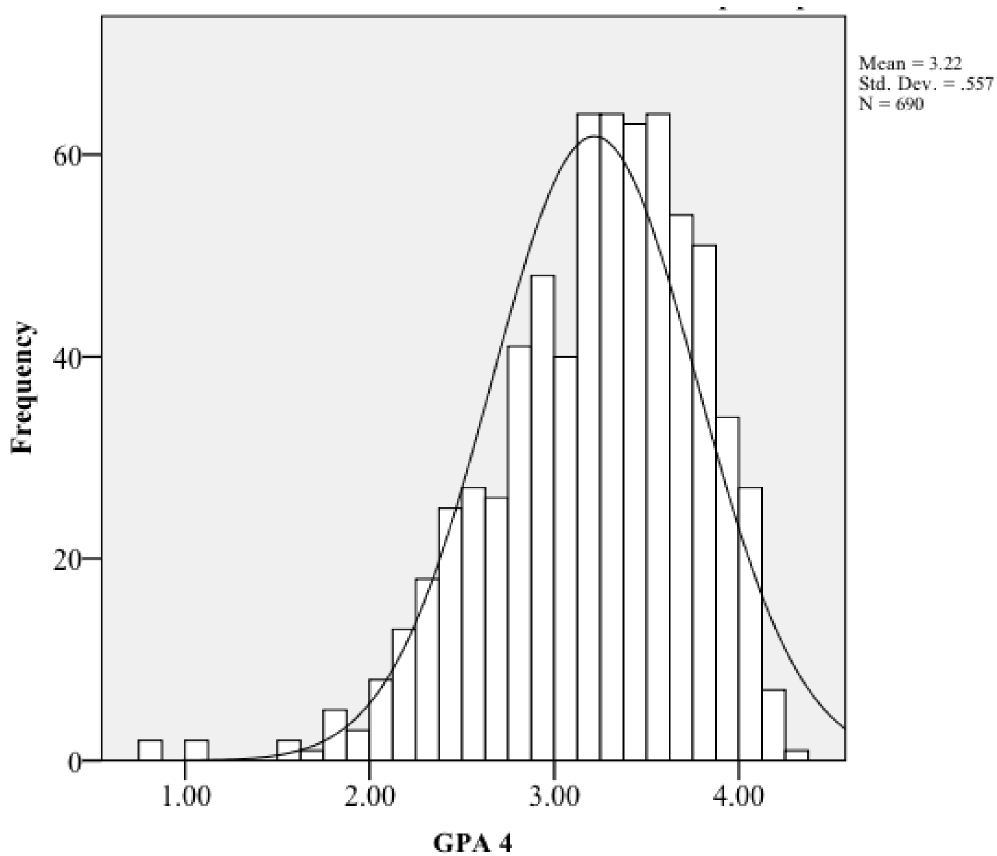
The dispersion around the mean for GPA 1 includes *Md* = 3.33 (*IQR* 2.90, 3.65). Figure 22 displays this dispersion.

Figure 22. Dispersion Around the Mean for GPA 1 Sample Scores.



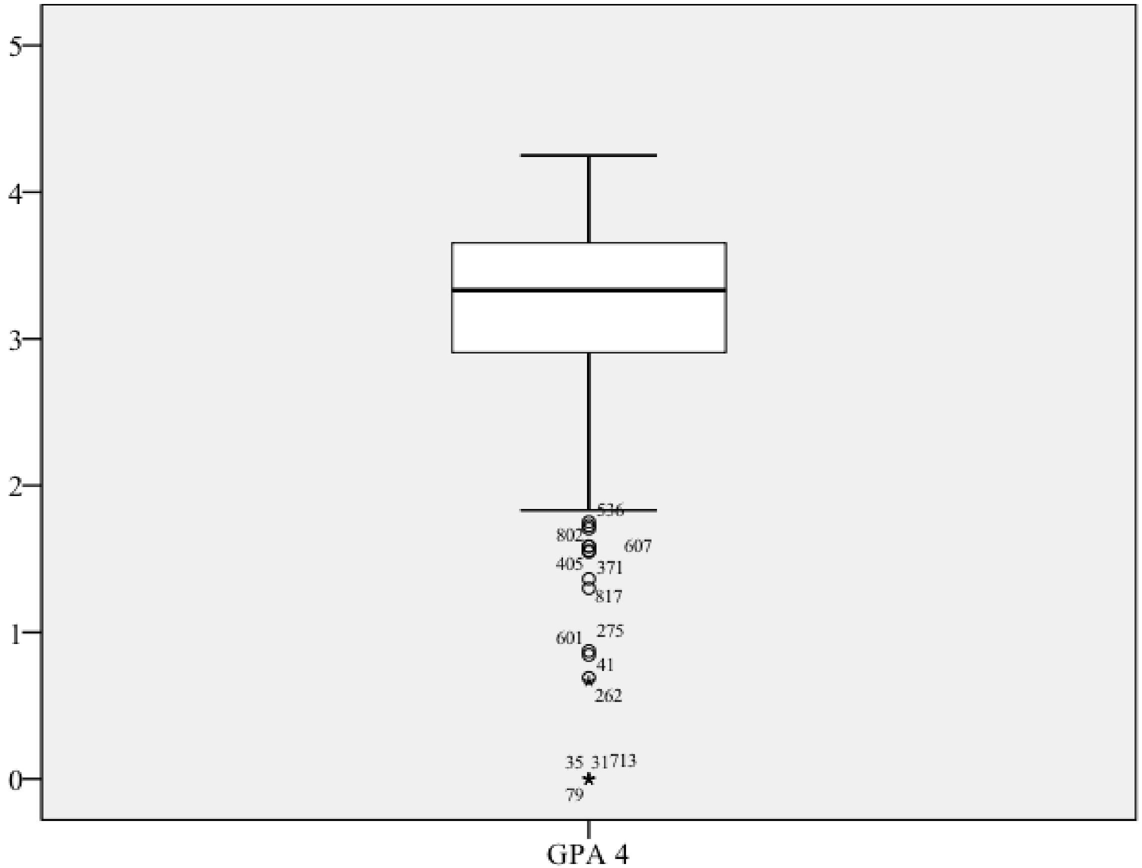
The variable GPA 4 is also skewed moderately to the left (slightly less than GPA 1), with a skewness value of -.762. Figure 23 displays the distribution of GPA 4.

Figure 23. Distribution of GPA 4 for the Total Sample Population.



The dispersion around the mean for GPA 4 includes *Md* = 3.29 (*IQR* 2.87, 3.63). Figure 24 shows the dispersion of GPA 4.

Figure 24. Dispersion Around the Mean for GPA 4 Sample Scores.



As described previously, females and URM students are of primary interest in the study. Figures 25 and 26 below display the GPA 1 sample values for females relative to males and URMs relative to majority students included in the study sample. Both graphs visually confirm approximately normally distributed data across both populations; the GPA 1 and GPA 4 distributions (see Figures 27 and 28) do not vary substantially based on gender or URM/majority status.

Figure 25. GPA 1 Values by Gender: .00 = Male, 1.00 – Female.

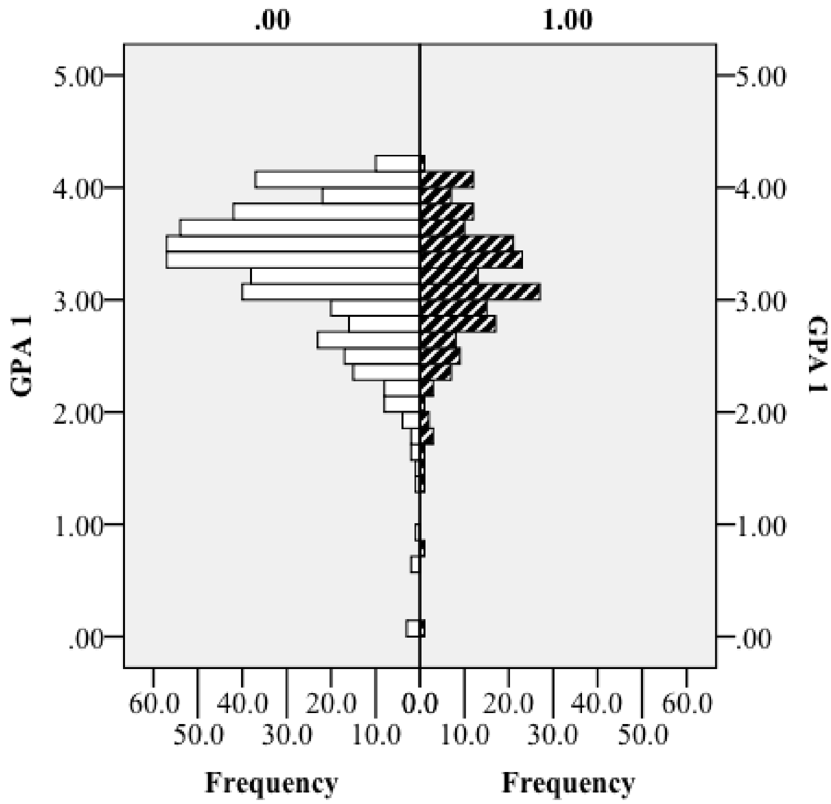


Figure 26. GPA 1 Values by URM/Majority: .00 = Majority, 1.00 = URM.

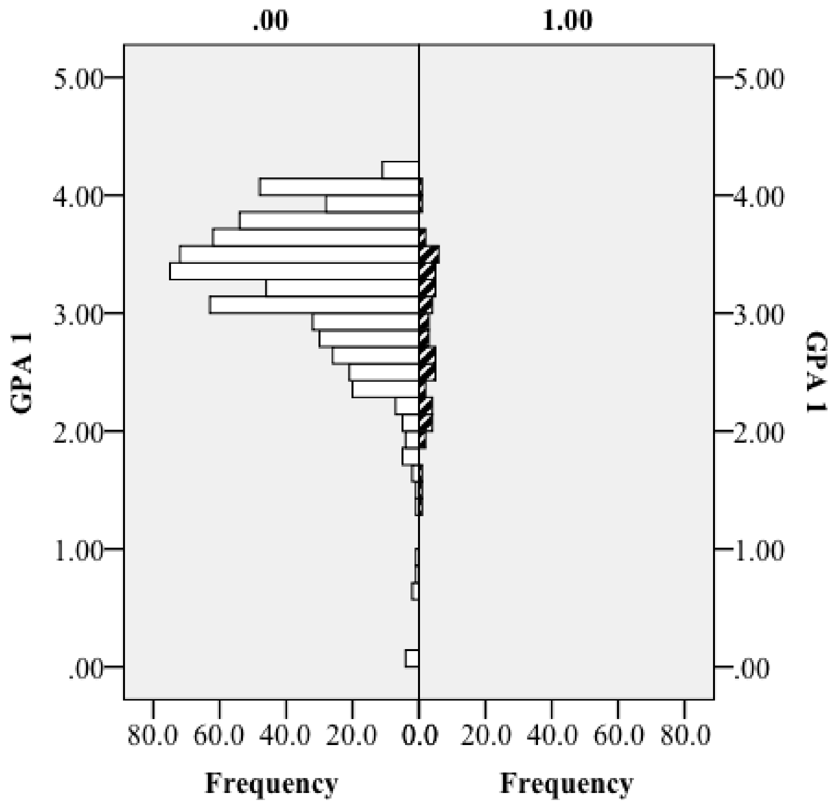


Figure 27. GPA Values by Gender: .00 = Male, 1.00 = Female.

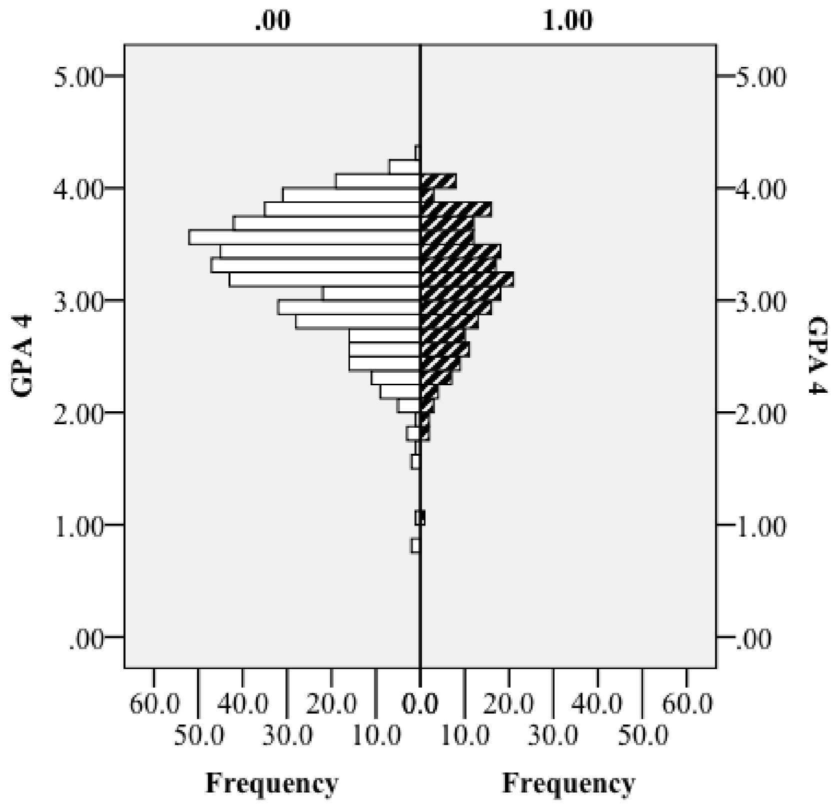
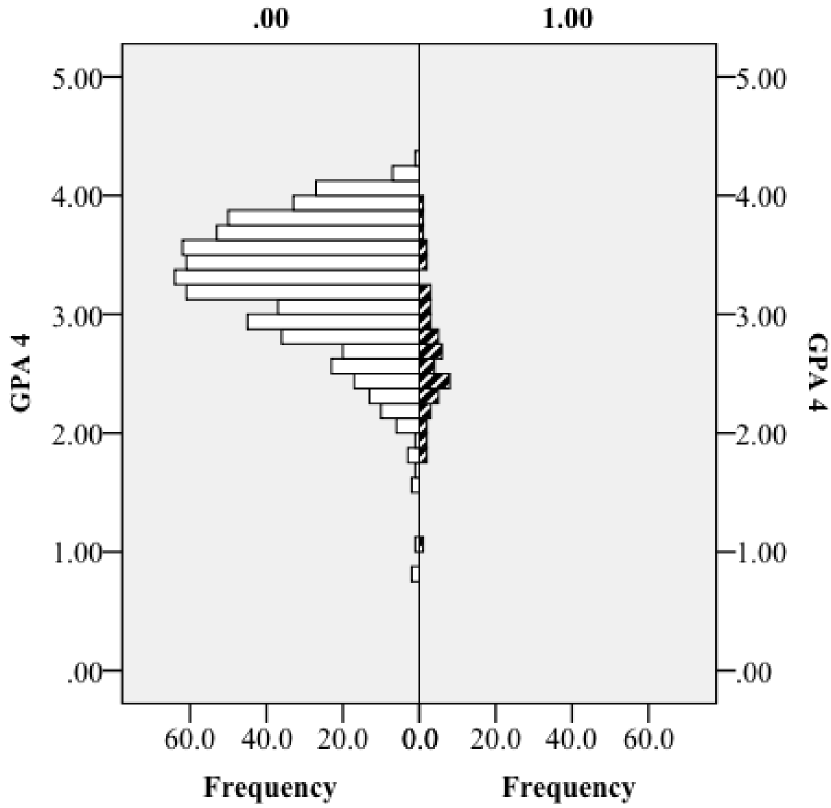


Figure 28. GPA 4 Values by URM/Majority: .00 = Majority, 1.00 = URM.



Having described the data, variables, and distributions of the variables used in Hypothesis 1C, I now describe the analysis used to determine whether there is a relationship between GPA performance after year 1 (GPA 1) of undergraduate engineering or GPA performance after year 4 (GPA 4) of undergraduate engineering with high school TT performance.

Correlation Analysis of GPA 1, GPA 4, and Technical Team Variables

Correlation Analysis: GPA 1 and technical team variables. To test the association between GPA 1 and GPA 4 (the dependent variables) and the four TT variables (the independent variables), I used the Pearson's *r* correlation coefficient as a parametric measure of association.

The full list of variables under study with regard to Hypothesis 1B is included in Table 26.

Table 26. Variables Included in the Analysis of Hypothesis 1B.

GPA 1	**Dependent Variable**
GPA 4	Dependent Variable
Self TT	Independent Variable
Self TT Leader	Independent Variable
CTTEE TT	Independent Variable
CTTEE TT Leader	Independent Variable
Gender	Control Variable
URM (Under-Represented Minority)	Control Variable
Unified Parental Education	Control Variable
Family Owned Number of Bookshelves	Control Variable

The goal of this portion of the study is to determine whether a linear relationship exists between GPA 1, GPA 4, and the independent variables as defined above. In layman's terms, I want to understand whether participating on a high school TT has any impact on students' cumulative GPAs as undergraduate engineers.

Bivariate Correlation Analysis 1: GPA 1 and High School Technical Team Experience. The variables under study in this section are the dependent variable, GPA 1, and the independent variables: self-reported high school TT experience, self-reported high school TT leadership, admissions committee–identified high school TT experience, and admissions committee–identified high school TT leadership. Table 27 presents the Pearson's *r* correlations.

Table 27. Pearson's r for GPA 1.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
GPA 1 Pearson's r	0.024	0.007	0.096*	0.011
Sig. (2-tailed)	0.539	0.858	0.013	0.780
R^2 Coefficient of determination	0.06%	0.01%	0.92%	0.01%
N	676	676	676	676

*. Correlation is significant at the 0.05 level (2-tailed).

Using Cohen's (1988) standards for interpreting Pearson's *r* values to assess the strength of the relationships between the variables, all four of the independent TT variables fall below the "small" threshold (.10 to .29). Only the admissions committee–identified TT variable approaches the small relationship category ($r = .096$, N = 676). The relationship was significant at the 0.05 level.

Summary of the Correlation Analysis of GPA 1 and Technical Team Variables. The Pearson product–moment correlation coefficient was calculated to examine the relationship between cumulative GPAs (as measured by GPA data provided by the college) at the conclusion of the first year of engineering and self-reported high school TT experience (as measured by the August 2006 Entry Survey). Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity. There was no correlation between the two variables ($r = .024$, $N = 676$). The same analysis was performed to examine the relationship between GPA 1 and self-reported high school TT leadership (as measured by the August 2006 Entry Survey). There was no correlation between the two variables ($r = .007$ $N = 676$). The same analysis was performed to examine the relationship between the GPA 1 and admissions committee–identified TT experience (as identified by engineering admissions committees during the admission review process). The correlation between the variables was significant at the 0.05 level (r = .096, N = 676, p = .05), with the R^2 coefficient of determination explaining .92% of the variation in GPA 1 based on admissions committee–identified TT experience. Finally, the same analysis was performed to examine the relationship between GPA 1 and admissions committee–identified TT leadership experience (as identified by engineering admissions committees during the admission review process). There was no correlation between the variables (r = .011, N = 676).

Correlation Analysis of GPA 1 and Technical Team Variables Based Upon Gender and URM Status. A similar analysis was performed on GPA 1 and the four TT variables with the analysis disaggregated first by gender and then by URM/majority status. Table 28 presents the Pearson's r correlations when the sample is disaggregated by gender.

Table 28. Bivariate correlations: GPA 1 and Technical Team by Gender.

Gender		Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Male	GPA 1 Pearson's r	0.005	-0.008	0.090*	-0.007
	Sig. (2-tailed)	0.907	0.861	0.048	0.875
	R^2 Coefficient of determination	0.003%	0.006%	0.81%	0.005%
	N	480	480	480	480
Female	GPA 1 Pearson's r	0.061	0.042	0.099	0.058
	Sig. (2-tailed)	0.395	0.554	0.165	0.423
	R^2 Coefficient of determination	0.37%	0.18%	0.98%	0.34%

N	196	196	196	196

*. Correlation is significant at the 0.05 level (2-tailed).

The Pearson product–moment correlation coefficient was calculated to examine the relationship between the GPA 1 (as measured by the cumulative grade point average of participants after the first year of undergraduate engineering) and self-reported high school TT experience (as measured by the August 2006 Entry Survey) by gender. Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity. There was no correlation between the GPA 1 variable and the self-reported TT participation variable for either male or female students (Male: $r = .005$, $N = 480$, Female: $r = .061$, $N = 196$).

The Pearson product–moment correlation coefficient was calculated to examine the relationship between the GPA 1 variable and self-reported high school TT leadership (as measured by the August 2006 Entry Survey) for males and females (males: $r = -.008$, $N = 480$, females: $r = .042$, $N = 196$). There was no correlation between the GPA 1 variable and high school technical leadership for either males or females.

The Pearson product–moment correlation coefficient was calculated to examine the relationship between the GPA 1 and admissions committee–identified TT experience (as identified by engineering admissions committees during the admission review process) for males and females (males: $r = .090$, $N = 480$, and females: $r = .099$, $N = 196$). There was a small, positive correlation between the GPA 1 variable and admissions committee–identified high school technical experience for males ($r = .090$, $N = 480$, $p < .05$).

Finally, the Pearson product–moment correlation coefficient was calculated to examine the relationship between the GPA 1 variable and admissions committee–identified TT leadership (as identified by engineering admissions committees during the admission review process) for males and females. There was no correlation between the GPA 1 variable and admissions committee–identified high school TT leadership for either males or females (males: r = -.007, N = 480, and females: r = .058, N = 196).

Summary of the Correlation Analysis of GPA 1 and Technical Team Variables by URM Status. The same analysis was completed comparing GPA 1 with the four TT variables disaggregated by URM/Majority status. Table 29 presents the Pearson's r correlations when the sample is disaggregated by URM status.

Table 29. Bivariate Correlations: GPA 1 and Technical Team by URM Status.

URM Status		Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Majority	GPA 1 Pearson's r	0.020	0.027	0.101*	0.003
	Sig. (2-tailed)	0.627	0.500	0.012	0.931
	R^2 Coefficient of determination	0.04%	0.07%	1.02%	0.001%
	N	621	621	621	621
URM	GPA 1 Pearson's r	0.020	-0.154	-0.087	-0.004
	Sig. (2-tailed)	0.885	0.263	0.528	0.978
	R^2 Coefficient of determination	0.04%	2.37%	0.76%	0.002%
	N	55	55	55	55

*. Correlation is significant at the 0.05 level (2-tailed).

The Pearson product–moment correlation coefficient was calculated to examine the relationship between first-year GPA (GPA 1, as measured by data provided by the college after year 1) and self-reported high school TT experience (as measured by the

August 2006 Entry Survey) by URM/Majority status. Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity.

There was no correlation between the GPA1 variable and the self-reported TT participation variable for majority subjects (r = .020, N = 621). There was also no correlation between the GPA 1 variable and the self-reported TT variable for URM subjects (r = .020, N = 55).

The Pearson product–moment correlation coefficient was calculated to examine the relationship between GPA 1 and self-reported high school TT leadership for majority and URM subjects. There was no correlation between the GPA variable and the self-reported TT participation variable for majority subjects (r = .027, N = 621). There was also no correlation between the GPA 1 variable and the self-reported TT leadership variable for URM subjects (r = -.154, N = 55).

Pearson product–moment correlation coefficients were calculated to examine the relationship between the GPA 1 and admissions committee–identified TT experience (as identified by engineering admissions committees during the admission review process) for majority and URM subjects. There was a small, positive correlation between the GPA 1 variable and admissions committee–identified high school TT experience for majority students (r = .101*, N = 621, $p < .05$). For URM students, however, there was no correlation between GPA 1 and admissions committee–identified high school TT experience (r = -.087, N = 55).

Finally, Pearson product–moment correlation coefficients were calculated to examine the relationship between the GPA 1 and admissions committee–identified TT leadership (as identified by engineering admissions committees during the admission review process) for majority students and URM students. There was no correlation between the GPA1 variable and admissions committee–identified high school TT experience for majority subjects (r = .003, N = 621 or for URM subjects, r = -.004, N = 55).

The study now turns to the same analysis applied to cumulative GPA after four years in engineering. The goal of this portion of the study is to determine whether relationships exist across time between high school TT participation and cumulative four-year GPA results. See Table 30.

Summary of the Correlation Analysis of GPA 4 and Technical Team Variables

Table 30. Pearson's *r* for GPA 4.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
GPA 4 Pearson's *r*	0.061	0.027	0.099**	0.000
Sig. (2-tailed)	0.111	0.473	0.009	0.995
R^2 Coefficient of determination	0.37%	0.07%	0.98%	0.00%
N	690	690	690	690

**. Correlation is significant at the 0.01 level (2-tailed).

Based on Cohen's (1988) standards for interpreting Pearson's r values to assess the strength of relationships between the variables, all four of the independent TT variables fell below the "small" threshold (.10 to .29). Only the admissions committee–identified TT variable approaches the small relationship category (r = .099, N = 690, $p < 0.01$).

Summary of the Correlation Analysis of GPA 4 and Technical Team Variables. The Pearson product–moment correlation coefficient was calculated to examine the relationship between cumulative GPA (as measured by GPA data provided by the college) at the conclusion of the fourth year of engineering (GPA4) and self-reported high school TT experience (as measured by the August 2006 Entry Survey). Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity. There was no correlation between the two variables (r = .061, N = 690). The same analysis was performed to examine the relationship between GPA 4 and self-reported high school TT leadership (as measured by the August 2006 Entry Survey). There was no correlation between the two variables (r = .027 N = 690). The same analysis was performed to examine the relationship between GPA 4 and admissions committee–identified TT experience (as identified by engineering admissions committees during the admission review process). The correlation between the variables was significant at the 0.01 level (r = .099, N = 690, p < .01), with the R^2 coefficient of determination explaining .98% of the variation in GPA 4 based on admissions committee–identified TT experience. Finally, the same analysis was performed to examine the relationship between GPA 4 and admissions committee–identified TT leadership experience (as identified by engineering admissions committees during the admission review process). There was no correlation between the variables (r = .000, N = 690).

Correlation Analysis of GPA 4 and Technical Team Variables Based Upon Gender and URM Status. A similar analysis was performed on GPA 4 and the four TT variables with the analysis disaggregated first by gender and then by URM/majority status. Table 31 presents the Pearson's *r* correlations when the sample is disaggregated by gender.

Table 31. Bivariate correlations: GPA 4 and Technical Team Participation by Gender.

Gender		Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Male	GPA 4 Pearson's r	0.032	0.015	0.093*	-0.003
	Sig. (2-tailed)	0.476	0.749	0.040	0.954
	R^2 Coefficient of determination	0.10%	0.02%	0.87%	0.01%
	N	487	487	487	487
Female	GPA 4 Pearson's r	0.121	0.054	0.099	0.001
	Sig. (2-tailed)	0.085	0.447	0.160	0.992
	R^2 Coefficient of determination	1.46%	0.29%	0.98%	0.00%
	N	203	203	203	203

*. Correlation is significant at the 0.05 level (2-tailed).

Pearson product–moment correlation coefficients were calculated to examine the relationship between the GPA 4 (as measured by the cumulative GPAs of participants after the first year of undergraduate engineering) and self-reported high school TT experience (as measured by the August 2006 Entry Survey) disaggregated by gender. Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity. There was no correlation between the GPA 4 variable and the self-reported TT participation variable for either male or female students (Male: $r = .032$, $N = 487$, Female: $r = .121$, $N = 203$).

Pearson product–moment correlation coefficients were calculated to examine the relationship between the GPA 4 variable and self-reported high school TT leadership (as measured by the August 2006 Entry Survey) for males and females (males: r = .015, N = 487, females: r = .054, N = 203). There was no correlation between the GPA 4 variable and self-reported high school TT leadership for either males or females.

Pearson product–moment correlation coefficients were calculated to examine the relationship between the GPA 4 and admissions committee–identified TT experience (as identified by engineering admissions committees during the admission review process) disaggregated by gender. There was a small, positive correlation between the GPA 4 variable and admissions committee–identified high school TT experience for males (r = .093, N = 503, $p < 0.05$). There was no correlation between the GPA 4 variable and admissions committee–identified high school TT experience for females (r = .099, N = 203).

Finally, Pearson product–moment correlation coefficients were calculated to examine the relationship between the GPA 4 variable and admissions committee–identified TT leadership (as identified by engineering admissions committees during the admission review process) for males and females. There was no correlation between the GPA 4 variable and admissions committee–identified high school TT leadership for either males or females (males: r = -.003, N = 487, and females: r = .001, N = 203).

Summary of the Correlation Analysis of GPA 4 and Technical Team Variables by Under-Represented Minority and Majority Status

The same analysis was completed comparing GPA 4 with the four TT variables disaggregated by URM/majority status. Table 32 presents the Pearson's *r* correlations when the sample is disaggregated by URM status.

Table 32. Bivariate Correlations: GPA 4 and Technical Team Participation by URM-Status.

URM Status		Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Majority	GPA 4 Pearson's *r*	0.045	0.038	0.093*	-0.019
	Sig. (2-tailed)	0.258	0.335	0.020	0.626
	R^2 Coefficient of determination	0.20%	0.144%	0.87%	0.04%
	N	636	636	636	636
URM	GPA 4 Pearson's *r*	0.219	-0.011	0.044	0.103
	Sig. (2-tailed)	0.112	0.937	0.749	0.460
	R^2 Coefficient of determination	4.8%	0.00%	0.19%	1.06%
	N	54	54	54	54

*. Correlation is significant at the 0.05 level (2-tailed).

Pearson product–moment correlation coefficients were calculated to examine the relationship between fourth-year cumulative GPA (GPA 4, as measured by data provided by the college after year 4) and self-reported high school TT experience (as measured by the August 2006 Entry Survey) disaggregated by URM/majority status. Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity.

There was no correlation between the GPA 4 variable and the self-reported TT participation variable for majority subjects (r = .045, N = 636). There was also no correlation between the GPA 4 variable and the self-reported TT leadership variable for URM subjects (*r* = .219, *N* = 54).

Pearson product–moment correlation coefficients were calculated to examine the relationship between GPA 4 and self-reported high school TT leadership for majority and URM subjects. There was no correlation between the GPA variable and the self-reported TT participation variable for majority subjects (*r* = .038, *N* = 636). There was also no correlation between the GPA 4 variable and the self-reported TT leadership variable for URM subjects (*r* = -.011, *N* = 54).

Pearson product–moment correlation coefficients were calculated to examine the relationship between the GPA 4 and admissions committee–identified TT experience (as identified by engineering admissions committees during the admission review process) for majority and URM subjects. There was a small, positive correlation between the GPA 4 variable and admissions committee–identified high school TT experience for majority students (*r* = .093*, *N* = 636, $p < .05$). For URM students, however, there was no correlation between GPA 4 and admissions committee–identified high school TT (*r* = .044, *N* = 54).

Finally, Pearson product–moment correlation coefficients were calculated to examine the relationship between GPA 4 and admissions committee–identified TT leadership (as identified by engineering admissions committees during the admission review process) for majority students and URM students. There was no correlation between the GPA 4 variable and admissions committee–identified high school TT experience for majority subjects (*r* = -.019, *N* = 636) or for URM subjects (*r* = .103, *N* = 54).

Regression Analysis of GPA 1, GPA 4, and Technical Team Variables

A further purpose of the study was to determine whether high school TT experiences interacted with first-year engineering cumulative GPA when controlling for the effects of gender, URM status, and socio-economic status. Multiple regression was used as an analytical technique to understand how much of the variation in GPA 1 and GPA 4 (the dependent variables) may be explained by high school TT experience (as represented by the independent variables), while holding gender, URM-status, and socio-economic status constant.

The five assumptions about the data that must be satisfied for multiple regression to be effective were satisfied:

1. Independence of observations suggests that adjacent observations must not be correlated. The Durbin–Watson statistic for the regression model used in the GPA 1 portion of the study was 2.02. The Durbin–Watson statistic for the regression model used in the GPA 4 portion of the study was 2.13. This suggests that the assumption of independence of observations for both GPA 1 and GPA 4 has been met.
2. A linear relationship exists between the dependent variable and the independent variables that are not categorical variables. I checked the linearity of the relationship between the dependent and independent variables by producing scatterplots of the residuals for both GPA 1 and GPA 4 (Figures 29 and 30):

Figure 29. Scatterplot for Studentized Residuals and the Predicted Values: Testing for Linearity and Homoscedasticity for Variable GPA 1.

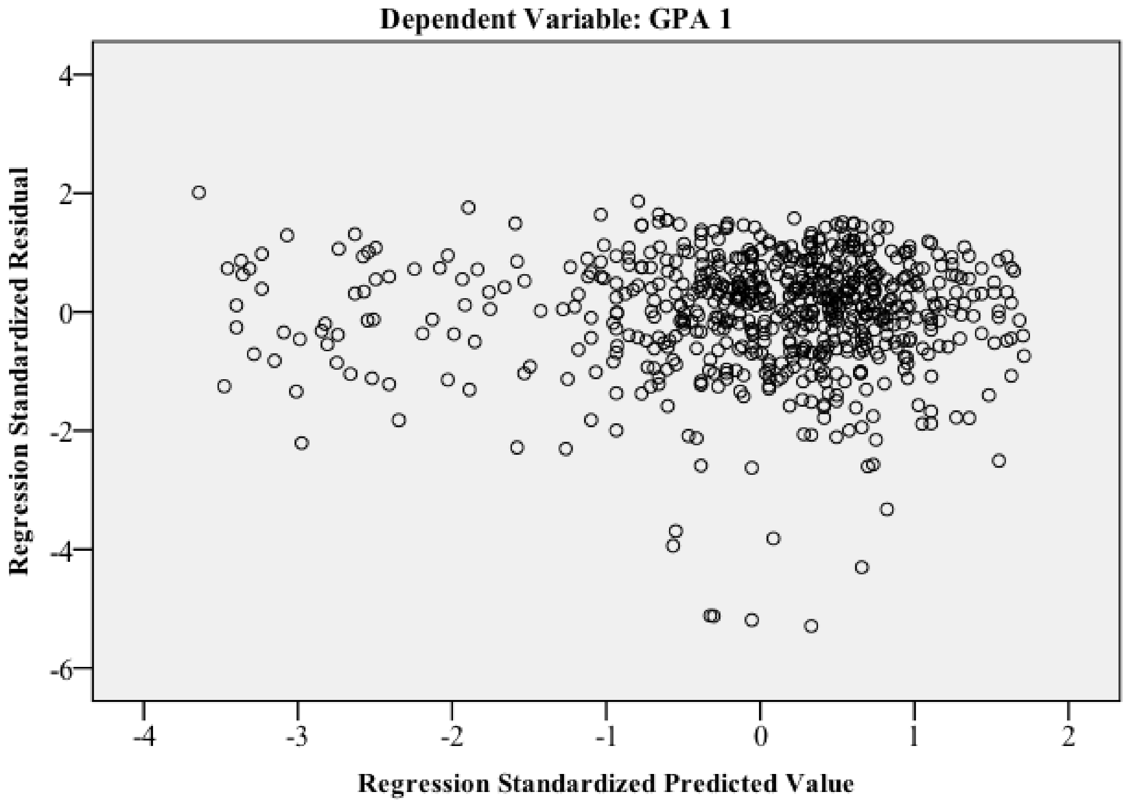
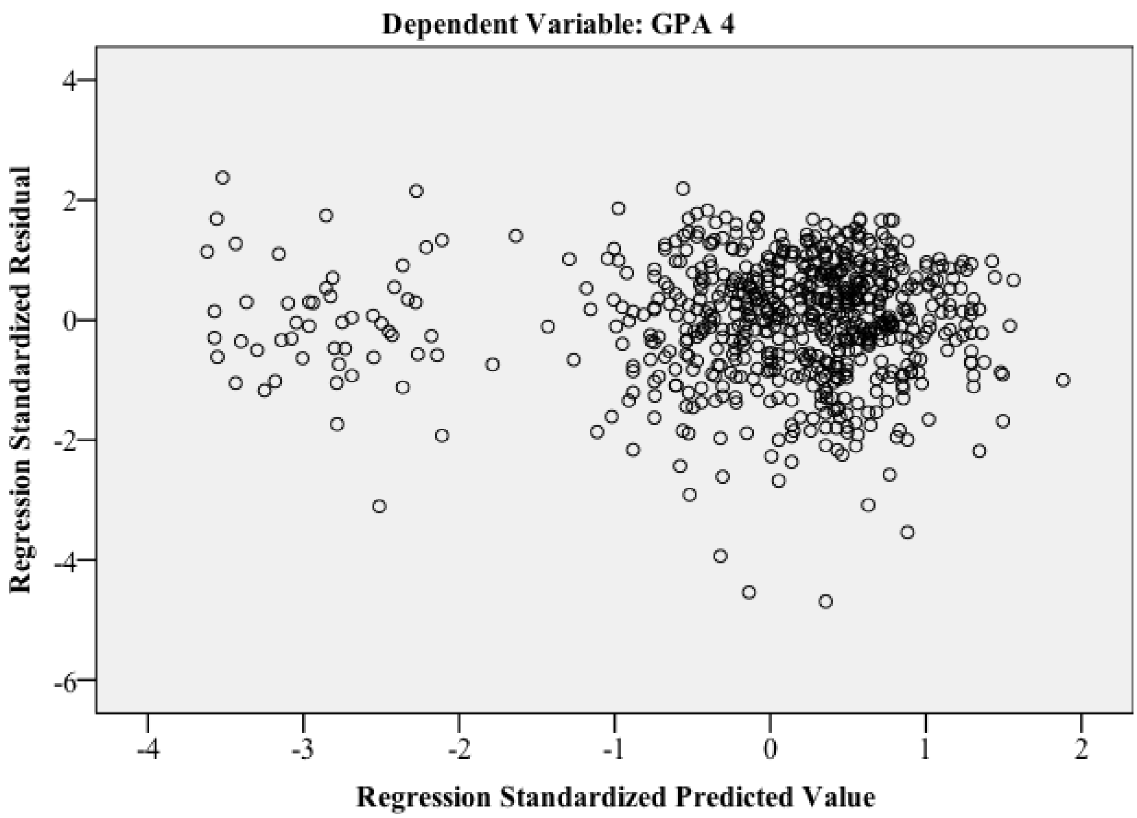


Figure 30. Scatterplot for Studentized Residuals and Predicted Values: Testing for Linearity and Homoscedasticity for Variable GPA 4.



While neither scatterplot (for GPA 1 or GPA 4) indicates that a perfect linear relationship between the residuals exists, a linear relationship can be visually discerned for both GPA 1 and GPA 4. This suggests that the assumption of linearity has been met.

The same scatterplots may be used to test for homoscedasticity (Princeton University Library, 2007). In the scatterplots, the points above *and* below the .00000 mark are approximately evenly distributed, suggesting that the assumption of homoscedasticity has been met.

I also created scatterplots (Figures 31–34) to examine the relationship between the dependent variables (GPA 1 and GPA 4) and the two non-categorical dependent variables (combined parental education and number of bookshelves in the home). These scatterplots indicate that approximately linear relationships exist between the dependent variables and the two independent variables.

Figure 31. Partial Regression Plot GPA1 and Unified Parental Education.

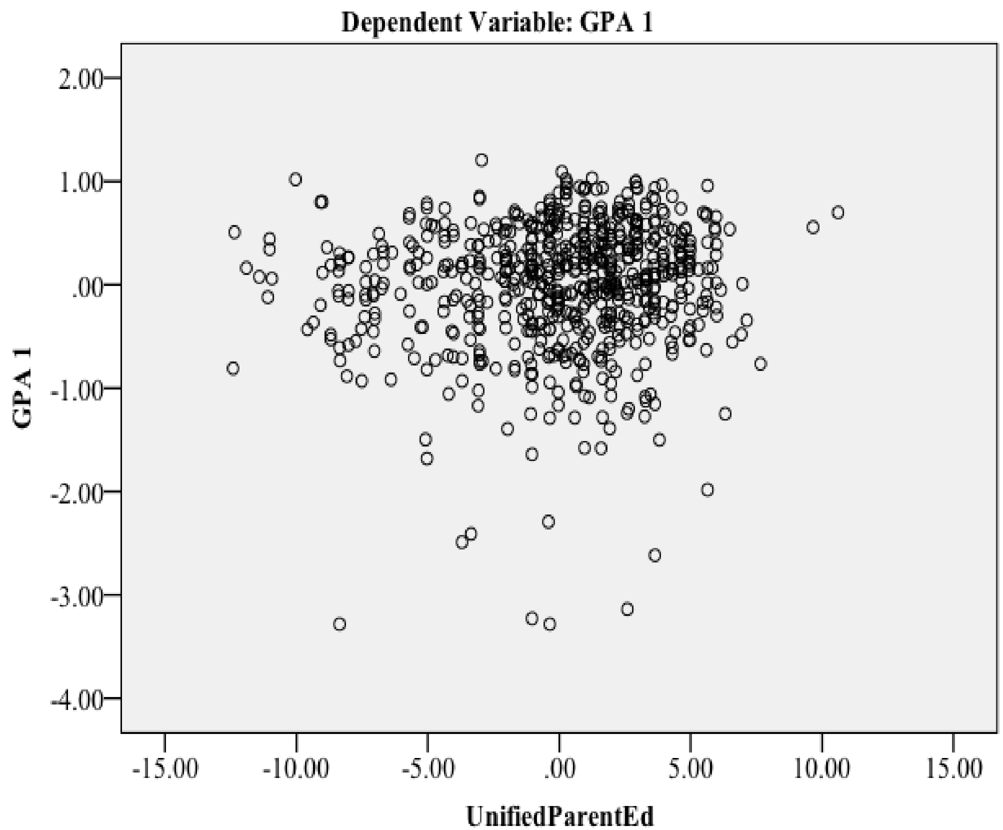


Figure 32. Partial Regression Plot GPA 1 and Number of Bookshelves in the Home.

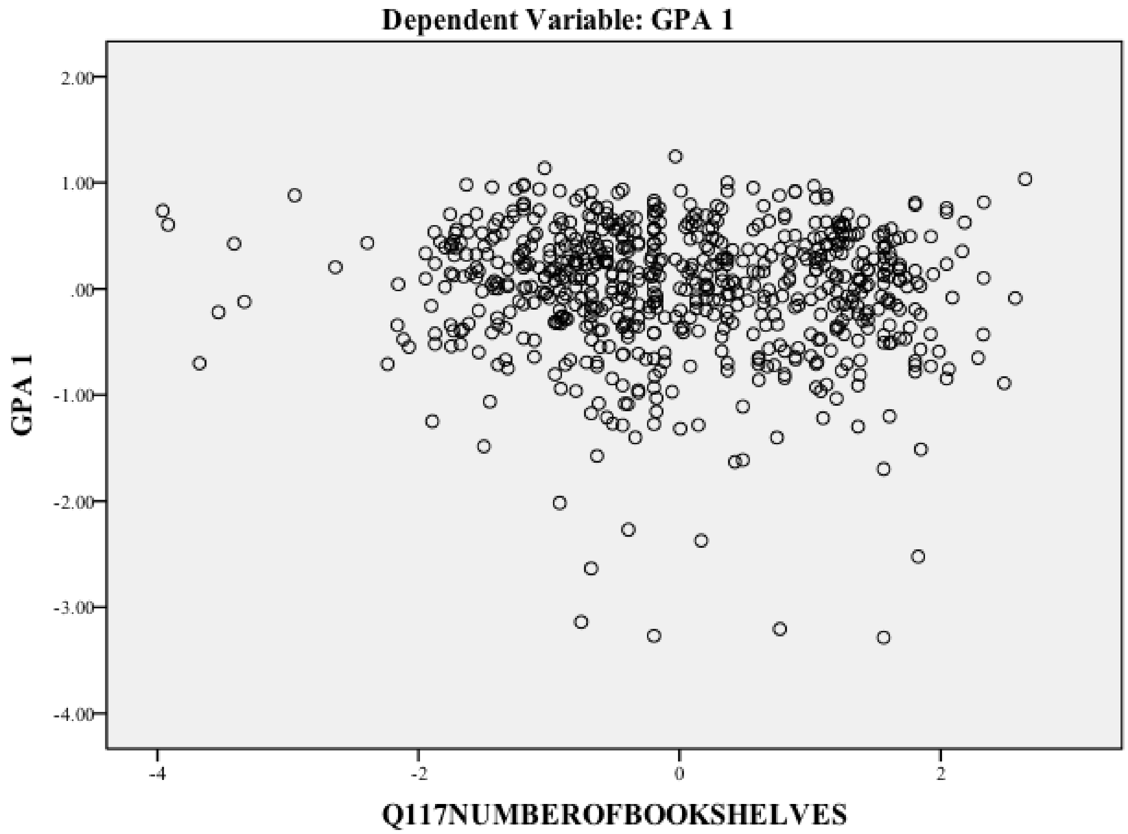


Figure 33. Partial Regression Plot GPA 4 and Unified Parent Education.

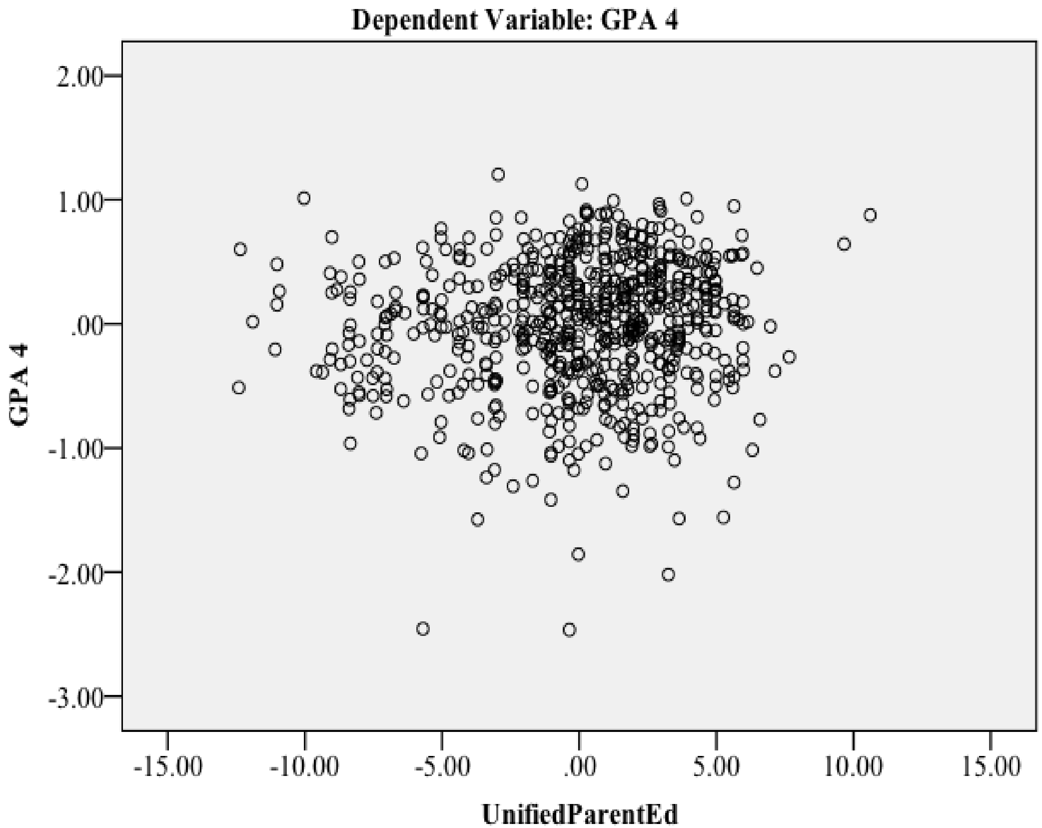
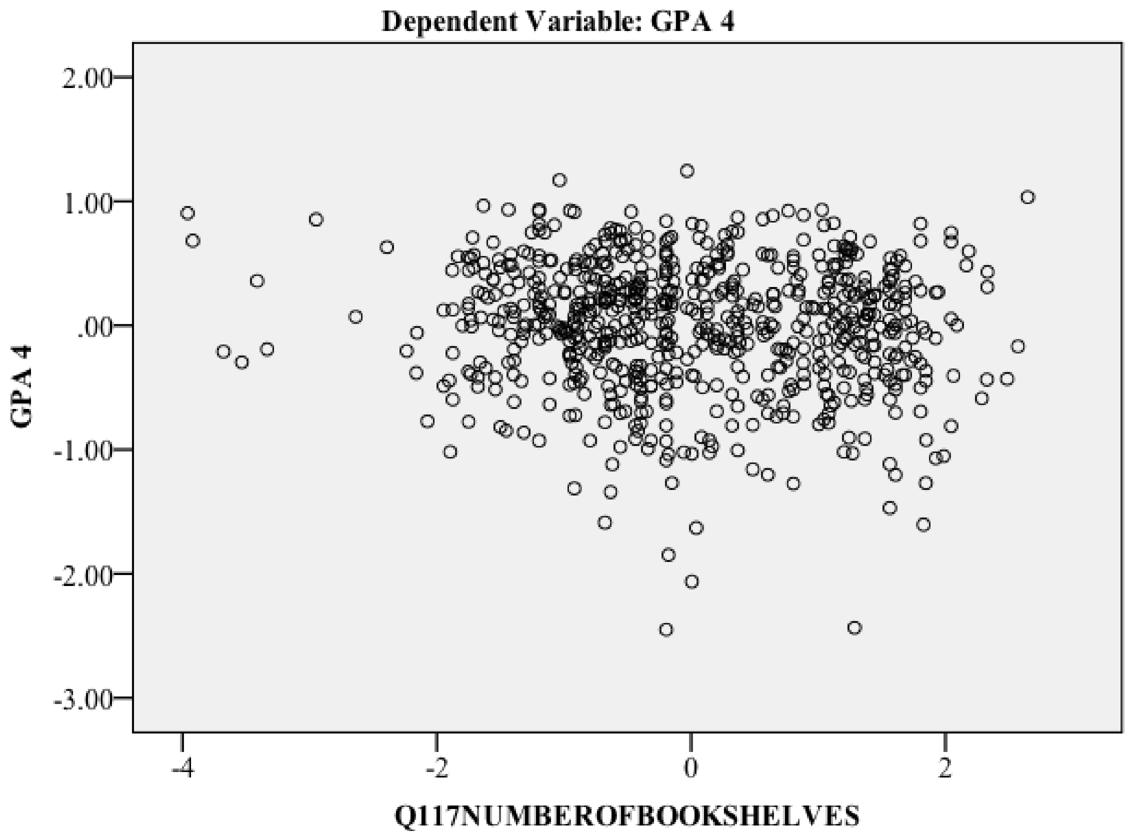


Figure 34. Partial Regression Plot GPA 4 and Number of Bookshelves in the Home.



The categorical variables for TT participation, gender, and URM-status were not graphed.

3. In both the GPA 1 and GPA 4 regression models, none of the Pearson's *r* correlation coefficients for the independent variables is greater than .70. This indicates that the independent variables are not highly correlated with one another, satisfying the assumption that multicollinearity does not confound the regression analysis.

An additional check for multicollinearity involves checking the variation inflation factor (VIF) output for each independent variable in the model. VIFs exceeding a score of 10 indicate multicollinearity (O'Brien, 2007). VIF scores for both the GPA 1 and GPA 4 models ranged from a low of 1.015 (gender) to a high of 1.223 (parental education). Neither the GPA 1 nor GPA 4 model exhibited VIF scores that exceeded the threshold score of 10, supporting the premise that there is no multicollinearity between the independent variables in either model.

4. The residuals must be normally distributed and, as indicated by the histograms in Figures 35 and 36, the residuals for both GPA 1 and GPA 4 display approximately normal distributions.

Figure 35. Histogram of Variable GPA 1.

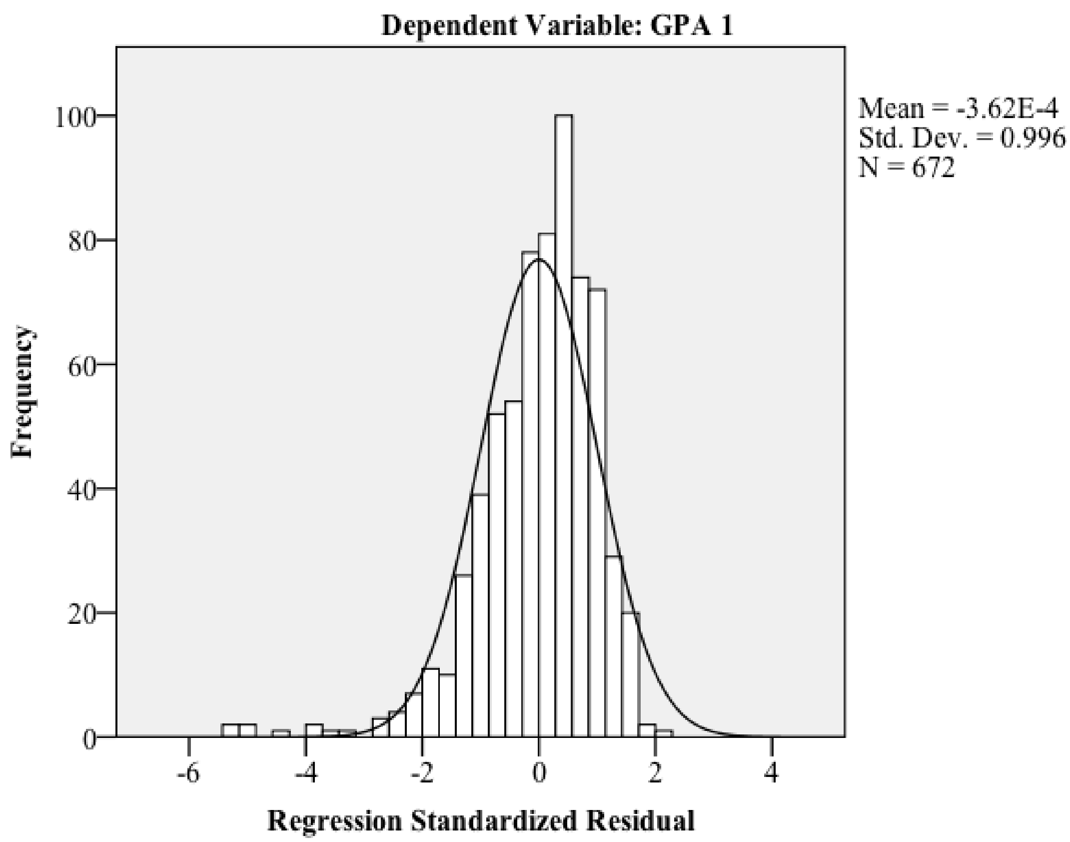
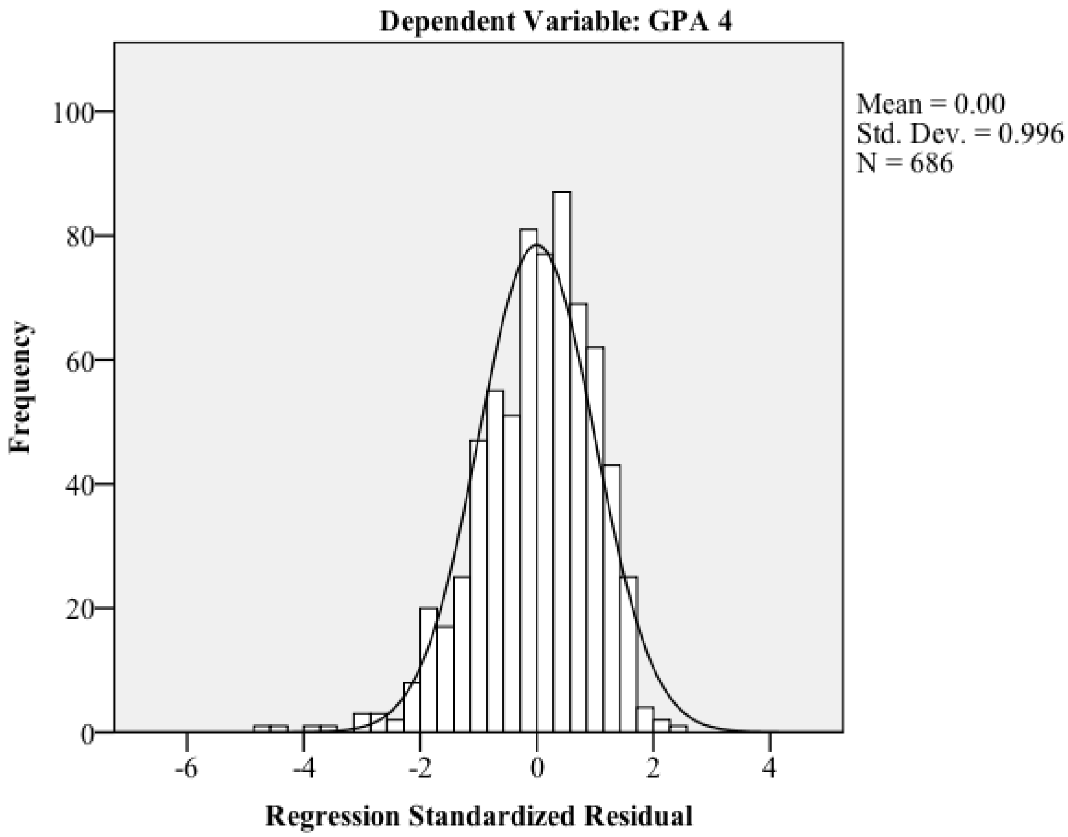


Figure 36. Histogram of Variable GPA 4.



The normality of the residuals was also confirmed by checking the P-P Plots for both GPA 1 and GPA 4 (Figures 37 and 38) with normality indicated by the residual points' approximating the diagonal line for both dependent variables. In both instances, the normality is not perfect (if it were, each point would be precisely on the line), but is still approximately normal for both GPA 1 and GPA 4.

Figure 37. Normal P-P Plot of Regression Standardized Residual for GPA 1.

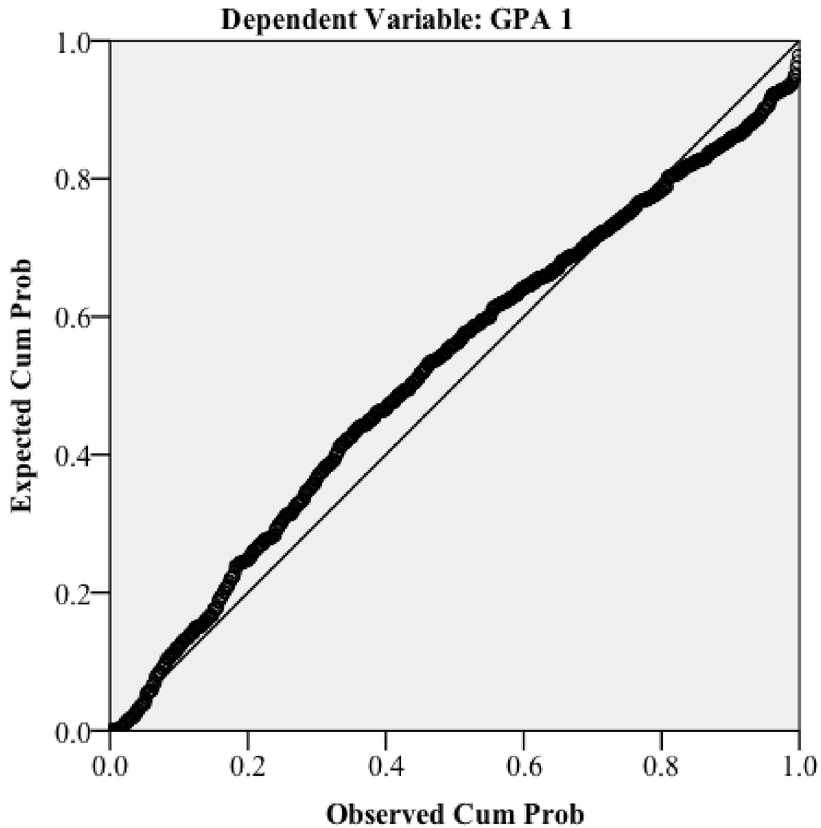
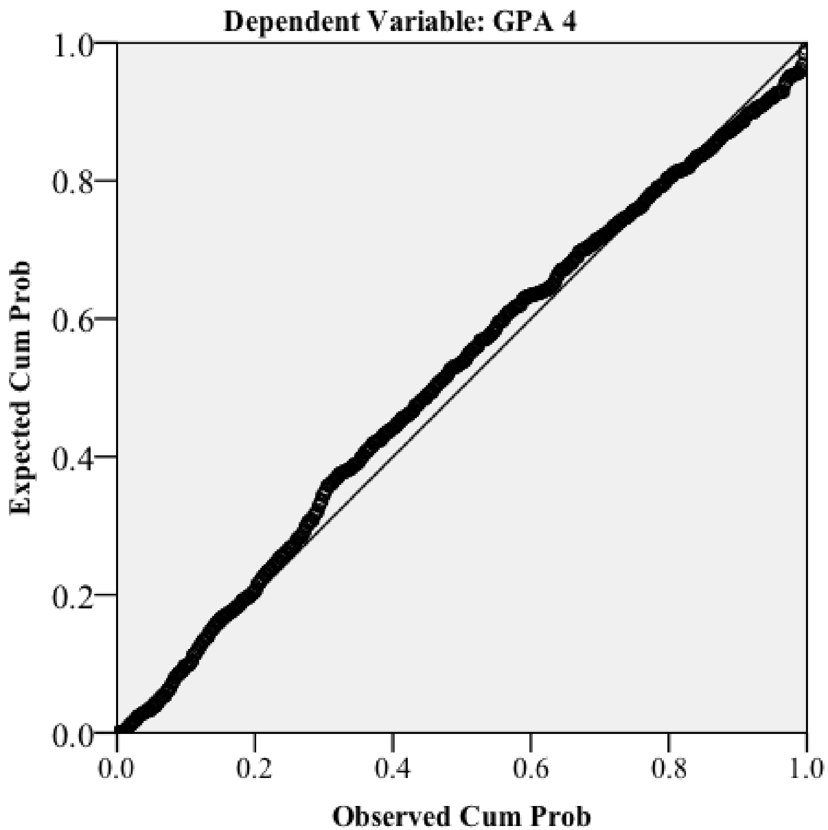


Figure 38. Normal P-P Plot of Regression Standardized Residual for Variable GPA 4.



The assumptions necessary for multiple regression analysis to proceed have been satisfied and the discussion now turns to the regression model, which was used to examine interactions between the dependent variables, GPA 1 and GPA 4, and the four independent variables for TT participation as well as gender, URM status, and socio-economic status.

The Multiple Regression Model and Associated Output

A primary objective of this portion of the study is to determine whether relationships exist between the dependent variables, cumulative GPA after year 1 in engineering and cumulative GPA after year 4 in engineering, and the four independent TT variables, while holding gender, URM status, and socio-economic status constant. To analyze these relationships, I carried out two standard multiple regressions. Model 1 predicts GPA 1 based on high school TT participation. Model 2 predicts GPA 4 based on high school TT participation. The variables described in Tables 33 and 34 were included in the regression analysis.

Table 33. Variables included in the multiple regression model 1: GPA 1.

Dependent Variable	Independent Variables	Control Variables
Grade Point Average 1 (GPA 1)	Self-Identified High School Technical Team Experience	URM
	Self-Identified High School Technical Team Leadership	Gender
	Admissions Committee– Identified High School Technical Team Experience	Unified Parental Education
	Admissions Committee– Identified High School Technical Team Leadership	Number of Family-Owned Bookshelves

Table 34. Variables included in the multiple regression model 2: GPA 4.

Dependent Variable	Independent Variables	Control Variables
Grade Point Average 4 (GPA 4)	Self-Identified High School Technical Team Experience	URM
	Self-Identified High School Technical Team Leadership	Gender
	Admissions Committee– Identified High School Technical Team Experience	Unified Parental Education
	Admissions Committee– Identified High School Technical Team Leadership	Number of Family-Owned Bookshelves

The Multiple Regression Model 1 (GPA 1) and Associated Output

Three measures indicate the how well the model fits the data: the multiple correlation coefficient (*R*) and the two measures indicating the total variation explained, which are the R^2 and adjusted R^2 results. For the GPA 1 regression model, $R = .259$, indicating a weak level of association between the dependent variable, GPA 1, and the independent variables. The R^2 equation measures the proportion of the variance *above* what the Pearson correlation coefficient (*R*) mean values measure between GPA 1, the four TT variables, and the control variables (gender, URM status, and socio-economic status). Table 35 presents the Model 1 summary.

Table 35. Model 1 Summary for GPA 1.

	R	*R Square*	*Adjusted R Square*
	0.259	0.067	0.056
Predictors	self-reported high school technical team experience, self-reported high school technical team leadership, admissions committee–identified technical team experience, admissions committee–identified technical team leadership, gender, URM status, unified parental education, and number of bookshelves in the home		
Dependent Variable	GPA 1		

The R^2 value for the GPA 1 regression Model 1 is .067. This suggests that the addition of the independent variables into the regression model explained 7% of the total variability of the GPA 1 measure. The adjusted R^2 value is .056, suggesting that the model explained 6% of the total variability of the GPA 1 measure. Adjusted R^2 values <.10 imply that the model is a poor fit for the data and that the effect size is minimal (Muijs, 2011).

Statistical Significance of the Model

An ANOVA indicates that at least one independent variable (self-identified high school TT participation, self-identified high TT leadership, admissions committee–identified TT participation, admissions committee–identified Tt leadership, gender, URM status, combined parental education level, or number of bookshelves in the home) does predict GPA 1 to a statistically significant extent ($F[8,664] = 5.984$, $p < .0005$). Table 36 presents the unstandardized coefficients.

Table 36. Unstandardized Coefficients for Model 1: GPA 1.

	Unstandardized *B*	Sig.
Constant	3.252	0.000
SELFTTBinary	-0.013	0.850
SELFTTLeaderBinary	0.012	0.940
CTTEEEXPnew2	0.128	0.023
CTTLDnew2	-0.057	0.474
SexNum	-0.145	0.006
URM_Binary	-0.444	0.000
UnifiedParentEd	0.014	0.030
Q117NUMBEROFBOOKSHELVES	-0.045	0.029

Summary Report of the Regression Analysis of Model 1: GPA 1

I ran a multiple regression analysis to predict GPA 1 based on self-reported high school TT participation, self-reported high school TT leadership, admissions committee–identified high school TT participation, admissions committee–identified high school TT leadership, gender, URM status, combined parental education, and the number of bookshelves in the home. The relationships between the dependent and independent variables were approximately linear and the assumption of homoscedasticity was met as indicated by a visual assessment of the scatterplots of the studentized residuals and predicted values and the partial regression plots. There was independence of the residual observations as indicated by a Durbin–Watson statistic of 2.05. The model did not suggest that multicollinearity exists between the variables given that no Pearson's *r* correlation coefficients were higher than .70. The assumption of normality was also met with a visual inspection of the P-P Plot.

The multiple regression model did predict GPA 1 to a statistically significant extent ($F[8, 664] = 5.984$, $p < .0005$, adj. $R^2 = .056$). The independent variables that added to the prediction of GPA 1 to a statistically significant extent were admissions committee–identified TT experience ($p = .023$), SexNum (Gender, $p = .006$), URM_Binary (URM status, $p = .000$), UnifiedParentEd (combined parental education, $p = .030$), and Q117NUMBEROFBOOKSHELVES (number of bookshelves in the home, $p = .029$). Table 37 presents the regression coefficients and standard errors of the model.

Table 37. Summary of the Multiple Regression Analysis of GPA 1 (Model 1).

Variable	B	SE_B	β
Intercept	3.252	0.089	
SELFTTBinary	-0.013	0.070	-0.008
SLEFTTLeaderBinary	0.012	0.163	0.003
CTTEXPnew2	0.128	0.057	0.092
CTTLDnew2	-0.057	0.080	-0.029
SexNum	-0.145	0.053	-0.104
URM_Binary	-0.444	0.090	-0.189
UnifiedParentEd	0.014	0.006	0.090
Q117NUMBEROFBOOKSHELVES	-0.045	0.021	-0.090

The Multiple Regression Model 2 (GPA 4) and Associated Output

For the GPA 4 regression model, $R = .352$, indicating a moderate level of association between the dependent variable, GPA 4, and the independent variables. The R^2 equation measures the proportion of the variance *above* what the Pearson correlation coefficient (*R*) mean values measure between GPA 4, the four TT variables, and the control variables (gender, URM status, and socio-economic status). The R^2 for the GPA 4 regression model is .124. This confirms that the model fit is modest, at best, bordering on weak.

For the model predicting GPA 4 with the independent variables (the four TT variables as well as gender, URM status, combined parental education, and number of bookshelves in the home), the adjusted R^2 for the GPA 4 regression model is .114, placing the model in the modest fit category. Table 38 summarizes the multiple correlation coefficients for Model 2.

Table 38. Model 2 Summary for GPA 4.

	R	***R Square***	***Adjusted R Square***
	0.352	0.124	0.114
Predictors	self-reported high school technical team experience, self-reported high school technical team leadership, admissions committee–identified technical team experience, admissions committee–identified technical team leadership, gender, URM status, unified parental education, and number of bookshelves in the home		
Dependent Variable	GPA 4		

The R^2 value for GPA 4 regression Model 2 is .124. This suggests that the addition of the independent variables into the regression model explained 12% of the total variability of the GPA 4 measure. The adjusted R^2 value is .114, suggesting that the model explained 11% of the total variability of the GPA 4 measure. Interestingly, the GPA 4 regression model does marginally improve over the GPA 1 regression model. There may be a range of reasons for this. One explanation may be that, because the GPA 1 model data are drawn after year 1 and the GPA 4 model data are drawn after year 4, some portion of the students with lower GPAs left engineering by year 4. This would remove the effects their lower GPAs could potentially have on the model.

Statistical Significance of the Model

An ANOVA indicates that self-identified high school TT participation, self-identified high TT leadership, admissions committee–identified TT participation, admissions committee–identified TT leadership, gender, URM status, unified parental education level, and number of bookshelves in the home predict self-efficacy to a statistically significant extent ($F[8,678] = 3.297$, $p < .0005$). Table 39 presents the unstandardized coefficients.

Table 39. Unstandardized Coefficients for Model 2: GPA 4.

	Unstandardized *B*	**Sig.**
Constant	3.255	0.000
SELFTTBinary	0.037	0.530
SELFTTLeaderBinary	0.062	0.647
CTTEEEXPnew2	0.103	0.030
CTTLDnew2	-0.086	0.202
SexNum	-0.157	0.000
URM_Binary	-0.587	0.000
UnifiedParentEd	0.013	0.011
Q117NUMBEROFBOOKSHELVES	-0.043	0.014

Summary Report of the Regression Analysis of Model 2: GPA 4

I ran a multiple regression analysis to predict GPA 4 based on self-reported high school TT participation, self-reported high school TT leadership, admissions committee–identified high school TT participation, admissions committee–identified high school TT leadership, gender, URM status, combined parental education, and the number of bookshelves in the home. The relationships between the dependent and independent variables were approximately linear and the assumption of homoscedasticity was met as indicated by a visual assessment of the scatterplots of the studentized residuals and predicted values and the partial regression plots. There was independence of the residual observations as indicated by a Durbin–Watson statistic of 2.085. The model did not suggest that multicollinearity exists between the variables given that no Pearson's *r* correlation coefficients were higher than .70. The assumption of normality was also met as indicated by a visual inspection of the P-P Plot.

The multiple regression model predicted GPA 4 to a statistically significant extent ($F(8, 678) = 11.997$, $p < .0005$, adj. $R^2 = .114$). Five of the eight independent variables added statistical significance to the prediction of GPA 4. The five variables that added statistical significance to Model 2 for GPA 4 are the same independent variables that added statistical significance to Model 1 for GPA 1: admissions committee–identified TT participation ($p = .030$), SexNum (Gender, $p = .000$), URM_Binary (URM status, $p = .000$), UnifiedParentEd (parental education, $p = .011$), and Q117NUMBEROFBOOKSHELVES (number of bookshelves in the home, $p = .014$). Table 40 presents the regression coefficients and standard errors of the model.

Table 40. Summary of the Multiple Regression Analysis of GPA 4 (Model 2).

Variable	B	SE_B	β
Intercept	3.255	0.074	
SELFTTBinary	0.037	0.059	0.025
SLEFTTLeaderBinary	0.062	0.136	0.018
CTTEXPnew2	0.103	0.047	0.085
CTTLDnew2	-0.086	0.067	-0.049
SexNum	-0.157	0.044	-0.129
URM_Binary	-0.587	0.075	-0.285
UnifiedParentEd	0.013	0.005	0.102
Q117NUMBEROFBOOKSHELVES	-0.043	0.017	-0.097

Hypothesis 1C Analysis and Results: Technical Team Participation and Confidence

Hypothesis 1C postulates that first-year engineering students who participated on a high school TT will be more confident in their abilities to succeed in an undergraduate engineering program than their first-year engineering classmates who did not participate on a high school technical team. The premise for this hypothesis is rooted in the notion that high school technical teams may serve as engineering incubators. Participation on a TT may preview engineering in applied, exciting ways that are interesting to high school students, draw them to the field of engineering, and motivate them to succeed as novice engineers. These experiences may also provide participants with a realistic sense of engineering through the act of designing and building substantive engineering projects within team settings, much as "real" engineers do in engineering-related industries. It is reasonable to suggest that these experiences provide a more realistic preview of engineering than performing well in calculus, physics, or chemistry classes, which are the academic prerequisites for studying engineering.

Engineering project teams often include professional engineers, providing participants with access to individuals who serve as key informants regarding what engineering entails, offering information about studying to become an engineer and the professional field of engineering as well as TT s into solving problems that engineers encounter.

Finally, TT s may offer high school students opportunities to develop basic engineering-related (non-academic) teamwork skills that are foundational to succeeding in undergraduate engineering curriculums and as professional engineers. The cumulative effect of these characteristics of high school TT participation may be an enhanced impetus to persist in undergraduate engineering, particularly during the academically arduous first year when novice engineering students are predominantly immersed in a series of calculus, physics, chemistry, computer science, and technical writing courses.

Variables included in the analysis of Hypothesis 1C

The variables involved in the analysis of Hypothesis 1C include the following categorical independent (predictor) variables: self-identified TT experience, self-identified technical leader, admissions committee–identified TT experience, and admissions committee–identified TT leadership. The dependent variables that represent interval data include 14 variables based on the Pittsburgh Freshman Engineering Attitude Survey © (PFEAS) (Besterfield-Sacre, Atman, & Shuman, 1998) plus one additional confidence variable that I included in the study. Control variables include gender (a categorical variable), socio-economic status as measured by combined parental education via a categorical questionnaire scale (an interval variable) and the number of bookshelves in the family home as measured by a categorical questionnaire scale (an interval variable). A third control variable is URM status as measured by a binary dummy (categorical) variable that defines URM status as 1 and majority status as 0.

The analysis includes descriptive statistics, confirmatory factor analysis of the PFEAS, bivariate correlations, and linear and multiple regressions. The null hypothesis is that no relationship exists between high school TT participation or high school TT leadership and student self-assessed confidence in engineering attitudes, perceptions, and abilities, as measured by the PFEAS variables.

Cronbach's Alpha Analysis of the PFEAS Variables

Table 41 presents the Cronbach's Alpha coefficients for the 14 PFEAS factors and the additional factor (Engineering Preview) that I created.

Table 41. Cronbach's Alpha Coefficients for the PFEAS + Author-Created Factor.

PFEAS Variable	Cronbach's Alpha	N of Items	N	Mean	Std. Dev.
Career Expectations	0.808	9	709	36.37	4.39
Jobs/Salary	0.613	4	717	13.12	2.31
Society Contribution	0.734	2	717	6.55	1.58
Perception of Work	0.734	7	717	28.78	3.60
Math Enjoyment	0.709	2	710	8.20	1.47
Exact Science	0.568	2	717	6.53	1.60
Family Influence	0.478	2	717	4.55	1.48
Basic Knowledge	0.715	5	717	18.16	3.37
Communication Skills	0.502	3	717	9.74	2.33
Study Habits	0.669	2	711	6.47	1.64
Group Work	0.677	3	715	8.85	2.15
Problem Solving Ability	0.724	5	717	19.24	2.65
Engineering Abilities	0.675	4	717	13.84	2.49
Engineering Preview	0.498	3	717	9.43	2.11

Recommended Cronbach's alpha coefficients that reflect internal scale validity are .70 or greater (Peterson, 1994). Three of the factors' Cronbach's alpha scores improved when specific questions were removed. In all three instances, the Cronbach's alpha scores improved with the removal of one question pertaining to each of the three factors. For the Communications Skills factor, I removed question 38 (Computer Skills rating) and Cronbach's alpha improved from .502 to .691 ($M = 6.52$, $SD = 1.89$). For the Group Work factor, I removed Question 48 ("In the past, I have not enjoyed working in assigned groups") and Cronbach's alpha improved from .677 to .781 ($M = 6.01$, $SD = 1.59$). Finally, for the Engineering Preview factor, I removed Question 44 ("Most of my friends that I 'hang out' with are studying engineering") and Cronbach's alpha improved from .498 to .682 (M = 6.68, SD = 1.71).

With these adjustments, the Cronbach's alpha scores for the 14 PFEAS factors are summarized in Table 42 below.

Table 42. Adjusted PFEAS Factors based upon removal of individual questions.

PFEAS Variable	Cronbach's Alpha	Strength of α	Keep/Eliminate
Career Expectations	0.808	Good	Keep
Jobs/Salary	0.613	Questionable	Keep
Society Contribution	0.734	Acceptable	Keep
Perception of Work	0.734	Acceptable	Keep
Math Enjoyment	0.709	Acceptable	Keep
Exact Science	0.568	Poor	Eliminate
Family Influence	0.478	Poor	Eliminate
Basic Knowledge	0.715	Acceptable	Keep
Communication Skills	0.691	Questionable	Keep
Study Habits	0.669	Questionable	Keep
Group Work	0.781	Acceptable	Keep
Problem Solving Ability	0.724	Acceptable	Keep
Engineering Abilities	0.675	Questionable	Keep
Engineering Preview	0.682	Questionable	Keep

Based on the Cronbach's alpha analysis, two of the 14 factors were eliminated from the study. "Exact Science" (α = .568) and "Family Influence" (α = .478) both had Cronbach's alpha scores below the .70 threshold. The remaining 12 variables' Cronbach's alpha coefficients provided the rationale for including each of the 12 factors in the study analysis as dependent variables. As described in an earlier section, the four independent variables involved in the analysis of Hypothesis 1C are the same four categorical variables that have been used in all other phases of Study 1.

Descriptive Statistics for Hypothesis 1C and the PFEAS variables

Descriptive statistics provide a framework for understanding the distribution of the results of the dependent variables (PFEAS values). The distributional properties of the PFEAS dependent variables are presented in Table 43.

Table 43. Distributional Properties of the Dependent Variable: 12 PFEAS Variables.

Variable	N	Min.	Max.	Mean	Std. Deviation	Skewness	Kurtosis
Career Expectations	709	22	45	36.37	4.38	-0.312	0.056
Jobs/Salary	717	6	20	13.12	2.31	0.066	0.321
Society Contribution	716	2	10	6.56	1.57	0.007	0.116
Perception of Work	717	4	65	28.78	3.60	0.075	21.943
Math Enjoyment	710	2	10	8.20	1.48	-0.912	1.033
Basic Knowledge	714	6	25	18.23	3.17	-0.399	0.386
Communication Skills	714	2	10	6.55	1.85	-0.179	-0.550
Study Habits	711	2	10	6.47	1.64	-0.052	-0.393
Group Work	715	2	10	6.01	1.59	0.063	-0.193
Problem Solving Ability	716	10	25	19.26	2.55	-0.063	0.316
Engineering Abilities	716	6	20	13.86	2.43	-0.105	-0.072
Engineering Preview	716	3	15	9.44	2.08	-0.345	0.099

I also calculated the 5% trimmed mean for the PFEAS variables. The 5% trimmed means are summarized in Table 44. None of the 5% trimmed means is substantially different from the overall sample means for the 12 PFEAS variables. As a result, I have concluded that extreme cases did not substantially affect the overall sample means.

Table 44. Distributional Properties of the Dependent Variable: 12 PFEAS Variables.

Variable	N	Mean	5% Trimmed Mean
Career Expectations	709	36.37	36.47
Jobs/Salary	717	13.12	13.11
Society Contribution	716	6.56	6.55
Perception of Work	717	28.78	28.85
Math Enjoyment	710	8.20	8.30
Basic Knowledge	714	18.23	18.31
Communication Skills	714	6.55	6.57
Study Habits	711	6.47	6.47
Group Work	715	6.01	6.01
Problem Solving Ability	716	19.26	19.28
Engineering Abilities	716	13.86	13.87
Engineering Preview	716	9.44	9.48

Finally, histograms of each of the PFEAS score distributions visually confirm that the data are approximately normally distributed (Figures 39 and 40). I included histograms of the PFEAS factors “Perceptions of Work” and “Math Enjoyment” because their distributions bear closer scrutiny than those of the other PFEAS variables. Perceptions of Work has a kurtosis of 21.943, which is unusually high. The questions comprising this factor ask respondents to describe how they believe the profession of engineering is perceived by other people and provide their own perceptions of the engineering profession. On the five-point Likert scale that was used in data collection, the third response choice was “Neutral.” It is feasible that respondents were uncomfortable projecting their views of the engineering profession in the abstract and so predominantly selected “Neutral.” It is likely that this led to the unusually high kurtosis of this factor.

The factor “Math Enjoyment” is skewed to the right with a kurtosis of -0.912. Again, it is likely that aspiring engineers would consider their abilities and perceptions of mathematics positively. As an admissions professional, I know that each of the subjects in the study had excellent math preparation and excelled in math in high school. It is within reason that their responses would reflect high levels of confidence in mathematics as a consequence. This may have led to the skew to the right in the distribution of responses to the Math Enjoyment PFEAS factor.

Figure 39. Histogram of Pitt Factor 4 Perceptions of Work.

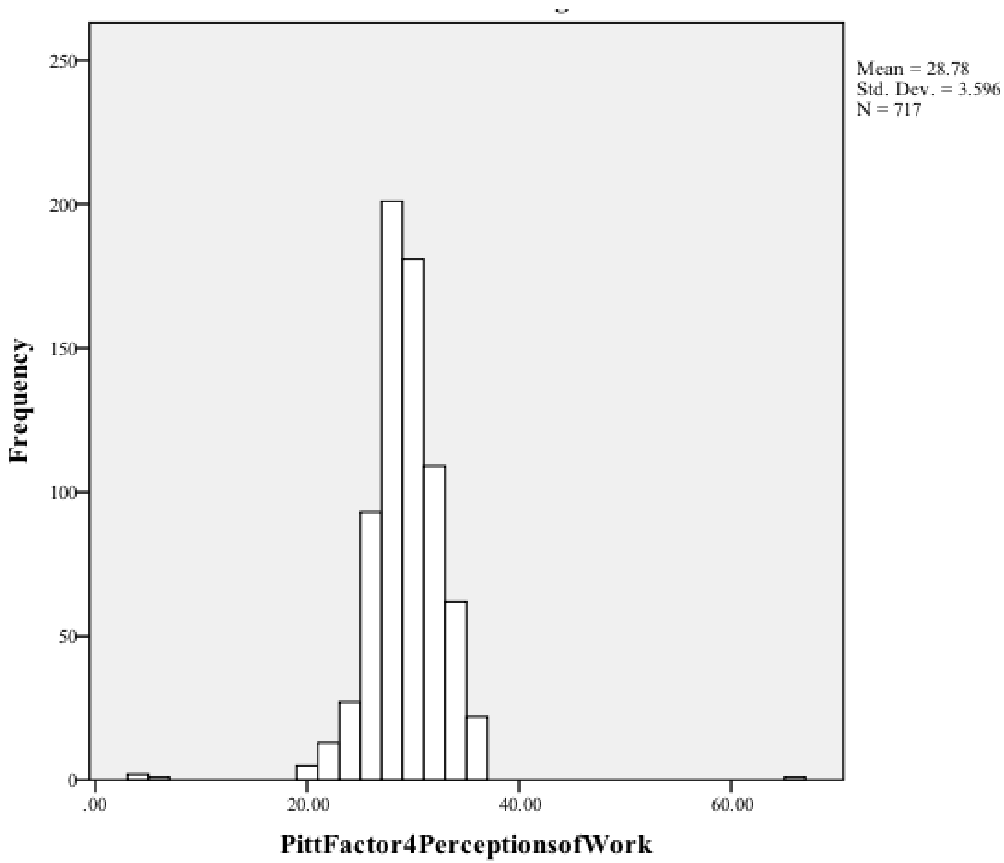
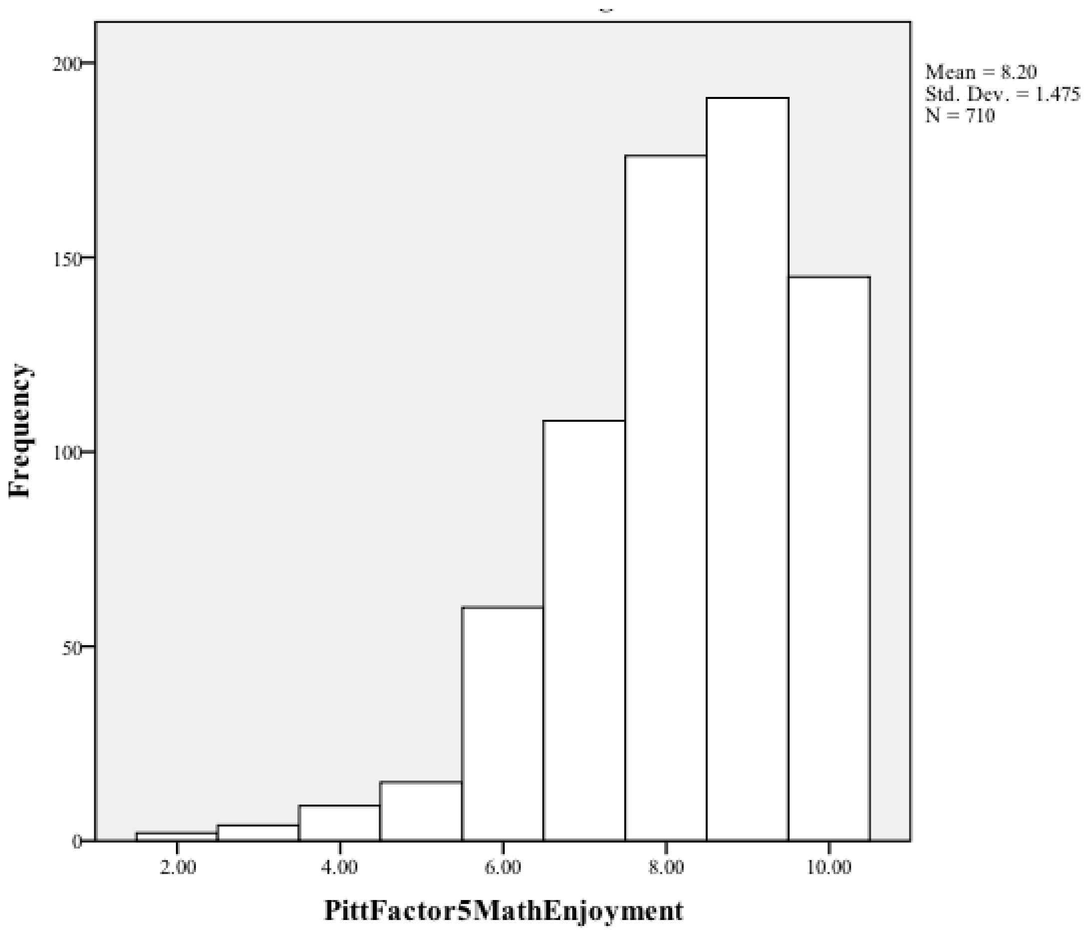


Figure 40. Histogram of Pitt Factor 5 Math Enjoyment.



Having described the data included in the analysis of Hypothesis 1C, I now proceed to the analysis used to determine whether there is a relationship between the PFEAS factors as proxies for confidence in engineering and high school TT participation.

Correlation Analysis of PFEAS Variables and Technical Team Variables

The goal of this part of the study is to determine, in accordance with Hypothesis 1C, whether there is a relationship between the PFEAS variables and the four dependent variables representing TT participation in high school. The null hypothesis is that no relationship exists between the PFEAS variables and high school TT participation or TT leadership. I used Pearson's *r* as a parametric measure of association. Table 45 presents the results of the Pearson's *r* correlations for the PFEAS variables and the four TT variables.

Table 45. Pearson r for PFEAS variables and four technical team variables.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Pearson's r Career Expectations	0.093*	0.028	0.091*	0.062
Sig. (2-tailed)	0.013	0.458	0.015	0.100
R^2 Coefficient of determination	0.86%	0.08%	0.83%	0.38%
N	709	709	709	709
Pearson's r Jobs/Salary	0.021	-0.027	0.001	-0.014
Sig. (2-tailed)	0.575	0.468	0.969	0.701
R^2 Coefficient of determination	0.04%	0.07%	0.00%	0.02%
N	717	717	717	717
Pearson's r Society Contribution	0.032	-0.004	-0.030	0.040
Sig. (2-tailed)	0.390	0.918	0.421	0.287
R^2 Coefficient of determination	0.10%	0.00%	0.09%	0.16%
N	716	716	716	716
Pearson's r Perception of Work	0.053	0.030	0.029	0.056
Sig. (2-tailed)	0.159	0.430	0.446	0.132
R^2 Coefficient of determination	0.28%	0.09%	0.08%	0.31%
N	717	717	717	717
Pearson's r Math Enjoyment	0.035	0.019	0.092*	0.026
Sig. (2-tailed)	0.357	0.608	0.014	0.482
R^2 Coefficient of determination	0.12%	0.04%	.085%	0.07%
N	710	710	710	710
Pearson's r Basic Knowledge	0.115**	0.007	0.131**	0.066
Sig. (2-tailed)	0.002	0.851	0.000	0.076
R^2 Coefficient of determination	1.32%	0.00%	1.72%	0.44%
N	714	714	714	714
Pearson's r Communication Skills	-0.023	-0.059	0.022	0.078*
Sig. (2-tailed)	0.538	0.118	0.551	0.036
R^2 Coefficient of determination	0.05%	0.35%	0.05%	0.61%
N	714	714	714	714
Pearson's r Study Habits	-0.022	0.031	0.021	-0.040
Sig. (2-tailed)	0.557	0.414	0.583	0.290
R^2 Coefficient of determination	0.05%	0.10%	0.04%	0.16%
N	711	711	711	711
Pearson's r Group Work	-0.064	-0.099**	-0.079*	-0.005
Sig. (2-tailed)	0.089	0.008	0.035	0.894
R^2 Coefficient of determination	0.41%	0.98%	0.62%	0.00%
N	715	715	715	715
Pearson r Problem Solving Ability	0.085*	-0.021	0.108**	0.061
Sig. (2-tailed)	0.023	0.583	0.004	0.104
R^2 Coefficient of determination	0.72%	0.04%	1.17%	0.37%
N	716	716	716	716
Pearson's r Engineering Abilities	0.102**	0.013	0.062	0.099**
Sig. (2-tailed)	0.006	0.720	0.099	0.008
R^2 Coefficient of determination	1.04%	0.013%	0.38*	0.98%
N	716	716	716	716
Pearson' r Engineering Preview	0.100**	0.036	0.082*	0.046
Sig. (2-tailed)	0.007	0.335	0.028	0.217
R^2 Coefficient of determination	1.00%	0.13%	0.67%	0.21%
N	716	716	716	716

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Summary of the Correlation Analysis of PFEAS variables and Technical Team Variables. Pearson product–moment correlation coefficients were calculated to examine the relationship between 12 PFEAS variables and self-reported high school TT participation. Both sets of data were collected by the August 2006 Entry Survey. Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity.

While 14 of the correlations found are statistically significant, none of the *r* values rises above the "small relationship" threshold defined by Cohen (1988). The largest *r* value is for the correlation between the PFEAS "Basic Knowledge" variable and the admissions committee–identified TT participation variable (r = .131). Additionally, none of the R^2 coefficients of determination rises above the 2% level. This would suggest that, even though there are 14 statistically significant correlations between the variables, the variance shared between any two variables never rises above 2%. The 14 statistically significant Pearson *r* correlations, and their associated R^2 coefficients, are isolated in Table 46.

The TT variable with the highest number of correlations with individual PFEAS variables is the admissions committee–identified TT participation variable, which has six statistically significant correlations with the PFEAS variables. The self-identified TT participation variable has five statistically significant correlations with the PFEAS variables, four of which overlap with the admissions committee–identified TT participation correlations.

Table 46. ISOLATED STATISTICALLY SIGNIFICANT Pearson *r* correlations for PFEAS variables and four technical team variables.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Pearson's *r* Career Expectations	0.093*		0.091*	
Sig. (2-tailed)	0.013		0.015	
R^2 Coefficient of determination	0.86%		0.83%	
N	709		709	
Pearson's *r* Math Enjoyment			0.092*	
Sig. (2-tailed)			0.014	
R^2 Coefficient of determination			.085%	
N			710	
Pearson's *r* Basic Knowledge	0.115**		0.131**	
Sig. (2-tailed)	0.002		0.000	
R^2 Coefficient of determination	1.32%		1.72%	
N	714		714	
Pearson's *r* Communication Skills				0.078*
Sig. (2-tailed)				0.036
R^2 Coefficient of determination				0.61%
N				714
Pearson's *r* Study Habits				
Sig. (2-tailed)				
R^2 Coefficient of determination				
N				
Pearson's *r* Group Work		-0.099**	-0.079*	
Sig. (2-tailed)		0.008	0.035	
R^2 Coefficient of determination		0.98%	0.62%	
N		715	715	
Pearson's *r* Problem Solving Ability	0.085*		0.108**	
Sig. (2-tailed)	0.023		0.004	
R^2 Coefficient of determination	0.72%		1.17%	
N	716		716	
Pearson's *r* Engineering Abilities	0.102**			0.099**
Sig. (2-tailed)	0.006			0.008
R^2 Coefficient of determination	1.04%			0.98%
N	716			716
Pearson's *r* Engineering Preview	0.100**		0.082*	
Sig. (2-tailed)	0.007		0.028	
R^2 Coefficient of determination	1.00%		0.67%	
N	716		716	

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Correlation Analysis of PFEAS and Technical Team Variables Based On Gender and URM Status.

The discussion now progresses to an analysis of the correlation between the PFEAS variables and the four TT variables with the gender and URM variables disaggregated from the sample population. The goal of this portion of the study is to understand the effect high school TT participation may have on students' confidence levels based on measurement of the PFEAS variables relative to gender and URM status.

Summary of the Correlation Analysis of PFEAS variables and Technical Team Variables by Gender. Table 47 presents the Pearson's *r* correlations when the sample is disaggregated by gender.

Table 47. Pearson r for PFEAS variables by gender.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Pearson's r Career Expectations MALE	0.072	0.018	0.081	0.053
Sig. (2-tailed)	0.109	0.694	0.070	0.235
R^2 Coefficient of determination	0.052%	0.03%	0.66%	0.28%
N	499	499	499	499
Pearson's r Career Expectations FEMALE	0.142*	0.051	0.110	0.083
Sig. (2-tailed)	0.040	0.462	0.111	0.230
R^2 Coefficient of determination	2.02%	0.26%	1.21%	0.69%
N	210	210	210	210
Pearson's r Jobs/Salary MALE	0.019	-0.044	0.005	-0.010
Sig. (2-tailed)	0.675	0.324	0.917	0.815
R^2 Coefficient of determination	0.04%	0.19%	0.00%	0.01%
N	503	503	503	503
Pearson's r Jobs/Salary FEMALE	0.027	0.024	-0.007	-0.024
Sig. (2-tailed)	0.699	0.726	0.922	0.729
R^2 Coefficient of determination	0.07%	0.06%	0.00%	0.06%
N	214	214	214	214
Pearson's r Society Contribution MALE	0.034	-0.014	-0.031	0.074
Sig. (2-tailed)	0.450	0.748	0.491	0.098
R^2 Coefficient of determination	0.12%	0.02%	0.10%	0.55%
N	503	503	503	503
Pearson's r Society Contribution FEMALE	0.024	0.023	-0.032	-0.039
Sig. (2-tailed)	0.726	0.739	0.642	0.572
R^2 Coefficient of determination	0.06%	0.05%	0.10%	0.15%
N	213	213	213	213
Pearson's r Perception of Work MALE	0.082	0.019	0.050	0.092*
Sig. (2-tailed)	0.066	0.677	0.263	0.038
R^2 Coefficient of determination	0.67%	0.04%	0.25%	0.85%
N	503	503	503	503
Pearson's r Perception of Work FEMALE	-0.003	0.061	-0.011	-0.012
Sig. (2-tailed)	0.961	0.374	0.872	0.857
R^2 Coefficient of determination	0.00%	0.37%	0.01%	0.01%
N	214	214	214	214
Pearson's r Math Enjoyment MALE	0.016	0.003	0.073	0.016
Sig. (2-tailed)	0.714	0.949	0.102	0.714
R^2 Coefficient of determination	0.03%	0.00%	0.53%	0.03%
N	500	500	500	500

Pearson's r Math Enjoyment FEMALE	0.079	0.066	0.136*	0.052
Sig. (2-tailed)	0.253	0.340	0.049	0.453
R^2 Coefficient of determination	0.62%	0.44%	1.85%	0.27%
N	210	210	210	210
Pearson's r Basic Knowledge MALE	0.072	0.018	0.110*	0.087
Sig. (2-tailed)	0.109	0.684	0.014	0.050
R^2 Coefficient of determination	0.52%	0.03%	1.21%	0.76%
N	501	501	501	501
Pearson's r Basic Knowledge FEMALE	0.206**	-0.070	0.171*	0.027
Sig. (2-tailed)	0.002	0.311	0.012	0.695
R^2 Coefficient of determination	4.24%	0.49%	2.92%	0.07%
N	213	213	213	213
Pearson's r Communication Skills MALE	-0.030	-0.073	-0.010	0.050
Sig. (2-tailed)	0.496	0.101	0.816	0.263
R^2 Coefficient of determination	0.09%	0.53%	0.01%	0.25%
N	501	501	501	501
Pearson's r Communication Skills FEMALE	0.006	-0.005	0.113	0.149*
Sig. (2-tailed)	0.929	0.942	0.100	0.030
R^2 Coefficient of determination	0.00%	0.00%	1.28%	2.22%
N	213	213	213	213
Pearson's r Study Habits MALE	0.015	0.035	-0.001	-0.052
Sig. (2-tailed)	0.739	0.430	0.987	0.247
R^2 Coefficient of determination	0.02%	0.12%	0.00%	0.27%
N	499	499	499	499
Pearson's r Study Habits FEMALE	-0.124	0.013	0.069	-0.011
Sig. (2-tailed)	0.071	0.855	0.317	0.876
R^2 Coefficient of determination	1.54%	0.02%	0.48%	0.01%
N	212	212	212	212
Pearson's r Group Work MALE	-0.104*	-0.115**	-0.065	-0.033
Sig. (2-tailed)	0.020	0.010	0.146	0.456
R^2 Coefficient of determination	1.08%	1.32%	0.42%	0.11%
N	502	502	502	502
Pearson's r Group Work FEMALE	0.041	-0.052	-0.109	0.063
Sig. (2-tailed)	0.550	0.454	0.113	0.361
R^2 Coefficient of determination	0.17%	0.27%	1.19%	0.40%
N	213	213	213	213
Pearson's r Problem Solving Ability MALE	0.064	-0.017	0.071	0.100*
Sig. (2-tailed)	0.154	0.703	0.111	0.024
R^2 Coefficient of determination	0.41%	0.03%	0.50%	1.00%
N	503	503	503	503
Pearson's r Problem Solving Ability FEMALE	0.127	-0.045	0.187**	-0.029
Sig. (2-tailed)	0.065	0.517	0.006	0.669
R^2 Coefficient of determination	1.61%	0.20%	3.50%	0.08%
N	213	213	213	213
Pearson's r Engineering Abilities MALE	0.104*	0.021	0.033	0.078
Sig. (2-tailed)	0.020	0.633	0.456	0.080
R^2 Coefficient of determination	1.08%	0.04%	0.11%	0.61%
N	503	503	503	503
Pearson's r Engineering Abilities FEMALE	0.082	-0.034	0.112	0.153*
Sig. (2-tailed)	0.231	0.624	0.104	0.026
R^2 Coefficient of determination	0.67%	0.12%	1.25%	2.34%
N	213	213	213	213
Pearson's r Engineering Preview MALE	0.077	0.024	0.066	0.019
Sig. (2-tailed)	0.083	0.585	0.141	0.674
R^2 Coefficient of determination	0.59%	0.06%	0.44%	0.04%
N	503	503	503	503
Pearson's r Engineering Preview FEMALE	0.140*	0.052	0.106	0.107
Sig. (2-tailed)	0.041	0.448	0.122	0.119
R^2 Coefficient of determination	1.96%	0.27%	1.12%	1.14%

N	213	213	213	213

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Pearson product–moment correlation coefficients were calculated to examine the relationship between the 12 PFEAS variables and self-reported high school TT experience by gender. Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity. The analysis revealed that, out of 96 possible correlations, there were 14 statistically significant correlations between the PFEAS variables and the four TT variables. Like the correlation analysis that was conducted between the PFEAS variables and the TT variables, none of the correlations rises above Cohen's "small relationship" definition (r = .10 to .29; Cohen, 1988) when the sample is disaggregated by gender. The largest Pearson's r value was for the correlation between the female PFEAS variable "Basic Knowledge" and the self-identified TT participation variable (r = 0.20, N = 213). Although the correlations between 14 of the PFEAS variables and the four TT variables were statistically significant, the effects of the relationships between the variables should be classified as weak.

Similarly, the R^2 coefficient of determination values was also small. The largest R^2 value was for the correlation between the female "Basic Knowledge" PFEAS variable and the self-identified TT participation variable (R^2 = 4.24%, N = 213). This suggests that, although the variables are correlated, they share only 4.23% of their variance.

Table 48 presents the statistically significant correlations between the PFEAS variables and the four TT variables disaggregated by gender.

Tale 48. ISOLATED STATISTICALLY SIGNIFICANT Pearson r correlations for PFEAS variables and four technical team variables – disaggregated by gender.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Pearson's r Career Expectations MALE				
Sig. (2-tailed)				
R^2 Coefficient of determination				
N				
Pearson's r Career Expectations FEMALE	0.142*			
Sig. (2-tailed)	0.040			
R^2 Coefficient of determination	2.02%			
N	210			
Pearson's r Perception of Work MALE				0.092*
Sig. (2-tailed)				0.038
R^2 Coefficient of determination				0.85%
N				503
Pearson's r Math Enjoyment FEMALE			0.136*	
Sig. (2-tailed)			0.049	
R^2 Coefficient of determination			1.85%	
N			210	
Pearson's r Basic Knowledge MALE			0.110*	
Sig. (2-tailed)			0.014	
R^2 Coefficient of determination			1.21%	
N			501	
Pearson's r Basic Knowledge FEMALE	0.206**		0.171*	
Sig. (2-tailed)	0.002		0.012	
R^2 Coefficient of determination	4.24%		2.92%	
N	213		213	
Pearson's r Communication Skills FEMALE				0.149*
Sig. (2-tailed)				0.030
R^2 Coefficient of determination				2.22%
N				213
Pearson's r Group Work MALE	-0.104*	-0.115**		
Sig. (2-tailed)	0.020	0.010		
R^2 Coefficient of determination	1.08%	1.32%		
N	502	502		
Pearson's r Problem Solving Ability MALE				0.100*
Sig. (2-tailed)				0.024
R^2 Coefficient of determination				1.00%
N			503	503
Pearson's r Problem Solving Ability FEMALE			0.187**	
Sig. (2-tailed)			0.006	
R^2 Coefficient of determination			3.50%	
N			213	
Pearson's r Engineering Abilities MALE	0.104*			
Sig. (2-tailed)	0.020			
R^2 Coefficient of determination	1.08%			
N	503			
Pearson's r Engineering Abilities FEMALE				0.153*
Sig. (2-tailed)				0.026
R^2 Coefficient of determination				2.34%
N				213
Pearson's r Engineering Preview FEMALE	0.140*			
Sig. (2-tailed)	0.041			
R^2 Coefficient of determination	1.96%			

N	213

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Summary of the Correlation Analysis of the PFEAS variables and Technical Team Variables by URM Status. Table 49 presents the Pearson's *r* correlations when the sample is disaggregated by URM status.

Table 49. Pearson r for PFEAS variables by URM/MAJORITY STATUS.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Pearson's r Career Expectations MAJORITY	0.084*	0.009	0.091*	0.062
Sig. (2-tailed)	0.032	0.820	0.020	0.113
R^2 Coefficient of determination	0.71%	0.01%	0.83%	0.38%
N	652	652	652	652
Pearson's r Career Expectations URM	0.257	0.206	0.192	0.134
Sig. (2-tailed)	0.053	0.124	0.153	0.319
R^2 Coefficient of determination	6.60%	4.24%	3.69%	1.80%
N	57	57	57	57
Pearson's r Jobs/Salary MAJORITY	0.023	-0.033	0.015	-0.023
Sig. (2-tailed)	0.550	0.395	0.696	0.560
R^2 Coefficient of determination	0.05%	0.11%	0.02%	0.05%
N	660	660	660	660
Pearson's r Jobs/Salary URM	0.022	0.011	-0.090	0.151
Sig. (2-tailed)	0.869	0.938	0.504	0.262
R^2 Coefficient of determination	0.05%	0.01%	0.81%	2.28%
N	57	57	57	57
Pearson's r Society Contribution MAJORITY	0.023	-0.022	-0.023	0.043
Sig. (2-tailed)	0.564	0.576	0.555	0.274
R^2 Coefficient of determination	0.05%	0.02%	0.05%	0.18%
N	659	659	659	659
Pearson's r Society Contribution URM	0.163	0.193	-0.135	-0.008
Sig. (2-tailed)	0.225	0.151	0.316	0.951
R^2 Coefficient of determination	2.66%	3.72%	1.82%	0.01%
N	57	57	57	57
Pearson's r Perception of Work MAJORITY	0.061	0.012	0.041	0.075
Sig. (2-tailed)	0.116	0.760	0.298	0.053
R^2 Coefficient of determination	0.37%	0.01%	0.17%	0.56%
N	660	660	660	660
Pearson's r Perception of Work URM	0.037	0.111	0.016	-0.013
Sig. (2-tailed)	0.787	0.412	0.904	0.924
R^2 Coefficient of determination	0.14%	1.23%	0.03%	0.02%
N	57	57	57	57
Pearson's r Math Enjoyment MAJORITY	0.028	0.005	0.084*	0.019
Sig. (2-tailed)	0.467	0.906	0.032	0.629
R^2 Coefficient of determination	0.08%	0.00%	0.71%	0.04%
N	655	655	655	655
Pearson's r Math Enjoyment URM	0.117	0.157	0.202	0.137
Sig. (2-tailed)	0.395	0.251	0.139	0.318
R^2 Coefficient of determination	1.37%	2.46%	4.08%	1.88%

N	55	55	55	55
Pearson's r Basic Knowledge MAJORITY	0.129**	0.002	0.140**	0.058
Sig. (2-tailed)	0.001	0.950	0.000	0.139
R^2 Coefficient of determination	1.66%	0.00%	1.96%	0.34%
N	658	658	658	658
Pearson's r Basic Knowledge URM	-0.058	0.054	0.012	0.183
Sig. (2-tailed)	0.672	0.695	0.928	0.177
R^2 Coefficient of determination	0.34%	0.29%	0.01%	3.35%
N	56	56	56	56
Pearson's r Communication Skills MAJORITY	-0.018	-0.045	0.040	0.092*
Sig. (2-tailed)	0.652	0.245	0.308	0.019
R^2 Coefficient of determination	0.02%	0.05%	0.16%	0.85%
N	658	658	658	658
Pearson's r Communication Skills URM	-0.075	-0.204	-0.154	-0.070
Sig. (2-tailed)	0.584	0.131	0.256	0.610
R^2 Coefficient of determination	0.56%	1.72%	2.37%	0.49%
N	56	56	56	56
Pearson's r Study Habits MAJORITY	-0.027	0.023	0.014	-0.026
Sig. (2-tailed)	0.497	0.563	0.730	0.500
R^2 Coefficient of determination	0.07%	0.05%	0.02%	0.07%
N	655	655	655	655
Pearson's r Study Habits URM	0.065	0.148	0.179	-0.166
Sig. (2-tailed)	0.633	0.278	0.188	0.222
R^2 Coefficient of determination	0.42%	2.19%	3.20%	2.76%
N	56	56	56	56
Pearson's r Group Work MAJORITY	-0.051	-0.075	-0.059	0.009
Sig. (2-tailed)	0.190	0.053	0.128	0.827
R^2 Coefficient of determination	0.26%	0.56%	0.35%	0.01%
N	658	658	658	658
Pearson's r Group Work URM	-0.224	-0.319*	-0.351**	-0.214
Sig. (2-tailed)	0.094	0.016	0.008	0.110
R^2 Coefficient of determination	5.02%	10.18%	12.32%	4.58%
N	57	57	57	57
Pearson's r Problem Solving Ability MAJORITY	0.114**	0.005	0.128**	0.083*
Sig. (2-tailed)	0.003	0.891	0.001	0.032
R^2 Coefficient of determination	1.30%	0.00%	1.64%	0.69%
N	659	659	659	659
Pearson's r Problem Solving Ability URM	-0.252	-0.260	-0.132	-0.248
Sig. (2-tailed)	0.058	0.051	0.328	0.063
R^2 Coefficient of determination	6.35%	6.76%	1.74%	6.15%
N	57	57	57	57
Pearson's r Engineering Abilities MAJORITY	0.133**	0.021	0.061	0.111**
Sig. (2-tailed)	0.001	0.599	0.117	0.004
R^2 Coefficient of determination	1.77%	0.04%	0.37%	1.23%
N	659	659	659	659
Pearson's r Engineering Abilities URM	-0.250	-0.046	0.052	-0.067
Sig. (2-tailed)	0.061	0.732	0.702	0.621
R^2 Coefficient of determination	6.25%	0.21%	0.27%	0.45%
N	57	57	57	57
Pearson's r Engineering Preview MAJORITY	0.114**	0.061	0.090*	0.064
Sig. (2-tailed)	0.003	0.115	0.021	0.099
R^2 Coefficient of determination	1.30%	0.37%	0.81%	0.41%
N	659	659	659	659
Pearson's r Engineering Preview URM	-0.050	-0.234	0.042	-0.169
Sig. (2-tailed)	0.714	0.079	0.755	0.209
R^2 Coefficient of determination	0.25%	5.48%	0.18%	2.86%
N	57	57	57	57

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

Pearson product–moment correlation coefficients were calculated to examine the relationship between the PFEAS variables and self-reported high school TT experience (as measured by the August 2006 Entry Survey) with respect to URM status. Prior to the analysis, the variables were examined for violations of assumptions of normality, linearity, and homoscedasticity. Fifteen of the 96 possible correlations reached the level of statistical significance in this portion of the study. However, of the 15 PFEAS variables that exhibited statistically significant correlations, only one ("Group Work") reached "medium" relationship strength by reference to Pearson's *r* values as defined by Cohen (1988). The PFEAS variable "Group Work" was negatively correlated with self-identified TT leadership participation (r = -0.318, N = 57, $p < .05$) and with admissions committee–identified TT participation (r = -0.319, N = 57, $p < .01$).

As was true of the other PFEAS correlation analysis, the R^2 coefficients of determination for the 15 statistically significant correlations were low. Thirteen of the correlations recorded R^2 coefficients that were less than 2%. While these correlations are statistically significant, the correlation analysis reveals that the shared variance between the variables is less than 2%. The PFEAS variable "Group Work" had the largest R^2 coefficients (self-identified TT leadership participation and Group Work: R^2 = 10.2%, N = 57; admissions committee–identified TT participation: R^2 = 12.3%, N = 57). It is worth noting again that both correlations were negative.

Finally, there are two interesting points to note regarding the URM/majority status PFEAS correlation analysis. While some of the correlation results are not statistically significant, they bear consideration nonetheless. The first point involves the three PFEAS variables "Problem Solving Ability," "Engineering Abilities," and

“Engineering Preview.” What is interesting in the results is that for each of the three PFEAS variables, the correlation results for the majority subjects were exclusively positive, with seven of the 12 possible correlations also showing statistically significant relationships. For the URM subjects, however, 10 of the 12 correlations between the three PFEAS variables and the four TT variables were negative (although none of the correlations was statistically significant).

The second point involves the PFEAS variable “Group Work.” For majority subjects, three of the four correlations were negative, although none was statistically significant. For the URM subjects, all four possible correlations were negative, with two (self-identified TT leadership experience and admissions committee–identified TT participation) being statistically significant. The fact that so many of the correlations were negative, and that the direction of the correlations was consistent across both populations, is interesting.

The main point of interest regarding these findings is that the traits, or characteristics, the variables are measuring (“Group Work,” “Problem Solving Ability,” “Engineering Abilities,” and “Engineering Preview”) are central to technical teams as well as to success in engineering. Their consistency (in the case of “Group Work”) and divergence (in the cases of “Problem Solving Ability,” “Engineering Abilities,” and “Engineering Preview”) will be discussed in Chapter 6. Table 50 presents the statistically significant correlations between the PFEAS variables and the four TT variables disaggregated by URM/majority status. The table leaves intact the four PFEAS variables of interest: “Group Work,” “Problem Solving Ability,” “Engineering Abilities,” and “Engineering Preview.”

Table 50. ISOLATED STATISTICALLY SIGNIFICANT Pearson r for PFEAS variables by URM/MAJORITY STATUS.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Pearson's r Career Expectations MAJORITY	0.084*		0.091*	
Sig. (2-tailed)	0.032		0.020	
R^2 Coefficient of determination	0.71%		0.83%	
N	652		652	
Pearson's r Math Enjoyment MAJORITY			0.084*	
Sig. (2-tailed)			0.032	
R^2 Coefficient of determination			0.71%	
N			655	
Pearson's r Basic Knowledge MAJORITY	0.129**		0.140**	
Sig. (2-tailed)	0.001		0.000	
R^2 Coefficient of determination	1.66%		1.96%	
N	658		658	
Pearson's r Communication Skills MAJORITY				0.092*
Sig. (2-tailed)				0.019
R^2 Coefficient of determination				0.85%
N				658
Pearson's r Group Work MAJORITY	-0.051	-0.075	-0.059	0.009
Sig. (2-tailed)	0.190	0.053	0.128	0.827
R^2 Coefficient of determination	0.26%	0.56%	0.35%	0.01%
N	658	658	658	658
Pearson's r Group Work URM	-0.224	-0.319*	-0.351**	-0.214
Sig. (2-tailed)	0.094	0.016	0.008	0.110
R^2 Coefficient of determination	5.02%	10.18%	12.32%	4.58%
N	57	57	57	57
Pearson's r Problem Solving Ability MAJORITY	0.114**		0.128**	0.083*
Sig. (2-tailed)	0.003		0.001	0.032
R^2 Coefficient of determination	1.30%		1.64%	0.69%
N	659		659	659
Pearson r Problem Solving Ability URM	-0.252	-0.260	-0.132	-0.248
Sig. (2-tailed)	0.058	0.051	0.328	0.063
R^2 Coefficient of determination	6.35%	6.76%	1.74%	6.15%
N	57	57	57	57
Pearson's r Engineering Abilities MAJORITY	0.133**	0.021	0.061	0.111**
Sig. (2-tailed)	0.001	0.599	0.117	0.004
R^2 Coefficient of determination	1.77%	0.04%	0.37%	1.23%
N	659	659	659	659
Pearson's r Engineering Abilities URM	-0.250	-0.046	0.052	-0.067
Sig. (2-tailed)	0.061	0.732	0.702	0.621
R^2 Coefficient of determination	6.25%	0.21%	0.27%	0.45%
N	57	57	57	57
Pearson's r Engineering Preview MAJORITY	0.114**	0.061	0.090*	0.064
Sig. (2-tailed)	0.003	0.115	0.021	0.099
R^2 Coefficient of determination	1.30%	0.37%	0.81%	0.41%
N	659	659	659	659
Pearson's r Engineering Preview URM	-0.050	-0.234	0.042	-0.169
Sig. (2-tailed)	0.714	0.079	0.755	0.209
R^2 Coefficient of determination	0.25%	5.48%	0.18%	2.86%
N	57	57	57	57

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

A further purpose of the study was to determine whether high school TT experiences contributed to the PFEAS variable scores when controlling for the effects of gender, URM status, and socio-economic status. Multiple regression was used to accomplish this goal.

Regression Analysis of the PFEAS variables and Technical Team Variables

An objective of this portion of the study is to determine whether a relationship exists between the twelve PFEAS dependent variables and the four independent TT variables, while holding gender, URM status, and socio-economic status constant. I calculated a standard multiple regression to predict the PFEAS variables based on high school TT participation. The variables listed in Table 51 were included in the regression analysis.

Table 51. Variables included in the PFEAS multiple regression model.

Dependent variables	**Independent Variables**	**Control Variables**
Career Expectations	Self-Identified High School Technical Team Experience	URM
Jobs/Salary	Self-Identified High School Technical Team Leadership	Gender
Society Contribution	Admissions Committee–Identified High School Technical Team Experience	Unified Parental Education
Perception of Work	Admissions Committee–Identified High School Technical Team Leadership	Number of Family-Owned Bookshelves
Math Enjoyment		
Basic Knowledge		
Communication Skills		
Study Habits		
Group Work		
Problem Solving Ability		
Engineering Abilities		
Engineering Preview		

Three measures indicate how well the model fits the data: the multiple correlation coefficient (*R*) and the two measures indicating the total variation explained, which are the R^2 and adjusted R^2 results.

For the model predicting the PFEAS results with the independent variables of self-reported high school TT participation, self-reported high school TT leadership, admissions committee–identified TT participation, admissions committee–identified TT leadership, gender, URM status, unified parental education, and number of bookshelves in the home, Table 52 presents the model summary.

Table 52: Model Summary for PFEAS.

Dependent Variables	R	R Square	Adjusted R Square
Career Expectations	0.186	0.035	0.024
Jobs/Salary	0.122	0.015	0.004
Society Contribution	0.095	0.009	-0.002
Perception of Work	0.152	0.023	0.012
Math Enjoyment	0.132	0.017	0.006
Basic Knowledge	0.390	0.152	0.142
Communication Skills	0.184	0.034	0.023
Study Habits	0.160	0.026	0.015
Group Work	0.138	0.019	0.008
Problem Solving Ability	0.181	0.033	0.022
Engineering Abilities	0.253	0.064	0.053
Engineering Preview	0.189	0.036	0.025
Predictors	self-reported high school technical team experience, self-reported high school technical team leadership, admissions committee–identified technical team experience, admissions committee–identified technical team leadership, gender, URM status, unified parental education, and number of bookshelves in the home		

Based on Muijs (2011, p. 145), adjusted R^2 values <.10 imply that the model is a poor fit for the data and that the effect size is minimal. One of the 12 PFEAS regression models meets Muijs's threshold for a "modest" fit: Basic Knowledge (Adjusted R^2 = 0.142). The remaining PFEAS variables' adjusted R^2 values fall into the poor fit category.

Statistical significance of the models

An ANOVA signifies the level of the overall statistical significance of each of the 11 regression models. The ANOVA results that determine whether self-identified high school TT participation, self-identified high TT leadership, admissions committee–identified TT participation, admissions committee–identified TT leadership, gender, URM status, unified parental education level, and number of bookshelves in the home statistically predict the 12 PFEAS are summarized in Table 53.

Table 53. ANOVA Summary for the PFEAS variables.

Dependent Variables	Df	F	Sig. ($p < .0005$)
Career Expectations	(8, 696)	3.12	0.002*
Jobs/Salary	(8, 704)	1.33	0.228
Society Contribution	(8, 703)	0.802	0.601
Perception of Work	(8, 704)	2.08	0.036
Math Enjoyment	(8, 697)	1.55	0.137
Basic Knowledge	(8, 701)	15.73	0.000*
Communication Skills	(8, 701)	3.06	0.002*
Study Habits	(8, 698)	6.09	0.019*
Group Work	(8, 702)	1.70	0.094
Problem Solving Ability	(8, 703)	2.98	0.003*
Engineering Abilities	(8, 703)	5.99	.000*
Engineering Preview	(8, 704)	3.25	.001*
Predictors	self-reported high school technical team experience, self-reported high school technical team leadership, admissions committee–identified technical team experience, admissions committee–identified technical team leadership, gender, URM status, unified parental education, and number of bookshelves in the home		
Note. * sig. at the $p < .05$ level.			

The ANOVA indicates that seven of the 12 models have at least one independent variable that statistically predicts a dependent PFEAS variable. It also indicates that the seven statistically significant regression models are a better fit at predicting the dependent variables than the mean model alone. Tables 54–65 present the unstandardized coefficients for each of the 12 PFEAS regression models.

Table 54. Unstandardized Coefficients for PFEAS variable 1: Career Expectations.

	Unstandardized B	SE_B	β	Sig.
Constant	35.701	0.610	-	0.000
SELFTTBinary	0.953	0.479	0.082	0.047*
SELFTTLeaderBinary	-0.697	1.102	-0.026	0.527
CTTEEEXPnew2	0.618	0.386	0.065	0.110
CTTLDnew2	0.490	0.551	0.036	0.374
SexNum	-0.588	0.359	-0.061	0.102
URM_Binary	1.683	0.607	0.105	0.006*
UnifiedParentEd	-0.042	0.043	-0.041	0.319
Q117NUMBEROFBOOKSHELVES	0.260	0.143	0.074	0.069
Note. * sig. at the p < .05 level.				

Self-reported technical team participation (SELFTTBinary) and being a URM student both predicted Career Expectations to a statistically significant extent (*F*[8, 696] = 3.12, *p* = < .05), accounting for 3.5% of the changes in Career Expectations with adjusted R^2 = 2.4%.

Table 55. Unstandardized Coefficients for PFEAS variable 2: Jobs/Salary.

	Unstandardized B	SE_B	β	Sig.
Constant	13.202	0.321	-	0.000
SELFTTBinary	0.258	0.254	0.042	0.310
SELFTTLeaderBinary	-0.621	0.587	-0.043	0.291
CTTEEEXPnew2	0.016	0.205	0.003	0.939
CTTLDnew2	-0.051	0.290	-0.007	0.861
SexNum	0.023	0.190	0.005	0.904
URM_Binary	0.764	0.323	0.090	0.018*
UnifiedParentEd	-0.034	0.023	-0.063	0.130
Q117NUMBEROFBOOKSHELVES	0.075	0.076	0.041	0.321
Note. * sig. at the p < .05 level.				

URM status predicted Jobs/Salary to a statistically significant extent (F[8, 704] = 1.33, *p* = < .05), accounting for 1.5% of the changes in Jobs/Salary with adjusted R^2 = 0.4%.

Table 56. Unstandardized Coefficients for PFEAS variable 3: Society Contribution.

	Unstandardized *B*	***SE_B***	***β***	**Sig.**
Constant	6.827	0.219	-	0.000
SELFTTBinary	0.202	0.174	0.048	0.245
SELFTTLeaderBinary	-0.257	0.400	-0.026	0.520
CTTEEEXPnew2	-0.204	0.140	-0.060	0.144
CTTLDnew2	0.313	0.198	0.064	0.114
SexNum	-0.108	0.130	-0.031	0.406
URM_Binary	-0.067	0.220	-0.012	0.762
UnifiedParentEd	-0.016	0.015	-0.043	0.305
Q117NUMBEROFBOOKSHELVES	-0.007	0.052	-0.006	0.888
Note. *** sig. at the *p* < .05 level.**				

None of the independent variables predicted Society Contribution to a statistically significant extent.

Table 57. Unstandardized Coefficients for PFEAS variable 4: Perception of Work.

	Unstandardized B	**SE_B**	**β**	**Sig.**
Constant	28.489	0.498	-	0.000
SELFTTBinary	0.480	0.394	0.050	0.224
SELFTTLeaderBinary	-0.003	0.911	0.000	0.997
CTTEEEXPnew2	0.036	0.318	0.005	0.910
CTTLDnew2	0.557	0.450	0.049	0.216
SexNum	0.327	0.295	0.042	0.267
URM_Binary	1.741	0.501	0.131	0.001*
UnifiedParentEd	0.004	0.035	0.004	0.919
Q117NUMBEROFBOOKSHELVES	-0.045	0.117	-0.016	0.699
Note. * sig. at the p < .05 level.				

URM status predicted Perception of Work to a statistically significant extent (F[8, 704] = 2.08, p = < .05), accounting for 2.3% of the changes in Perception of Work with adjusted R^2 = 1.2%.

Table 58. Unstandardized Coefficients for PFEAS variable 5: Math Enjoyment.

	Unstandardized B	SE_B	β	Sig.
Constant	8.474	0.205	-	0.000
SELFTTBinary	0.031	0.163	0.008	0.848
SELFTTLeaderBinary	0.026	0.375	0.003	0.945
CTTEEEXPnew2	0.285	0.131	0.088	0.030*
CTTLDnew2	-0.003	0.186	-0.001	0.987
SexNum	-0.125	0.122	-0.039	0.304
URM_Binary	0.029	0.209	0.005	0.889
UnifiedParentEd	-0.001	0.014	-0.002	0.965
Q117NUMBEROFBOOKSHELVES	-0.095	0.049	-0.081	0.051
Note. * sig. at the p < .05 level.				

Admissions committee–identified TT participation (CTTEEEXPnew2) predicted Math Enjoyment to a statistically extent (F[8, 697] = 1.55, p = < .05), accounting for 1.7% of the changes in Math Enjoyment with adjusted R^2 = 0.6%.

Table 59. Unstandardized Coefficients for PFEAS variable 6: Basic Knowledge.

	Unstandardized B	SE_B	β	Sig.
Constant	18.084	0.408	-	0.000
SELFTTBinary	0.845	0.323	0.100	0.009*
SELFTTLeaderBinary	-1.022	0.745	-0.062	0.102
CTTEEEXPnew2	0.610	0.260	0.088	0.019*
CTTLDnew2	0.281	0.370	0.028	0.477
SexNum	-2.45	0.242	-0.355	0.000*
URM_Binary	-0.293	0.414	-0.025	0.480
UnifiedParentEd	-0.005	0.029	-0.007	0.865
Q117NUMBEROFBOOKSHELVES	0.188	0.096	0.074	0.051
Note. * sig. at the p < .05 level.				

Self-identified TT participation (SELFTTBinary) and admissions committee–identified TT participation predicted Basic Knowledge to a statistically significant extent (F[8, 701] = 15.73, p = < .05), accounting for 1.5% of the changes in Basic Knowledge with adjusted R^2 = 1.42%.

Table 60. Unstandardized Coefficients for PFEAS variable 7: Communication Skills.

	Unstandardized B	SE_B	β	Sig.
Constant	5.849	0.255	-	0.000
SELFTTBinary	-0.034	0.201	-0.007	0.865
SELFTTLeaderBinary	-0.899	0.465	-0.078	0.054
CTTEEEXPnew2	0.054	0.162	0.013	0.738
CTTLDnew2	0.517	0.231	0.089	0.026*
SexNum	0.362	0.151	0.090	0.017*
URM_Binary	0.564	0.258	0.082	0.029*
UnifiedParentEd	0.010	0.018	0.023	0.580
Q117NUMBEROFBOOKSHELVES	0.113	0.060	0.077	0.061
Note. * sig. at the p < .05 level.				

Admissions committee–identified TT leadership experience (CTTLDnew2), gender (SexNum), and URM status (URM_Binary) predicted Communication Skills to a statistically significant extent ($F[8, 701] = 3.06$, $p = < .05$), accounting for 3.4% of the changes in Communication Skills with adjusted $R^2 = 2.3\%$.

Table 61. Unstandardized Coefficients for PFEAS variable 8: Study Habits.

	Unstandardized B	SE_B	β	Sig.
Constant	6.92	0.227	-	0.000
SELFTTBinary	-0.188	0.180	-0.043	0.296
SELFTTLeaderBinary	0.536	0.422	0.052	0.205
CTTEEEXPnew2	0.165	0.145	0.046	0.253
CTTLDnew2	-0.259	0.209	-0.049	0.215
SexNum	-0.102	0.134	-0.029	0.447
URM_Binary	0.503	0.229	0.083	0.029*
UnifiedParentEd	-0.001	0.016	-0.004	0.928
Q117NUMBEROFBOOKSHELVES	-0.133	0.054	-0.102	0.013*
Note. * sig. at the p < .05 level.				

URM status (URM_Binary) and the number of bookshelves in the family home (Q117NUMBEROFBOOKSHELVES) predicted Study Habits to a statistically significant extent ($F[8, 698] = 6.09$, $p = < .05$), accounting for 2.6% of the changes in Study Habits with adjusted $R^2 = 1.9\%$.

Table 62. Unstandardized Coefficients for PFEAS variable 9: Group Work.

	Unstandardized B	SE_B	β	Sig.
Constant	6.162	0.221	-	0.000
SELFTTBinary	-0.076	0.175	-0.018	0.664
SELFTTLeaderBinary	-0.893	0.404	-0.090	0.027*
CTTEEEXPnew2	-0.249	0.141	-0.071	0.079
CTTLDnew2	0.215	0.201	0.043	0.285
SexNum	0.082	0.131	0.024	0.530
URM_Binary	-0.250	0.223	-0.043	0.262
UnifiedParentEd	-0.014	-.016	-0.038	0.360
Q117NUMBEROFBOOKSHELVES	0.034	0.052	0.027	0.511
Note. * sig. at the p < .05 level.				

Self-identified high school TT leadership experience predicted Group Work to a statistically significant extent ($F[8, 702] = 1.70$, $p = < .05$), accounting for 1.9% of the changes in Group Work with adjusted $R^2 = 0.8\%$.

Table 63. Unstandardized Coefficients for PFEAS variable 10: Problem Solving Ability.

	Unstandardized B	SE_B	β	Sig.
Constant	18.821	0.351	-	0.000
SELFTTBinary	0.559	0.278	0.082	0.044*
SELFTTLeaderBinary	-1.19	0.641	-0.075	0.064
CTTEEEXPnew2	0.466	0.224	0.084	0.038*
CTTLDnew2	0.246	0.318	0.031	0.440
SexNum	-0.609	0.208	-0.109	0.003*
URM_Binary	-0.029	0.353	-0.003	0.934
UnifiedParentEd	0.010	0.025	0.017	0.686
Q117NUMBEROFBOOKSHELVES	0.080	0.083	0.039	0.334
Note. * sig. at the p < .05 level.				

Self-identified high school TT participation, admissions committee–identified TT participation, and gender predicted Problem Solving Ability to a statistically significant extent ($F[8, 703] = 2.98$, $p = < .05$), accounting for 3.3% of the changes in Problem Solving Ability with adjusted $R^2 = 2.2\%$.

Table 64. Unstandardized Coefficients for PFEAS variable 11: Engineering Abilities.

	Unstandardized B	SE_B	β	Sig.
Constant	13.72	0.330	-	0.000
SELFTTBinary	0.658	0.261	0.102	0.012*
SELFTTLeaderBinary	-0.768	0.603	-0.051	0.203
CTTEEEXPnew2	0.030	0.210	0.006	0.887
CTTLDnew2	0.676	0.299	0.088	0.024*
SexNum	-1.10	0.195	-0.208	.000*
URM_Binary	-0.279	0.332	-0.031	0.400
UnifiedParentEd	-0.007	0.023	-0.012	0.759
Q117NUMBEROFBOOKSHELVES	0.118	0.078	0.061	0.129
Note. * sig. at the p < .05 level.				

Self-identified high school TT participation, admissions committee–identified TT leadership experience, and gender predicted Engineering Abilities to a statistically significant extent (*F*[8, 703] = 5.99, *p* = < .05), accounting for 6.4% of the changes in Engineering Abilities with adjusted R^2 = 5.3%.

Table 65. Unstandardized Coefficients for PFEAS variable 12: Engineering Preview.

	Unstandardized *B*	SE_B	*β*	Sig.
Constant	6.60	0.235	-	0.000
SELFTTBinary	0.418	0.186	0.092	.025*
SELFTTLeaderBinary	0.119	0.429	0.011	0.781
CTTEEEXPnew2	0.132	0.150	0.035	0.379
CTTLDnew2	0.150	0.212	0.028	0.480
SexNum	-0.306	0.139	-0.082	0.028*
URM_Binary	0.576	0.236	0.092	0.015*
UnifiedParentEd	-0.024	0.017	-0.059	0.149
Q117NUMBEROFBOOKSHELVES	0.088	0.055	0.064	0.113
Note. *** sig. at the *p* < .05 level.**				

Self-identified high school TT participation, gender, and URM status predicted Engineering Preview to a statistically significant extent (*F*[8, 704] = 3.25, *p* = < .05), accounting for 3.6% of the changes in Engineering Abilities with adjusted R^2 = 2.5%.

CHAPTER 5

STUDY 2 ANALYSIS: TECHNICAL TEAM PARTICIPATION AND SOCIAL CAPITAL

Introduction

The purpose of this chapter is to describe the analysis conducted for Study 2. The focus of Study 2 is to understand how high school technical team (TT) participation may affect engineering-specific social capital. The chapter includes a description of the Study 2 hypothesis, a description of the study sample, descriptive statistics, and the series of statistical tests used to test the hypothesis. The chapter reports the Study 2 analysis, which includes study sample distributions, univariate analysis, correlations, bivariate analysis, simple multiple regression, and a statement of the key findings derived from the study.

Study 2 represents the heart of the original research question that spawned the full study. As an admissions officer, I noticed that some applicants with high school TT experiences were able to describe engineering in ways that applicants who did not have high school TT experience could not. The TT participants had a more profound and complex sense of engineering and many referenced robust networks of engineers with whom they had worked on their TT projects. Many of the TT participants seemed aware that working with experienced engineers was providing them with engineering-related insights and, in some cases, admissions advantages. While the technical projects were of obvious importance to the students, for many the social interactions they enjoyed with engineering experts also seemed to offer them advantages. The selectivity involved in being admitted to an undergraduate engineering program made it increasingly clear that applicants with TT experiences were becoming aware of the advantage that the social capital derived from participation on a TT could potentially offer them as an important form of admissions currency.

From an admissions vantage point, the initial study question emerged from curiosity about the perceived advantages that social connections to engineers within a TT–based setting were providing the TT participants. Specifically, the original research question was framed as follows: "Does high school technical team participation provide broader engineering-related social capital to technical team participants?" The corollary question pertains to understanding how social capital derived from a high school TT experience might connect with social capital resources students build as undergraduate engineers. Hypothesis 2 provides the basis for understanding these questions.

Study 2 hypothesis

Hypothesis 2: Participation on an extracurricular technical team in high school provides participants with more engineering-specific high school and College of Engineering social capital resources relative to engineering classmates who did not participate on a technical team in high school.

For the purpose of this study, I am defining the concept of social capital based on Baker's (1990, p. 619) view of social capital as "a resource that actors derive from specific social structures and then use to pursue their interests." In this sense, social capital is derived from important relationships that one can exploit for benefit or gain. Bourdieu's conceptual definition of social capital as "the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition"

(Bourdieu & Wacquant, 1992, p. 119) is also relevant to Study 2. Finally, Lin (1999, p. 39) describes social capital in fundamental terms as "investment in social relations by individuals through which they gain access to embedded resources to enhance expected returns of instrumental or expressive actions."

Lin (1999) then clarifies two major anticipated outcome expectations individuals have based on their social capital resources—instrumental and expressive actions. Instrumental action provides returns to individuals that, on their own, actors do not possess. In this sense, social capital affords individuals real and novel gains across three areas: economic returns (financial gains), political returns (positions within a social hierarchy or organization), and social returns (the ability to ask for and also give favors in an organization; Lin, 1999). The second outcome, expressive action, reflects the fact that social capital resources reinforce the abilities individuals use to retain resources they already possess. In this sense, social capital increases the ability to defend resources already possessed.

Social capital, then, consists in useful social networks that enable individuals to access advantageous information and resources while also protecting their status and ability to thrive within specific social hierarchies. Social capital is important for this study because it provides prospective engineering students with information and other useful resources that are not evenly distributed across the population. Students with TT experiences in high school may accrue social capital advantages as undergraduate engineers relative to their classmates who did not participate on high school TTs. The potential outcomes of this asymmetry may be perceived both positively and negatively. The resources involved may provide information that supports or improves student success in engineering. However, they may also provide the basis for those in already advantaged positions to maintain their advantages.

Measuring social capital

To measure the engineering-related social capital resources of first-year engineering students I used an adapted version of an existing instrument, the Resource Generator. The Resource Generator is specifically designed to measure the social capital of individuals so that comparisons may be made between distinct populations (for instance, URM/Majority, male/female, TT participants/non–TT participants) and different socio-economic groups. Additionally, the Resource Generator was designed to measure network ties that allow individuals to access information through specific socially constructed ties. The developers of the original Resource Generator argue that social capital resources can be used for individual "productivity." They describe the Resource Generator as an instrument for measuring "how [productivity] helps individuals to attain their goals in addition to personal resource collections" (Van Der Gaag & Snijders, 2005, p. 2).

The primary use of the Resource Generator for this analysis is to understand varying degrees of the *volume* of an individual respondent's engineering-specific social capital. Lin, Cook, and Burt (2001) describes the volume of an individual actor's network ties as a source of advantage in terms of information gathering. Lin, Cook, and Burt measured "bridge connections" between individuals in an organization and found that individuals with larger sets of bridging social capital (or greater network connectivity to other actors) gain advantages based on access to a number of varied information sources

(Lin, Cook, & Burt, 2001). Cross and Lin (2008) take the concept of volume further, stating that the volume of an individual's network ties increases the potential for social attainment by that individual: "[T]he quantity and quality of social capital is expected to contribute to its value as a means of social mobility . . . the greater the size of the total network, the greater one's resources may be from which to draw" (Lin & Erickson, 2008, p. 365). By adapting the Resource Generator for the purposes of this study I was able to measure the volume of engineering-related individual social capital resources across two time periods for each individual in the sample: during high school and during the first few months of first-year undergraduate engineering study.

The Resource Generator instrument

See Appendix 3 for the full Resource Generator document used in this study. The Resource Generator instrument was delivered as an online questionnaire to first-year engineering students who had also completed the 2006 paper-and-pencil Entry Survey. The instrument was used to record student social capital. Students were invited via e-mail to take the survey and were supplied with a web link to a site where they could complete the questionnaire. Responses were recorded in a ColdFusion database and then migrated to an Excel database. Once in Excel, they were prepared for migration to SPSS for statistical analysis.

Sections of the questionnaire

The instrument consists of 51 questions organized into four sections. Sections one through three follow the Resource Generator format (questions 1–49). The final section asks a unique question that is described below.

Section one focuses on respondents' high school engineering–related social capital resources. The high school section of the instrument comprises two sub-sections. The first subsection (questions 1–13) focuses on respondents' technical, engineering-related social capital. The second section (questions 14–27) focuses on engineering application-and-admissions-related social capital resources that exist by virtue of engineering-related social capital resources. The questions in both of the high school subsections are framed as sets of retrospective questions, asking respondents to think back to their time in high school and answer questions based on their recollected experiences and social capital resources.

Section 2 (questions 28–42) focuses on the social capital resources respondents had developed at the moment they were completing the survey as first-year engineering students within the College of Engineering. The questions focus on immediately available College of Engineering–specific social capital resources that respondents had gathered as undergraduate engineers from August 2006 to the point at which they were completing the survey (roughly from 3 to 6 months into the first year of undergraduate engineering). The goal of the two sections was to have two social capital measures, one a high school measure and the other an undergraduate engineering measure, so that social capital resources in the two periods could be compared.

Section 3 (questions 43–49) also focuses on College of Engineering–specific social capital. Question 43 measures the number of engineering *friends* respondents have in the College of Engineering. Question 44 measures the number of engineering *friends* that respondents work with on their *engineering homework* (homework network). Question 45 measures the number of times respondents accessed engineering student services since entering the engineering program in August 2006. Question 45 measures the number of *engineering clubs* to which respondents belong. Question 46 measures the number of *engineering clubs* of which respondents are *leaders*. The data loading for Questions 45 and 46 were compromised so they were excluded from the study. Question 48 measures the number of *engineering student project teams* (14 possible team options existed in 2006) of which respondents are members. Finally, question 49 is a binary question asking whether respondents are participating in science or engineering *research*.

Questions 50A and 50B offer novel inquiries that I constructed. The goal is to determine how deeply respondents feel they are part of the College of Engineering at two points: upon entry into the college and at the present moment (when responding to the questionnaire). Question 50A asks respondents to indicate, on a six-point Likert scale, where they would locate their membership in the College of Engineering when they entered in August 2006. Question 50B asks respondents to indicate the same measure at the moment they were completing the survey instrument. The results measure where respondents located their initial membership in the College of Engineering and indicate how those locations may have changed across time. A dummy variable that sums the responses of the two questions provides a "socialization trajectory" value for each respondent. The maximum score of this variable is 12 (fully integrated into the college, a college “insider”). The minimum score is 2 (not integrated into the college, an “outsider”).

Table 66 describes the Resource Generator social capital variables.

Table 66. Resource Generator Social Capital Variables.

SECTION	QUESTIONS	SECTION FOCUS
SECTION 1 A	1–13	High school technical engineering social capital
SECTION 1 B	14–27	High school engineering application and admissions social capital
SECTION 2	28–42	College of Engineering social capital
SECTION 3	43	Number of engineering friends
SECTION 4	44	Number of engineering friends in homework network
SECTION 5	45	Number of engineering student services visited since enrolling
SECTION 6	49	Participating in research? (Y/N)
SECTION 7	50 & 50 B	Socialization placement upon entering engineering & socialization placement at the time of completing the Resource Generator.

Resource Generator question structure

For the high school portion of the survey, an initial question was posed as follows: “Other than your high school teachers and guidance counselors, when you were in high school, did you have personal access to someone who . . .” This uniform prompt was then followed by another set of statements that completed the prompt. For example, the first question’s prompt completion asks: “. . . could teach you how to build a robot” followed by “No” and “Yes” response options. If a subject responded “No,” he or she would move on to the next question (“. . . could teach you about engineering”). If a subject responded “Yes” then a series of additional response options would appear automatically on the same line. The response options were designed to record the depth and volume of respondents’ social capital resources with the following set of response options: Immediate Family, Wider Family, Friend, Teammate, Mentor, Neighbor, Acquaintance. Respondents could check “Yes” for all options that applied and a score of “1” would be recorded for each box that was checked. The total score was summed automatically, providing a numerical measure for each question. Again, the goal was to measure, in a quantifiable way, the number of engineering-related social capital resources students had. For sections 1A, 1B, and section 2 of the Resource Generator, all responses were summed to provide macro-totals for each section. All remaining sections provided one total score per question.

The first responses to the survey were recorded on November 20, 2006 and the final respondent completed the instrument on March 29, 2007. All first-year engineering students who completed the initial Entry Survey in August 2006 were sent multiple e-mails between November and March asking them to complete the online instrument. Because URM students comprised a small part of the initial overall sample, I worked closely with the Diversity Programs in Engineering Office (DPE) to encourage URM students to complete the survey. DPE is located within the College of Engineering and has a professional staff that works directly with engineering women and URM students. The Director of DPE sent an e-mail message to all first-year URM engineering students encouraging them to complete the survey. In her message students were notified that if they completed the survey they would be entered into a raffle to win an iPod. In my e-mail messages to URM students asking them to complete the survey I also included the iPod raffle incentive. The DPE Associate Director also personally asked URM students to complete the survey when she was meeting with student groups and student leaders.

Variables involved in the analysis of Hypothesis 2

The variables involved in the analysis of Hypothesis 2 comprise independent (predictor) variables that are categorical: Self-identified TT experience, self-identified TT leader, admissions committee–identified TT experience, and admissions committee–identified TT leadership (four total variables). Ten dependent variables (interval and categorical variables) were derived from the Resource Generator. The variables are divided into two sections. Section 1 reflects high school social capital. Section 2 reflects College of Engineering social capital. Each variable corresponds to the social capital measurement sections of the Resource Generator (see Table 67).

Table 67. Resource Generator (RG) Social Capital Variables Utilized in the Analysis.

RG Section	Variable description	Variable Name
Section 1 (1)	High school technical/engineering social capital (interval)	HS Tech/EN
Section 1 (2)	High school engineering application and admissions social capital (interval)	HS Admiss
Section 2 (3)	College of Engineering social capital (interval)	CoE SC
Section 2 (4)	Number of engineering friends (interval)	EN Friends
Section 2 (5)	Number of engineering friends in homework network (interval)	EN Homework Net
Section 2 (6)	Number of engineering student services visited since enrolling (interval)	EN StdSrvc
Section 2 (7)	Participating in research? (Y/N, categorical)	Rsrch
Section 2 (8)	(A) Socialization placement upon entering engineering (interval)	AugOrgSoc
Section 2 (9)	(B) Socialization placement at the time of completing the Resource Generator (interval)	ENOrgSoc
Section 2 (10)	Sum of Socialization placement A + B (interval)	OrgSocSum

One additional variable was derived from the 2006 Entry Survey. The variable measures the support of family and individuals within the immediate social realm of respondents. Question 135 asks "For each of the following people, what is their opinion about your pursuit of an engineering major or career? *Mark whether their opinion is strongly supportive, moderately supportive, neutral, moderately opposed, or strongly opposed.* I present the response set in Table 68:

Table 68. Sample Response Set for Resource Generator.

	Strongly supportive	Moderately Supportive	Neutral	Moderately opposed	Strongly Opposed
Mother					
Father					
Sibling					
Best friend(s)					
Boyfriend/girlfriend					
Most influential high school teacher					
High school guidance counselor					
FIRST Robotics or technical team mentor (if not applicable, leave blank)					

The results were summed to produce a dummy variable (Q135) that provides a measure of high school social capital support for studying engineering relative to each respondent's immediate family and social network in high school. It is important to note that, like the data for the self-efficacy variable, the Q135 variable data were also recorded at a particularly important moment for the respondents. It was recorded as part of the Entry Survey (not the Resource Generator) when respondents were transitioning from high school to undergraduate engineering. While they had graduated from high school, they had not begun taking classes in the College of Engineering when these data were collected. Because of the timing, responses were recorded during a small window of time that immediately preceded their full engagement with undergraduate engineering.

Data were also collected by the Resource Generator that were not utilized in the study analysis. Data were also collected on the variables listed in Table 69, but were also not used in the analysis. When reviewing scatterplots of the variables it became clear that the data were corrupted. Because of this the three variables were excluded from the analysis.

Table 69: Resource Generator Social Capital Variables Excluded from the Analysis.

Section 2 (7)	**Number of engineering clubs currently a member of (interval) – Corrupted data, excluded from the analysis**
Section 2 (8)	Number of engineering clubs currently an officer of (interval) – Corrupted data, excluded from the analysis
Section 2 (9)	Number of project teams a member of (interval) – Corrupted data, excluded from the analysis

Control variables include gender (categorical variable, women are classified as 1, men are classified as 0) and URM status as measured by a binary dummy (categorical) variable that defines URM status as 1 and majority status as 0. URM status is also aggregated by ethnicity, including African American, Mexican American, and Native American. Majority status is aggregated by ethnicity, including Caucasian, Asian, and Other.

The analysis includes two additional variables, socio-economic status as measured by combined parental education via a categorical questionnaire scale (interval variable) and the number of bookshelves in the family home as measured by a categorical questionnaire scale (interval variable) that records the number of bookshelves in each respondent's home as a proxy for socio-economic status.

Overall Sample Description for Study 2: Distributions of gender, URM/Majority, and socio-economic status relative to technical team participation and leadership

The sample for Study 2 included first-year engineering students who completed the Resource Generator survey between November 2006 and March 2007. The sample is a sub-set of the initial sample of students who completed the Entry Survey in August 2016. A description of the study sample is included in the narrative and in Tables 70 – 72 in this section. The social capital study sample includes N = 312 participants. Of the 312 participants, 63% (195 students) were male and 37% (117 students) were female.

Table 70. Sample Gender Distribution.

	Count	**Percent**
Male (0)	195	63%
Female (1)	117	37%

Of the sample, 87% (273) of the students were Majority, while 13% (39 students) were URM.

Table 71. Sample Under-Represented Minority/Majority Distribution.

	Count	**Percent**
Majority (0)	273	87%
URM (1)	39	13%

Regarding gender, 26% (10) of the URM students were women, while 74% (29 subjects) were men.

Table 72. Sample URM/Majority by Gender Composition

	Male N	Male %	Female N	Female %	Total N
Majority	166	61%%	107	39%	273
URM	29	74%	10	26%	39

The Study 2 sample is further distributed across the four TT variables by gender and URM status. Of the 51 subjects who self-identified as high school TT participants on the August 2006 Entry Survey and who completed the Resource Generator survey, 37% (19) were female while 63% (32) were male (see Tables 73 – 80).

Table 73. Study 2: Self-Identified Technical Team Participation by Gender.

	Non-TT	Non-TT %	TT	TT %	Total
Male	146	61%	32	63%	178
Female	93	39%	19	37%	112
Total	239		51		N = 290

Of the self-identified TT participants who completed the Resource Generator survey, 22% (11) of the 51 participants indicated that they were leaders on their technical teams. Of the 11 leaders, 73% (8) were male while 27% (3) were female.

Table 74. Self-Identified Technical Team Leaders by Gender.

	TT Leader	TT Leader %
Male	8	73%
Female	3	27%
Total	11	

Of the students who completed the Resource Generator survey and were identified by admissions committees as having participated on a TT in high school, 66% (62) were male while 34% (32) were female.

Table 75. Admissions Committee–Identified Technical Team by Gender.

	AD CTTEE Count	AD CTTEE %
Male	62	66%
Female	32	34%
Total	94	

Of the admissions committee–identified TT leaders who completed the Resource Generator survey, 61% (25) were male while 39% (16) were female.

Table 76. Admissions Committee–Identified Technical Team Leaders by Gender.

	AD CTTEE LD Count	AD CTTEE LD %
Male	25	61%
Female	16	39%
Total	41	

URM students were also represented across all four TT variables.

Table 77. Study 2: Self-Identified Technical Team Participation by URM Composition.

	Non-TT	Non-TT %	TT	TT %	Total
Majority	210	88%	45	88%	255
URM	29	12%	6	12%	35
Total	239		51		290

Of the self-identified TT participants who completed the Resource Generator survey, 22% (11) of the 51 participants indicated that they were leaders on their TTs. Of the 11 leaders, 91% (10) were Majority while only 1 (9%) was a URM student.

Table 78. Self-Identified Technical Team Leaders by URM Composition.

Self-Identified Technical Team Leaders by URM Composition		
	TT Leader	TT Leader %
Majority	10	91%
URM	1	9%
Total	11	

Of the students who completed the Resource Generator survey and were identified by admissions committees as having participated on a TT in high school, 88% (83) were Majority while 12% (11) were URM.

Table 79. Admissions Committee–Identified Technical Team by URM Composition.

	AD CTTEE Count	**AD CTTEE %**
Majority	83	88%
URM	11	12%
Total	94	

Of the admissions committee–identified leaders who completed the Resource Generator survey, 93% (38) were Majority while 7% (3) were URM.

Table 80. Admissions Committee–Identified Technical Team Leaders by URM Composition.

	AD CTTEE LD Count	**AD CTTEE LD %**
Majority	38	93%
URM	3	7%
Total	41	

Descriptive statistics for Hypothesis 2

As described in Chapter 4, descriptive statistics provide a framework for understanding the distribution of the results of analyzing the effects of the dependent variables. In this instance, the variables of interest include the social capital variables. In the following sections, Tables 81–83 describe the dependent variables in terms of each variable's mean, standard deviation from the mean, skewness, and kurtosis. Minimum and maximum scores for each variable are also included.

Descriptive Statistics: All Social Capital Variables

Table 81. Distributional Properties of All Social Capital Dependent Variables.

Variable	N	Mean	Std. Dev	Skewness	Kurtosis	Min	Max
HS Tech/EN	290	9.69	7.72	1.55	3.59	0	46
HS Admiss	290	3.41	4.45	2.21	6.13	0	28
CoE SC	290	15.57	12.28	1.10	6.73	0	89
EN Friends	290	7.04	3.65	.641	.132	0	18
EN Homework Net	290	1.56	1.13	1.25	2.73	0	7
EN StdServc	290	3.68	2.82	1.15	1.56	0	14
Rsrch - Excluded because the variable is categorical.							
AugOrgSoc	287	2.30	1.02	.662	.137	1	5
ENOrgSoc	287	3.67	1.04	-.335	.007	1	6
OrgSocSum	287	5.97	1.82	.250	.066	2	11
Q135	678	28.45	5.49	-.855	1.39	5	40

Descriptive Statistics: Social Capital Variables by Gender

Table 82. Distributional Properties of the Social Capital Dependent Variables: Independent Variable is Gender.

Variable	N	Mean	Std. Dev	Skewness	Kurtosis	Min	Max
HS Tech/EN (0)	170	9.47	7.05	1.22	2.05	0	40
HS Tech/EN (1)	108	10.30	8.38	1.76	4.53	0	46
HS Admiss (0)	170	3.38	4.44	2.55	8.66	0	28
HS Admiss (1)	108	3.61	4.53	1.77	3.03	0	21
CoE SC (0)	170	14.57	11.04	1.43	2.97	0	65
CoE SC (1)	108	17.41	13.42	2.48	9.43	0	89
EN Friends (0)	170	6.85	3.67	.645	.380	0	18
EN Friends (1)	108	7.42	3.58	.634	-.096	1	18
EN Homework Net (0)	170	1.42	1.08	1.13	2.08	0	6
EN Homework Net (1)	108	1.80	1.21	1.41	3.25	0	7
EN StdServc (0)	170	3.05	2.52	1.47	3.16	0	14
EN StdServc (1)	108	4.63	2.92	.920	1.04	0	14
Rsrch (0) Excluded because the variable is categorical.							
Rsrch (1) Excluded because the variable is categorical.							
AugOrgSoc (0)	170	2.38	1.02	.593	.070	1	5

AugOrgSoc (1)	108	2.19	.978	.718	.381	1	5
ENOrgSoc (0)	170	3.71	.994	-.163	-.149	1	6
ENOrgSoc (1)	108	3.65	1.03	-.568	.215	1	6
OrgSocSum (0)	170	6.09	1.75	.316	-.012	2	11
OrgSocSum (1)	108	5.83	1.79	.146	.158	2	11
Q135 (0)	170	28.73	5.78	-1.20	2.37	6	40
Q135 (1)	108	28.13	5.51	-.988	1.58	10	40

Descriptive Statistics: Social Capital Variables by URM/Majority

Table 83. Distributional Properties of the Social Capital Dependent Variables: Independent Variable is URM/Majority Status.

Variable	N	Mean	Std. Dev	Skewness	Kurtosis	Min	Max
HS Tech/EN (0)	245	9.84	7.63	1.63	4.07	0	46
HS Tech/EN (1)	33	9.42	7.37	.672	-.244	0	27
HS Admiss (0)	245	3.43	4.33	2.23	6.46	0	28
HS Admiss (1)	33	3.82	5.46	2.11	5.11	0	24
CoE SC (0)	245	15.15	12.07	2.23	8.42	0	89
CoE SC (1)	33	19.52	11.60	.874	1.11	0	53
EN Friends (0)	245	6.89	3.55	.681	.450	0	18
EN Friends (1)	33	8.45	4.09	.192	-.860	1	17
EN Homework Net (0)	245	1.55	1.16	1.35	3.05	0	7
EN Homework Net (1)	33	1.70	1.05	.487	-.187	0	4
EN StdServc (0)	245	3.43	2.62	1.23	2.10	0	14
EN StdServc (1)	33	5.42	3.40	.703	.369	0	14
Rsrch (0) Excluded because the variable is categorical.							
Rsrch (1) Excluded because the variable is categorical.							
AugOrgSoc (0)	245	2.24	.964	.663	.341	1	5
AugOrgSoc (1)	33	2.79	1.19	.202	-.706	1	5
ENOrgSoc (0)	245	3.63	.956	-.329	-.086	1	6
ENOrgSoc (1)	33	4.12	1.24	-.865	.821	1	6
OrgSocSum (0)	245	5.87	1.68	.208	.030	2	11
OrgSocSum (1)	33	6.91	2.11	-.127	.022	2	11
Q135 (0)	245	28.36	5.60	-1.04	1.64	7	40
Q135 (1)	33	29.55	6.22	-1.72	5.38	6	40

Descriptive Statistics: Social capital variables by the four technical team independent variables

The distributional properties of the dependent variables used in Study 2 relative to the four TT independent variables are described in the following tables. Table 84 summarizes the self-identified high school TT variable relative to the social capital dependent variables. Table 85 summarizes the results pertaining to the self-identified high school TT leader variable relative to the social capital dependent variables. Table 86 summarizes the results pertaining to the admissions committee–identified high school TT variable relative to the social capital dependent variables. Table 87 summarizes the admissions committee–identified high school TT leader variable relative to the social capital dependent variables.

Table 84. Distributional Properties of the Social Capital Dependent Variables: Independent Variable is Self-identified High School Technical Team Experience.

Independent variable: Self-identified High School Technical Team Experience								
Variable	N	Cases Excluded	Mean	Std. Dev	Skewness	Kurtosis	Min	Max
HS Tech/EN (0)	228	0	9.15	6.92	1.52	4.22	0	46
HS Tech/EN (1)	50	0	12.68	9.65	1.18	1.50	0	43
HS Admiss (0)	228	0	3.17	4.11	2.28	6.39	0	24
HS Admiss (1)	50	0	4.86	5.68	1.82	4.36	0	28
CoE SC (0)	228	0	15.55	12.33	2.17	7.97	0	89
CoE SC (1)	50	0	16.22	10.96	1.19	1.87	0	53
EN Friends (0)	228	0	7.00	3.72	.658	.276	0	18
EN Friends (1)	50	0	7.40	3.29	.523	-.536	2	15
EN Homework Net (0)	228	0	1.56	1.18	1.24	2.61	0	7
EN Homework Net (1)	50	0	1.60	.948	1.50	3.23	0	5
EN StdServc (0)	228	0	3.61	2.75	1.17	1.87	0	14
EN StdServc (1)	50	0	3.90	2.99	1.25	1.55	0	13
Rsrch (0) Excluded because the variable is categorical.								
Rsrch (1) Excluded because the variable is categorical.								
AugOrgSoc (0)	228	0	2.30	.994	.613	.098	1	5
AugOrgSoc (1)	50	0	2.32	1.08	.744	.411	1	5
ENOrgSoc (0)	228	0	3.65	1.02	-.399	-.016	1	6
ENOrgSoc (1)	50	0	3.86	.948	.140	-.250	2	6
OrgSocSum (0)	228	0	5.95	1.76	.152	-.111	2	11
OrgSocSum (1)	50	0	6.18	1.80	.633	.741	3	11
Q135 (0)	228	0	28.39	5.64	-1.17	2.07	6	40
Q135 (1)	50	0	29.00	5.87	-.914	2.02	10	40

Table 85. Distributional Properties of the Social Capital Dependent Variables: Independent Variable is Self-identified High School Technical Team Leadership.

Variable	N	Cases Excluded	Mean	Std. Dev	Skewness	Kurtosis	Min	Max
HS Tech/EN (0)	267	0	9.42	6.94	1.34	3.25	0	46
HS Tech/EN (1)	11	0	18.82	14.85	0.431	-1.14	0	43
HS Admiss (0)	267	0	3.28	4.18	2.01	5.16	0	24
HS Admiss (1)	11	0	8.09	8.06	1.58	3.19	0	28
CoE SC (0)	267	0	15.69	12.13	2.04	7.33	0	89
CoE SC (1)	11	0	15.09	11.21	1.89	4.35	5	44
EN Friends (0)	267	0	7.04	3.64	0.635	0.222	0	18
EN Friends (1)	11	0	7.73	3.88	0.504	-0.452	2	15
EN Homework Net (0)	267	0	1.56	1.14	1.22	2.68	0	7
EN Homework Net (1)	11	0	1.64	1.21	2.54	7.03	1	5
EN StdServc (0)	267	0	3.66	2.81	1.19	1.80	0	14
EN StdServc (1)	11	0		3.73	1.13	0.951	1	9
Rsrch (0) Excluded because the variable is categorical.								
Rsrch (1) Excluded because the variable is categorical.								
AugOrgSoc (0)	267	0	2.30	1.0	0.643	0.153	1	5
AugOrgSoc (1)	11	0	2.45	1.21	0.539	0.562	1	5
ENOrgSoc (0)	267	0	3.69	1.01	-0.361	-0.028	1	6
ENOrgSoc (1)	11	0	3.73	1.01	0.661	2.28	2	6
OrgSocSum (0)	267	0	5.99	1.75	0.209	-0.007	2	11
OrgSocSum (1)	11	0	6.18	2.18	0.705	1.42	3	11
Q135 (0)	267	0	28.39	5.64	-1.17	2.13	6	40
Q135 (1)	11	0	31.18	6.05	-0.275	-1.49	23	40

Table 86. Distributional Properties of the Social Capital Dependent Variables: Independent Variable is Admissions Committee–identified High School Technical Team Experience.

Independent variable: Admissions Committee–identified High School Technical Team Experience								
Variable	N	Cases Excluded	Mean	Std. Dev	Skewness	Kurtosis	Min	Max
HS Tech/EN (0)	196	0	9.17	6.57	0.906	0.616	0	31
HS Tech/EN (1)	82	0	11.27	9.47	1.74	3.52	0	46
HS Admiss (0)	196	0	3.17	4.16	2.23	6.10	0	24
HS Admiss (1)	82	0	4.20	5.10	2.12	5.73	0	28
CoE SC (0)	196	0	15.53	12.70	2.28	8.32	0	89
CoE SC (1)	82	0	16.01	10.50	0.935	0.801	0	53
EN Friends (0)	196	0	7.06	3.71	0.683	0.454	0	18
EN Friends (1)	82	0	7.10	3.49	0.473	-0.666	1	16
EN Homework Net (0)	196	0	1.59	1.18	1.27	2.55	0	7
EN Homework Net (1)	82	0	1.51	1.06	1.22	3.35	0	6
EN StdServc (0)	196	0	3.66	2.66	0.982	1.11	0	13
EN StdServc (1)	82	0	3.67	3.09	1.51	2.64	0	14
Rsrch (0) Excluded because the variable is categorical.								
Rsrch (1) Excluded because the variable is categorical.								

AugOrgSoc (0)	196	0	2.28	0.990	0.576	-0.014	1	5
AugOrgSoc (1)	82	0	2.38	1.05	0.758	0.453	1	5
ENOrgSoc (0)	196	0	3.63	1.01	-0.368	0.012	1	6
ENOrgSoc (1)	82	0	3.83	0.979	-0.214	-0.051	1	6
OrgSocSum (0)	196	0	5.90	1.74	0.168	-0.097	2	11
OrgSocSum (1)	82	0	6.21	1.82	.379	0.330	2	11
Q135 (0)	196	0	28.25	5.39	-1.06	1.87	7	40
Q135 (1)	82	0	29.09	6.31	-1.28	2.39	6	40

Table 87. Distributional Properties of the Social Capital Dependent Variables: Independent Variable is Admissions Committee–identified High School Technical Team Leadership.

Variable	N	Cases Excluded	Mean	Std. Dev	Skewness	Kurtosis	Min	Max
HS Tech/EN (0)	238	0	9.08	6.78	1.38	3.58	0	46
HS Tech/EN (1)	40	0	13.98	10.42	1.18	1.14	0	43
HS Admiss (0)	238	0	3.11	3.94	2.06	5.33	0	24
HS Admiss (1)	40	0	5.60	6.51	1.77	3.05	0	28
CoE SC (0)	238	0	15.33	11.39	1.68	4.54	0	72
CoE SC (1)	40	0	17.68	15.57	2.67	10.58	0	89
EN Friends (0)	238	0	6.97	3.63	0.651	0.139	0	18
EN Friends (1)	40	0	7.68	3.70	0.522	0.698	1	18
EN Homework Net (0)	238	0	1.55	1.09	0.918	1.09	0	6
EN Homework Net (1)	40	0	1.68	1.42	2.14	5.76	0	7
EN StdServc (0)	238	0	3.76	2.85	1.13	1.60	0	14
EN StdServc (1)	40	0	3.13	2.36	1.58	3.78	0	12
Rsrch (0) Excluded because the variable is categorical.								
Rsrch (1) Excluded because the variable is categorical.								
AugOrgSoc (0)	238	0	2.26	0.986	0.647	0.182	1	5
AugOrgSoc (1)	40	0	2.55	1.11	0.522	-0.003	1	5
ENOrgSoc (0)	238	0	3.65	1.00	-0.346	-0.106	1	6
ENOrgSoc (1)	40	0	3.90	1.01	-0.266	0.862	1	6
OrgSocSum (0)	238	0	5.92	1.72	0.192	-0.062	2	11
OrgSocSum (1)	40	0	6.45	1.99	0.284	0.290	2	11
Q135 (0)	238	0	28.17	5.72	-1.14	2.10	6	40
Q135 (1)	40	0	30.43	5.08	-0.873	0.810	15	40

An important assumption that underlies bivariate correlations is that the variance of the means between the two variables is equal within the total population under study. I checked the homogeneity of variances between the dependent and independent variables using Levene's Test for Equality of Variances. *P* values greater than 0.05 indicate that the assumption of equality of variances has been met, signifying that the population variance is equal. *P* values that are less than 0.05 indicate that the population variance is unequal.

Tables 88 through 91 describe the results of Levene's Test for Equality of Variances for the four independent TT variables.

Table 88. Distributional Properties of the Social Capital Dependent Variables: Independent Variable is Self-identified High School Technical Team Experience.

Variable	Levene Statistic for the Mean	df1	df2	Sig.	Assumption of Homogeneity Met?
HS Tech/EN	10.21	1	276	0.002	No
HS Admiss	9.22	1	276	0.003	No
CoE SC	0.176	1	276	0.675	Yes
EN Friends	0.505	1	276	0.478	Yes
EN Homework Net	3.07	1	276	0.081	Yes
EN StdServc	0.176	1	276	0.676	Yes
AugOrgSoc	0.389	1	276	0.533	Yes
ENOrgSoc	0.953	1	276	0.330	Yes
OrgSocSum	0.004	1	276	0.949	Yes
Q135	0.119	1	276	0.731	Yes

Table 89. Distributional Properties of the Social Capital Dependent Variables: Independent Variable is Self-identified High School Technical Team Leadership.

Variable	Levene Statistic for the Mean	df1	df2	Sig.	Assumption of Homogeneity Met?
HS Tech/EN	24.57	1	276	0.000	No
HS Admiss	7.55	1	276	0.006	No
CoE SC	0.278	1	276	0.598	Yes
EN Friends	0.192	1	276	0.662	Yes
EN Homework Net	0.140	1	276	0.709	Yes
EN StdServc	0.288	1	276	0.592	Yes
AugOrgSoc	0.680	1	276	0.410	Yes
ENOrgSoc	0.356	1	276	0.551	Yes
OrgSocSum	0.653	1	276	0.420	Yes
Q135	0.773	1	276	0.380	Yes

Table 90. Distributional Properties of the Social Capital Dependent Variables: Independent variable: Admissions Committee–identified High School Technical Team Experience.

Variable	Levene Statistic for the Mean	df1	df2	Sig.	Assumption of Homogeneity Met?
HS Tech/EN	6.68	1	276	0.010	No
HS Admiss	3.95	1	276	0.048	No
CoE SC	0.076	1	276	0.783	Yes
EN Friends	0.127	1	276	0.722	Yes
EN Homework Net	1.17	1	276	0.281	Yes
EN StdServc	1.01	1	276	0.316	Yes
AugOrgSoc	0.230	1	276	0.632	Yes
ENOrgSoc	0.399	1	276	0.528	Yes
OrgSocSum	0.050	1	276	0.823	Yes
Q135	1.14	1	276	0.286	Yes

Table 91. Distributional Properties of the Social Capital Dependent Variables: Independent variable: Admissions Committee–identified High School Technical Team Leadership.

Variable	Levene Statistic for the Mean	df1	df2	Sig.	Assumption of Homogeneity Met?
HS Tech/EN	12.70	1	276	0.000	No
HS Admiss	15.05	1	276	0.000	No
CoE SC	1.53	1	276	0.218	Yes
EN Friends	0.003	1	276	0.955	Yes
EN Homework Net	0.687	1	276	0.408	Yes
EN StdServc	1.63	1	276	0.203	Yes
AugOrgSoc	1.14	1	276	0.286	Yes
ENOrgSoc	0.760	1	276	0.384	Yes
OrgSocSum	1.22	1	276	0.270	Yes
Q135	0.277	1	276	0.599	Yes

There was homogeneity of variances for eight of the ten dependent variables measured relative to each of the four high school TT independent variables. The variables that violate the homogeneity of variances assumption are HS Tech/EN, which measures high school social capital relative to engineering and technical information, and HS Admiss, which measures access to high school engineering admissions social capital. To remedy the violation of the homogeneity of variances for these two variables, I used nonparametric correlation analysis in the subsequent bivariate correlation analysis. For all other variables, parametric correlation analysis was used.

Although skewness and kurtosis may be somewhat ameliorated by the large sample size of the study, I am also reporting the median (*Md*) values along with respective inter-quartile ranges (*IQR*) for each of the dependent social capital variables. Unlike mean values, median values are less sensitive to skewed data while still providing insight into the dispersion of the data. Table 92 reports the sample N, median, mean, standard deviation, and inter-quartile values for the social capital dependent variables.

Table 92. Distributional Properties of the Social Capital Dependent Variables.

Variable	N	Median	Mean	5% Trimmed Mean	Std. Dev	IQR
HS Tech/EN	278	8.0	9.8	9.14	7.59	8.0
HS Admiss	278	2.0	3.47	2.89	4.47	5.0
CoE SC	278	13.0	15.67	14.51	15.08	14.0
EN Friends	278	7.0	7.07	6.93	3.64	4
EN Homework Net	278	1.0	1.56	1.48	1.14	1
EN StdServc	278	3.0	3.67	3.44	2.79	3
AugOrgSoc	278	2.0	2.3	2.24	1.01	1
ENOrgSoc	278	4.0	3.7	3.71	1.01	1
OrgSocSum	278	6.0	5.9	5.96	1.77	2.0
Q135	278	30.0	28.5	28.96	5.67	8.0

To check the normality of the distributions of each of the social capital dependent variables I produced histograms of each variable and visually inspected each graph to determine normality. The results of the visual inspection are summarized in Table 93.

Table 93. Distributional Properties of the Social Capital Dependent Variables: Visual Check for Normal Distribution of the Data Based on Histograms of each SC Variable

Visual Check for Normal Distribution of the Data Based on Histograms of each SC Variable	
Variable	**Data is approximately normally distributed**
HS Tech/EN	Yes, but some skew to the left
HS Admiss	No, skewed to the left
CoE SC	Somewhat normal, but some skew to the left
EN Friends	Yes, mild skew to the left
EN Homework Net	Somewhat normal, but skew to the left
EN StdServc	Somewhat normal, but skewed to the left
AugOrgSoc	Yes, but some skew to the left
ENOrgSoc	Yes
OrgSocSum	Yes
Q135	Yes, but skewed to the right

The table indicates that all variables with the exception of the High School Admissions social capital variable are approximately normally distributed.

Correlation Analysis of Social Capital Variables and Technical Team Variables

Correlation analysis is used to determine whether a linear relationship exists between two variables. Pearson's *r* can be used to determine if a relationship exists between two variables, whether the relationship is positive or negative, and the overall strength of the relationship. Pearson's *r* assumes values ranging from -1 to +1, with positive relationships between the variables denoted by a "+" sign and negative relationships denoted by a "-" sign. A +1 Pearson's *r* score indicates that a perfectly positive relationship exists between the variables. Likewise, a -1 Pearson's *r* score indicates a perfectly inverse relationship between the two variables. A score of 0 indicates that no relationship exists between the variables. The absolute value of the Pearson's *r* correlation coefficient indicates the strength of the overall relationship between the two variables.

The variables under study in Study 2 include eleven social capital dependent variables and self-reported high school TT experience, self-reported high school TT leadership experience, admissions committee–identified TT experience, and admissions committee–identified TT leadership experience. The goal of the study is to determine whether there is a relationship between high school social capital resources and college of engineering social capital resources and TT participation in high school. For the variables HS Tech/EN and HS Admiss, non-parametric (Spearman's rank correlation coefficient) analysis as well as parametric (Pearson's *r*) bivariate analysis were used because both variables violated the assumption of homogeneity of the variance of the means. Table 94 describes the results of the Pearson's *r* correlation and Spearman's Rho.

Table 94. Pearson's r and Spearman Rho for Social Capital (SC) Resources.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Pearson's *r* HS Tech/EN	0.164**	0.235**	0.130*	0.213**
Sig. (2-tailed)	0.05	0.000	0.021	0.000
R^2 Coefficient of determination	2.69%	5.52%	1.69%	4.54%
N	290	290	290	290
Spearman's *Rho* HS Tech/EN	0.121*	0.120*	0.084	0.177**
Sig. (2-tailed)	0.039	0.041	0.140	0.002
R^2 Coefficient of determination	1.46%	1.44%	0.71%	3.13%
N	290	290	312	312
Pearson's *r* HS Admiss	0.140*	0.209*	0.090	0.593**
Sig. (2-tailed)	0.017	0.000	0.111	0.001
R^2 Coefficient of determination	1.96%	4.37%	0.81%	35.16%
N	290	290	290	290
Spearman's *Rho* HS Admiss	0.108	0.143*	0.100	0.164**
Sig. (2-tailed)	0.066	0.015	0.077	0.004
R^2 Coefficient of determination	1.17%	2.04%	1.0%	2.69%
N	290	290	312	312
Pearson's *r* CoE SC	0.013	-0.008	-0.002	0.071
Sig. (2-tailed)	0.831	0.896	0.975	0.213
R^2 Coefficient of determination	0.02%	0.01%	0.0%	0.50%
N	290	290	312	312
Spearman's *Rho* CoE SC	0.035	-0.005	0.024	0.053
Sig. (2-tailed)	0.548	0.929	0.673	0.348

R^2 Coefficient of determination	0.12%	0.0%	0.06%	0.28%
N	290	290	312	312
Pearson's *r* EN Friends	0.032	0.038	-0.017	0.076
Sig. (2-tailed)	0.582	0.524	0.769	0.182
R^2 Coefficient of determination	0.1%	0.14%	0.03%	0.58%
N	290	290	312	312
Spearman's *Rho* EN Friends	0.040	0.035	-0.017	0.089
Sig. (2-tailed)	0.494	0.551	0.771	0.116
R^2 Coefficient of determination	0.16%	0.12%	0.03%	0.79%
N	290	290	312	312
Pearson's *r* EN Homework Net	0.011	0.013	-0.053	0.030
Sig. (2-tailed)	0.856	0.825	0.349	0.595
R^2 Coefficient of determination	0.01%	0.02%	0.28%	0.09%
N	290	290	312	312
Spearman's *Rho* EN Homework Net	0.030	0.000	-0.033	-0.004
Sig. (2-tailed)	0.614	1.00	0.562	0.937
R^2 Coefficient of determination	0.09%	0.0%	0.11%	0.0%
N	290	290	312	312
Pearson's *r* EN StdServc	0.027	0.003	-0.019	-0.073
Sig. (2-tailed)	0.649	0.954	0.659	0.181
R^2 Coefficient of determination	0.07%	0.0%	0.04%	0.53%
N	290	290	312	312
Spearman's *Rho* EN StdServc	0.017	0.011	-0.044	-0.070
Sig. (2-tailed)	0.776	0.851	0.435	0.217
R^2 Coefficient of determination	0.03%	0.01%	0.19%	0.49%
N	290	290	312	312
Pearson's *r* Rsrch	0.024	-0.045	.018	0.045
Sig. (2-tailed)	0.687	0.446	0.758	0.432
R^2 Coefficient of determination	0.06%	0.2%	0.03%	0.20%
N	287	287	309	309
Spearman's *Rho* Rsrch	0.024	-0.045	0.018	0.045
Sig. (2-tailed)	0.687	0.446	0.758	0.432
R^2 Coefficient of determination	0.06%	0.20%	0.03%	0.20%
N	287	287	309	309
Pearson's *r* AugOrgSoc	-0.003	0.030	0.051	0.100
Sig. (2-tailed)	0.966	0.609	0.374	0.080
R^2 Coefficient of determination	0.0%	0.09%	0.26%	1.00%
N	287	287	309	309
Spearman's *Rho* AugOrgSoc	-0.008	0.030	0.039	0.098
Sig. (2-tailed)	0.892	0.615	0.491	0.086
R^2 Coefficient of determination	0.01%	0.09%	0.15%	0.96%
N	287	287	309	309
Pearson's *r* ENOrgSoc	0.059	0.011	0.101	0.103
Sig. (2-tailed)	0.319	0.858	0.075	0.070
R^2 Coefficient of determination	0.35%	0.01%	1.02%	1.06%
N	287	287	309	309
Spearman's *Rho* ENOrgSoc	0.049	-0.004	0.088	0.097
Sig. (2-tailed)	0.408	0.943	0.121	0.087
R^2 Coefficient of determination	0.24%	0.00%	0.77%	0.94%
N	287	287	309	309
Pearson's *r* OrgSocSum	0.032	0.023	0.086	0.114*

Sig. (2-tailed)	0.586	0.697	0.131	0.044
R^2 Coefficient of determination	0.10%	0.05%	0.74%	1.30%
N	281	281	309	309
Spearman's *Rho* OrgSocSum	0.028	0.019	0.074	0.106
Sig. (2-tailed)	0.637	0.751	0.197	0.062
R^2 Coefficient of determination	0.08%	0.04%	0.55%	1.12%
N	287	287	309	309
Pearson's *r* Q135	0.009	0.064	0.027	0.065
Sig. (2-tailed)	0.819	0.094	0.482	0.090
R^2 Coefficient of determination	0.01%	0.41%	0.07%	0.42%
N	678	678	678	678
Spearman's *Rho* Q135	0.012	0.051	0.028	0.066
Sig. (2-tailed)	0.756	0.188	0.471	0.084
R^2 Coefficient of determination	0.01%	0.26%	0.08%	0.44%
N	678	678	678	678

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Cohen (1988) interprets the strength of the relationship of Pearson's *r* as small when *r* = .10 to .29, medium when *r* = .30 to .49, and large when *r* = .50 to 1. Based on Cohen's parameters for the strength of Pearson's *r* relationships, all but five of the relationships between the four TT variables and the eleven social capital variables fell below the small relationship threshold. The social capital variable measuring high school technical/engineering–related social capital resources is statistically significantly related to three of the four independent TT variables. The independent variable showing no statistical relationship with high school technical/engineering–related social capital is the admissions committee–identified TT variable. In each instance where there is a statistically significant relationship, the relationship is positive. Additionally, the social capital variable measuring high school engineering admissions social capital resources is also statistically significantly related to three of the four independent TT variables. The independent variable with which a relationship cannot be discerned between high school engineering admissions social capital and the independent variable is admissions committee–identified TT experience.

The R^2 coefficients of determination represent the effect size—the proportion of the variance in the social capital variables that may be predicted by the four TT independent variables. In all cases, the effect size measurements were minimal, ranging from 0.0% (no measured effect) to 5.52%. The largest effect sizes occurred between the two high school TT leadership variables and the two high school social capital variables.

Correlation analysis of social capital and technical team variables based on gender and under-represented minority status

The discussion now progresses to an analysis of the correlation between the eleven social capital variables and the four TT variables with the gender and URM variables disaggregated from the sample population. Both gender and URM variables are of primary interest in the study because both populations of students are under-represented in undergraduate engineering. The goal of this portion of the study was to understand the potential effect high school TT experiences may have on students' social capital resources relative to engineering and based on gender and URM status.

Summary of the correlation analysis of the social capital variables and technical team variables by gender

Table 95 describes the results of Pearson's *r* correlation when the sample is disaggregated by gender.

Table 95. Pearson's r for Social Capital (SC) Resources by Gender.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Pearson's *r* HS Tech/EN MALE	0.180*	0.288**	0.090	0.132
Sig. (2-tailed)	0.016	0.000	0.235	0.080
R^2 Coefficient of determination	3.24%	8.29%	0.81%	1.74%
N	178	178	178	178
Pearson's *r* HS Tech/EN FEMALE	0.144	0.158	0.190*	0.346*
Sig. (2-tailed)	0.130	0.096	0.045	0.000
R^2 Coefficient of determination	2.07%	2.5%	3.61%	11.97%
N	112	112	112	112
Pearson's *r* HS Admiss MALE	0.173*	0.270**	0.087	0.098
Sig. (2-tailed)	0.021	0.000	0.248	0.193
R^2 Coefficient of determination	2.99%	7.29%	0.76%	0.096%
N	178	178	178	178
Pearson's *r* HS Admiss FEMALE	0.088	0.093	0.158	0.348**
Sig. (2-tailed)	0.357	0.331	0.096	0.000
R^2 Coefficient of determination	0.77%	0.86%	2.5%	12.11%
N	112	112	112	112
Pearson's *r* CoE SC MALE	0.047	0.016	0.018	0.030
Sig. (2-tailed)	0.533	0.827	0.808	0.691
R^2 Coefficient of determination	0.22%	0.03%	0.03%	0.09%
N	178	178	178	178
Pearson's *r* CoE SC FEMALE	-0.033	-0.038	0.002	0.119
Sig. (2-tailed)	0.733	0.689	0.986	0.211
R^2 Coefficient of determination	0.11%	.14%	0.0%	1.42%
N	112	112	112	112
Pearson's *r* EN Friends MALE	0.042	.052	-0.097	-0.034
Sig. (2-tailed)	0.582	0.489	0.199	0.653
R^2 Coefficient of determination	0.18%	0.27%	0.94%	0.12%
N	178	178	178	178
Pearson's *r* EN Friends FEMALE	0.019	.016	0.150	0.237*
Sig. (2-tailed)	0.839	0.866	0.115	0.012
R^2 Coefficient of determination	0.04	0.03	2.25%	5.62%
N	112	112	112	112
Pearson's *r* EN Homework Net MALE	0.105	0.068	0.010	-0.061
Sig. (2-tailed)	0.162	0.368	0.895	0.417
R^2 Coefficient of determination	1.10%	0.46%	0.01%	0.37%
N	178	178	178	178
Pearson's *r* EN Homework Net FEMALE	-0.122	-0.064	-0.065	0.178
Sig. (2-tailed)	0.200	0.500	0.495	0.061
R^2 Coefficient of determination	1.49%	0.41%	0.42%	3.17%
N	112	112	112	112
Pearson's *r* EN StdServc MALE	0.026	0.109	-0.043	-0.081
Sig. (2-tailed)	0.727	0.147	0.571	.282
R^2 Coefficient of determination	0.07%	1.19%	0.18%	0.66%
N	178	178	178	178
Pearson's *r* EN StdServc FEMALE	0.039	-0.151	0.040	-0.091

Sig. (2-tailed)	0.681	0.111	0.677	0.342
R^2 Coefficient of determination	0.15%	2.28%	0.16%	0.83%
N	112	112	112	112
Pearson's *r* Rsrch MALE	0.055	-0.044	0.046	0.089
Sig. (2-tailed)	0.465	0.560	0.541	0.239
R^2 Coefficient of determination	0.30%	0.19%	0.21%	0.79%
N	177	177	177	177
Pearson's *r* Rsrch FEMALE	-0.015	-0.044	-0.071	-0.002
Sig. (2-tailed)	0.879	0.651	0.458	0.984
R^2 Coefficient of determination	0.02%	0.19%	0.50%	0.00%
N	112	112	112	112
Pearson's *r* AugOrgSoc MALE	-0.008	0.029	0.051	0.069
Sig. (2-tailed)	0.915	0.702	0.499	0.364
R^2 Coefficient of determination	0.01%	0.08%	0.26%	0.48%
N	177	177	177	177
Pearson's *r* AugOrgSoc FEMALE	0.005	0.023	0.025	0.153
Sig. (2-tailed)	0.959	0.813	0.793	0.111
R^2 Coefficient of determination	0.00%	0.05%	0.06%	2.34%
N	110	110	110	110
Pearson's *r* ENOrgSoc MALE	0.078	0.016	0.124	0.061
Sig. (2-tailed)	0.305	0.830	0.099	0.417
R^2 Coefficient of determination	0.61%	0.03%	1.54%	0.37%
N	177	177	177	177
Pearson's *r* ENOrgSoc FEMALE	0.029	-0.001	0.050	0.131
Sig. (2-tailed)	0.768	0.992	0.604	0.171
R^2 Coefficient of determination	0.08%	0.00%	0.25%	1.72%
N	110	110	110	110
Pearson's *r* OrgSocSum MALE	0.040	0.026	0.100	0.074
Sig. (2-tailed)	0.601	0.734	0.186	0.328
R^2 Coefficient of determination	0.16%	0.07%	1.00%	0.55%
N	177	177	177	177
Pearson's *r* OrgSocSum FEMALE	0.019	0.012	.043	0.159
Sig. (2-tailed)	0.843	0.902	0.659	0.097
R^2 Coefficient of determination	0.04%	0.01%	0.18%	2.53%
N	110	110	110	110
Pearson's *r* Q135 MALE	0.016	0.070	0.012	0.044
Sig. (2-tailed)	0.723	0.128	0.802	0.336
R^2 Coefficient of determination	0.03%	0.49%	0.01%	0.19%
N	472	472	472	472
Pearson's *r* Q135	-0.019	0.040	0.061	0.115
Sig. (2-tailed)	0.787	0.566	0.384	0.099
R^2 Coefficient of determination	0.04%	0.16%	0.37%	0.132%
N	206	206	206	206

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Of the 88 possible bivariate correlation possibilities, eight total correlations reached the level of statistical significance. The remaining 80 possible correlations were not statistically significant. Based on Cohen's (1988) interpretation of the strength of the relationship of Pearson's *r*, six of the eight correlations that reached statistical significance had Pearson's *r* values that connote a small relationship. The Pearson's *r* values for the remaining two variables connote a relationship of medium strength.

For males, there was a small, positive correlation between the HS Tech/EN variable and the self-reported TT variable for male subjects, $r = 0.180$, $N = 178$, $p < .05$, with higher levels of high school technical/engineering–related social capital associated with high school TT experiences. The R^2 coefficient of determination was equal to 3.24%, indicating that 3.24% of the variance between the means of the two variables was shared. There was a small, positive correlation between the HS Tech/EN variable and the self-reported TT leadership variable for male subjects, $r = 0.288$, $N = 178$, $p < .01$, with higher levels of high school technical/engineering–related social capital associated with high school TT leadership experiences. The R^2 coefficient of determination was equal to 8.29%, indicating that 8.29% of the variance between the means of the two variables was shared. There was also a small, positive correlation between the HS Admiss variable and the self-reported TT variable for male subjects, $r = 0.173$, $N = 178$, $p < .05$, with higher levels of high school engineering admissions–related social capital associated with high school TT experiences. The R^2 coefficient of determination was equal to 2.99%, indicating that 2.99% of the variance between the means of the two variables was shared. Finally, there was also a small, positive correlation between the HS Admiss variable and the self-reported TT leadership variable for male subjects, $r = 0.270$, $N = 178$, $p < .01$, with higher levels of high school engineering admissions–related social capital associated with high school TT leadership experiences. The R^2 coefficient of determination was equal to 7.29%, indicating that 7.29% of the variance between the means of the two variables was shared.

For females, the admissions committee–identified TT variables were the variables that showed some measure of statistically significant relationships with some of the social capital variables. There was a small, positive correlation between the HS Tech/EN variable and the admissions committee–identified TT variable for female subjects, $r = 0.190$, $N = 112$, $p < .05$, with higher levels of high school technical/engineering–related social capital associated with admissions committee–identified high school TT experiences. The R^2 coefficient of determination was equal to 3.61%, indicating that 3.61% of the variance between the means of the two variables was shared. There was a medium, positive correlation between the HS Tech/EN variable and the admissions committee–identified TT leadership variable for female subjects, $r = 0.346$, $N = 112$, $p < .05$, with higher levels of high school technical/engineering–related social capital associated with admissions committee–identified high school TT experiences. The R^2 coefficient of determination was equal to 11.97%, indicating that 11.97% of the variance between the means of the two variables was shared. There was a medium, positive correlation between the HS Admiss variable and the admissions committee–identified TT leadership variable for female subjects, $r = 0.348$, $N = 112$, $p < .01$, with higher levels of high school engineering admissions–related social capital associated with admissions committee–identified high school TT leadership experiences. The R^2 coefficient of determination was equal to 12.11%, indicating that 12.11% of the variance between the means of the two variables was shared. Finally, there was a small, positive correlation between the EN Friends variable and the admissions committee–

identified TT leadership variable for female subjects, $r = 0.237$, $N = 112$, $p < .05$, with higher levels of high school engineering admissions–related social capital associated with admissions committee–identified high school TT leadership experiences. The R^2 coefficient of determination was equal to 5.62%, indicating that 5.62% of the variance between the means of the two variables was shared.

Summary of the correlation analysis of the social capital variables and technical team variables by under-represented minority status

Table 96 describes the results of the Pearson's *r* correlations when the sample is disaggregated by URM/Majority status.

Table 96. Pearson's *r* for Social Capital (SC) Resources by URM/Majority Status.

	Self TT	Self TT Leader	CTTEE TT	CTTEE TT Leader
Pearson's *r* HS Tech/EN MAJORITY	0.123*	0.214**	0.130*	0.236**
Sig. (2-tailed)	0.049	0.001	0.038	0.000
R^2 Coefficient of determination	1.51%	4.58%	1.69%	5.57%
N	255	255	255	255
Pearson's *r* HS Tech/EN URM	0.480**	0.422*	0.087	0.073
Sig. (2-tailed)	0.004	0.012	0.619	0.677
R^2 Coefficient of determination	23.04%	17.81%	0.76%	0.53%
N	35	35	35	35
Pearson's *r* HS Admiss MAJORITY	0.111	0.202*	0.115	0.239**
Sig. (2-tailed)	0.077	0.001	0.068	0.000
R^2 Coefficient of determination	1.23%	4.08%	1.32%	5.71%
N	255	255	255	255
Pearson's *r* HS Admiss URM	0.321	0.272	0.106	-0.093
Sig. (2-tailed)	0.060	0.114	0.544	0.597
R^2 Coefficient of determination	10.82%	7.40%	1.12%	0.86%
N	35	35	35	35
Pearson's *r* CoE SC MAJORITY	-0.004	-0.046	0.005	0.102
Sig. (2-tailed)	0.945	0.460	0.995	0.105
R^2 Coefficient of determination	0.0%	0.21%	0.0%	1.04
N	255	255	255	255
Pearson's *r* CoE SC URM	0.131	0.312	0.088	-0.125

Sig. (2-tailed)	0.452	0.068	0.615	0.476
R^2 Coefficient of determination	1.72%	9.73%	0.77%	1.56%
N	35	35	35	35
Pearson's *r* EN Friends MAJORITY	0.052	0.037	-0.019	0.118
Sig. (2-tailed)	0.408	0.553	0.763	0.059
R^2 Coefficient of determination	0.27%	0.14%	0.04%	1.39%
N	255	255	255	255
Pearson's *r* EN Friends URM	-0.085	0.066	0.082	-0.232
Sig. (2-tailed)	0.628	0.707	0.638	0.180
R^2 Coefficient of determination	0.72%	0.44%	0.67%	5.38%
N	35	35	35	35
Pearson's *r* EN Homework Net MAJORITY	0.031	0.027	-0.052	0.066
Sig. (2-tailed)	0.621	0.664	0.406	0.291
R^2 Coefficient of determination	0.10%	0.07%	0.27%	0.44%
N	255	255	255	255
Pearson's *r* EN Homework Net URM	-0.159	-0.117	0.183	-0.208
Sig. (2-tailed)	0.361	0.504	0.291	0.230
R^2 Coefficient of determination	2.53%	1.37%	3.35%	4.33%
N	35	35	35	35
Pearson's *r* EN StdServc MAJORITY	0.029	0.022	-0.067	-0.052
Sig. (2-tailed)	0.641	0.724	0.290	0.408
R^2 Coefficient of determination	0.08%	0.05%	0.45%	0.27%
N	255	255	255	255
Pearson's *r* EN StdServc URM	0.027	-0.082	0.277	-0.177
Sig. (2-tailed)	0.875	0.638	0.108	0.308
R^2 Coefficient of determination	0.07%	0.67%	7.67%	3.13%
N	35	35	35	35
Pearson's *r* Rsrch MAJORITY	0.035	-0.047	-0.039	0.056
Sig. (2-tailed)	0.580	0.455	0.536	0.378
R^2 Coefficient of determination	0.12%	0.22%	0.15%	0.31%
N	253	253	253	253
Pearson's *r* Rsrch URM	-0.081	-0.030	0.314	-0.054
Sig. (2-tailed)	0.651	0.865	0.071	0.761
R^2 Coefficient of determination	0.66%	0.09%	9.86%	0.29%
N	34	34	34	34
Pearson's *r* AugOrgSoc MAJORITY	0.023	0.054	0.030	0.081
Sig. (2-tailed)	0.719	0.395	0.633	0.200
R^2 Coefficient of determination	0.05%	0.29%	0.09%	0.66%
N	253	253	253	253
Pearson's *r* AugOrgSoc URM	-0.156	-0.107	0.189	0.329
Sig. (2-tailed)	0.380	0.547	0.286	0.057
R^2 Coefficient of determination	2.43%	1.14%	3.57%	10.82%
N	34	34	34	34
Pearson's *r* ENOrgSoc MAJORITY	0.031	0.016	0.061	0.090
Sig. (2-tailed)	0.629	0.805	0.337	0.153
R^2 Coefficient of determination	0.10%	0.03%	0.37%	0.81%
N	253	253	253	253
Pearson's *r* ENOrgSoc URM	0.224	-0.004	0.341*	0.151

Sig. (2-tailed)	0.203	0.983	0.048	0.395
R^2 Coefficient of determination	5.02%	0.0%	11.63%	2.28%
N	34	34	34	34
Pearson's *r* OrgSocSum MAJORITY	0.030	0.039	0.052	0.097
Sig. (2-tailed)	0.632	0.534	0.415	0.124
R^2 Coefficient of determination	0.09%	0.15%	0.27%	0.94%
N	253	253	253	253
Pearson's *r* OrgSocSum URM	0.049	-0.060	0.305	0.268
Sig. (2-tailed)	0.782	0.735	0.079	0.126
R^2 Coefficient of determination	0.24%	0.36%	9.3%	7.18%
N	34	34	34	34
Pearson's *r* Q135 MAJORITY	0.000	0.052	0.032	0.068
Sig. (2-tailed)	0.996	0.196	0.423	0.089
R^2 Coefficient of determination	0.0%	0.27%	0.10%	0.46%
N	626	626	626	626
Pearson's *r* Q135 URM	0.128	0.182	-0.004	0.054
Sig. (2-tailed)	0.364	0.196	0.975	0.702
R^2 Coefficient of determination	1.64%	3.31%	0.0%	0.29%
N	52	52	52	52

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

For the bivariate correlation analysis of social capital resources relative to the four TT variables and disaggregated by URM/Majority status, nine of the 88 possible correlations reached statistical significance.

For Majority students, the HS Tech/EN social capital variable was statistically significantly correlated with all four of the TT variables. There was a small, positive correlation between the HS Tech/EN variable and the self-reported TT variable for Majority subjects, $r = 0.123$, $N = 255$, $p < .05$, with higher levels of high school technical/engineering–related social capital associated with self-reported high school TT experiences. The R^2 coefficient of determination was equal to 1.51%, indicating that 1.51% of the variance between the means of the two variables was shared. There was a small, positive correlation between the HS Tech/EN variable and the self-reported TT leadership variable for Majority subjects, $r = 0.214$, $N = 255$, $p < .01$, with higher levels of high school technical/engineering–related social capital associated with self-reported high school TT leadership experiences. The R^2 coefficient of determination was equal to 4.58%, indicating that 4.58% of the variance between the means of the two variables was shared. There was a small, positive correlation between the HS Tech/EN variable and the admissions committee–identified TT variable for Majority subjects, $r = 0.130$, $N = 255$, $p < .05$, with higher levels of high school technical/engineering–related social capital associated with admissions committee–identified high school TT experiences. The R^2 coefficient of determination was equal to 1.69%, indicating that 1.69% of the variance between the means of the two variables was shared. There was also a small, positive correlation between the HS Tech/EN variable and the admissions committee–identified TT leadership variable for Majority subjects, $r = 0.236$, $N = 255$, $p < .01$, with higher levels of high school technical/engineering–related social capital associated with admissions committee–identified high school TT leadership experiences. The R^2 coefficient of determination was equal to 5.57%, indicating that 5.57% of the variance between the means of the two variables was shared. There was a small, positive correlation between the HS Admiss variable and the self-reported TT leadership variable for Majority subjects, $r = 0.202$, $N = 255$, $p < .05$, with higher levels of high school engineering admissions–related social capital associated with self-reported high school TT leadership experiences. The R^2 coefficient of determination was equal to 4.08%, indicating that 4.08% of the variance between the means of the two variables was shared. There was also a small, positive correlation between the HS Admiss variable and the admissions committee–identified TT leadership variable for Majority subjects, $r = 0.239$, $N = 255$, $p < .01$, with higher levels of high school engineering admissions–related social capital associated with admissions committee–identified high school TT leadership experiences. The R^2 coefficient of determination was equal to 5.71%, indicating that 5.71% of the variance between the means of the two variables was shared.

For URM subjects, three of the bivariate correlations were statistically significant. There was a medium, positive correlation between the HS Tech/EN variable and the self-reported TT variable for URM subjects, $r = 0.480$, $N = 35$, $p < .01$, with higher levels of high school technical/engineering–related social capital associated with self-reported high school TT experiences. The R^2 coefficient of determination was equal to 23.04%, indicating that 23.04% of the variance between the means of the two variables was shared. There was a medium, positive correlation between the HS Tech/EN variable and the self-reported TT leadership variable for URM subjects, $r = 0.422$, $N = 35$, $p < .05$, with higher levels of high school technical/engineering–related social capital associated with self-reported high school technical TT experiences. The R^2 coefficient of determination was equal to 17.81%, indicating that 17.81% of the variance between the means of the two variables was shared. There was also a medium, positive correlation between the ENOrgSoc variable (the variable that measured student perceptions of how they fit in the engineering college during orientation week of their first year) and the admissions committee–identified TT leadership variable for URM subjects, $r = 0.341$, $N = 34$, $p < .05$, with higher levels of social capital that was measured during orientation week associated with admissions committee–identified high school TT leadership experiences. The R^2 coefficient of determination was equal to 11.63%, indicating that 11.63% of the variance between the means of the two variables was shared.

Regression Analysis of Social Capital and Technical Team Variables

An objective of this portion of the study is to determine whether a relationship exists between the social capital–dependent variables and four independent TT variables, while holding gender, URM status, and socio-economic status constant. I calculated a standard multiple regression to predict perceived social capital based on high school TT participation. The variables described in Table 97 were included in the regression analysis.

Table 97. Variables included in the Social Capital multiple regression model.

Dependent variables	**Independent Variables**	**Control Variables**
HS Tech/EN	Self-Identified High School Technical Team Experience	URM
HS Admiss	Self-Identified High School Technical Team Leadership	Gender
CoE SC	Admissions Committee–Identified High School Technical Team Experience	Unified Parental Education
EN Friends	Admissions Committee–Identified High School Technical Team Leadership	Number of Family-Owned Bookshelves
EN Homework Net		
EN StdServc		
AugOrgSoc		
ENOrgSoc		
OrgSocSum		
Q135		

Three measures indicate how well the model fits the data: the multiple correlation coefficient (*R*) and the two measures indicating the total variation explained, which are the R^2 and adjusted-R^2 results.

As described in the bivariate analysis section on the self-efficacy–dependent variable, the *R* value, or Pearson correlation coefficient, ranges from 0 to 1 and indicates the strength of association between the dependent variable and the independent variables.

Scores closer to 1 indicate a strong association and scores closer to 0 indicate minimal, or no, association between the variables.

For the model predicting social capital with the independent variables of self-reported high school TT experience, self-reported high school TT leadership, admissions committee–identified TT experience, admissions committee–identified TT leadership, gender, URM status, unified parental education, and number of bookshelves in the home, Table 98 represents the model summary.

Table 98. Model Summary for Social Capital

Dependent Variables	*R*	*R Square*	*Adjusted R-Square*
HS Tech/EN	0.417	0.174	0.150
HS Admiss	0.309	0.096	0.070
CoE SC	0.219	0.048	0.020
EN Friends	0.243	0.059	0.032
EN Homework Net	0.236	0.056	0.029
EN StdServc	0.408	0.166	0.142
AugOrgSoc	0.237	0.056	0.029
ENOrgSoc	0.204	0.042	0.014
OrgSocSum	0.241	0.058	0.031
Q135	0.149	0.022	0.011
Predictors	self-reported high school technical team experience, self-reported high school technical team leadership, admissions committee–identified technical team experience, admissions committee–identified technical team leadership, gender, URM status, unified parental education, and number of bookshelves in the home		

An adjusted-R^2 guide that may be used to determine how well the model fits the data is as follows:

<0.1: poor fit
0.11-0.3: modest fit
0.31-0.5: moderate fit
>0.5: strong fit

Based on Muijs (2011, p. 145), adjusted-R^2 values <.10 imply that a model is a poor fit for data and that the effect size is minimal. Two of the social capital regression models meet Muijs's threshold for a modest fit: HS Tech/EN, which represents high school technical and/or engineering social capital as measured by the Resource Generator, and EN StdServc, which represents accessed College of Engineering student services social capital. The adjusted-R^2 values of the remaining social capital variables fall into the poor fit category.

Statistical significance of the models

The ANOVA signifies the level of the overall statistical significance of each of the eleven regression models. The ANOVA results that determine whether self-identified high school TT participation, self-identified high school TT leadership, admissions committee–identified Tt participation, admissions committee–identified TT leadership, gender, URM status, combined parental education level, and number of bookshelves in the home statistically predict social capital are summarized in Table 99.

Table 99. ANOVA Summary for Social Capital

Dependent Variables	*df*	*F*	*Sig. (p < .0005)*
HS Tech/EN	(8, 279)	7.351	.000*
HS Admiss	(8, 279)	3.686	.000*
CoE SC	(8, 279)	1.749	.087
EN Friends	(8, 279)	2.195	.028*
EN Homework Net	(8, 279)	2.059	.040*
EN StdServc	(8, 279)	6.948	.000*
AugOrgSoc	(8, 276)	1.988	.041*
ENOrgSoc	(8, 276)	1.573	.156
OrgSocSum	(8, 276)	2.127	.033*
Q135	(8, 668)	1.897	.058
Predictors	self-reported high school technical team experience, self-reported high school technical team leadership, admissions committee–identified technical team experience, admissions committee–identified technical team leadership, gender, URM status, combined parental education, and number of bookshelves in the home		
Note. * sig. at the *p* < .05 level.			

The ANOVA indicates that seven of the ten models have at least one independent variable that statistically predicts the dependent social capital variable. It also indicates that the seven statistically significant regression models are better at predicting the dependent variable than the mean model alone. Table 100 describes the unstandardized coefficients for each of the ten regression models.

Table 100. Unstandardized Coefficients for social capital variable 1: HS_EN_SC, high school technical/engineering social capital resources.

	Unstandardized *B*	SE_B	β	Sig.
Constant	0.663	1.636	-	.686
SELFTTBinary	1.230	1.234	.062	.320
SELFTTLeaderBinary	7.521	2.426	.191	.002*
CTTEEEXPnew2	0.351	0.980	.021	.721
CTTLDnew2	2.801	1.302	.128	.032*
SexNum	.510	0.858	.033	.553
URM_Binary	.650	1.301	.028	.618
UnifiedParentEd	.395	0.112	.216	.000*
Q117NUMBEROFBOOKSHELVES	.745	0.378	.119	.050
Note. *** sig. at the $p < .05$ level.**				

For the regression model predicting high school technical/engineering–related social capital resources, three of the variables—self-reported TT leader, admissions committee–identified TT leadership, and unified parental education—statistically significantly predicted such social capital at the $p < .05$ level. See Table 101.

Table 101. Unstandardized Coefficients for social capital variable 2: HS_ADMISS_SC, high school engineering admissions social capital resources

	Unstandardized *B*	SE_B	β	Sig.
Constant	0.207	1.005	-	.837
SELFTTBinary	0.494	0.758	.042	.516
SELFTTLeaderBinary	3.810	1.490	.165	.011*
CTTEEEXPnew2	0.265	0.602	.027	.660
CTTLDnew2	1.591	0.800	.124	.048*
SexNum	0.146	0.527	.016	.782
URM_Binary	0.764	0.800	.056	.340
UnifiedParentEd	0.129	0.069	.120	.062
Q117NUMBEROFBOOKSHELVES	0.246	0.232	.067	.291
Note. *** sig. at the *p* < .05 level.**				

For the regression model predicting high school engineering admissions–related social capital resources, two of the variables—self-reported TT leader and admissions committee–identified TT leadership—significantly predicted such social capital at the $p < .05$ level. See Table 102.

Table 102. Unstandardized Coefficients for social capital variable 3: Coll_EN_SC, college of engineering social capital resources.

	Unstandardized *B*	SE_B	β	Sig.
Constant	9.789	2.845	-	.001
SELFTTBinary	.474	2.145	.015	.825
SELFTTLeaderBinary	-0.972	4.217	-.015	.818
CTTEEEXPnew2	-0.511	1.704	-.019	.764
CTTLDnew2	2.689	2.263	.076	.236
SexNum	2.726	1.491	.109	.069
URM_Binary	6.475	2.262	.173	.005*
UnifiedParentEd	0.306	0.194	.103	.116
Q117NUMBEROFBOOKSHELVES	-0.095	0.657	-.009	.885
Note. *** sig. at the *p* < .05 level.**				

For the regression model predicting College of Engineering–related social capital resources, one variable—URM—significantly predicted such social capital at the $p < .05$ level. See Table 103.

Table 103. Unstandardized Coefficients for social capital variable 4: Sum Engineering Social Network, college of engineering friends that are engineers social capital resources

	Unstandardized *B*	SE_B	β	Sig.
Constant	4.776	.845	-	.000
SELFTTBinary	0.191	.637	.020	.765
SELFTTLeaderBinary	0.666	1.253	.035	.596
CTTEEEXPnew2	-0.289	.506	-.036	.568
CTTLDnew2	0.694	.672	.066	.303
SexNum	0.554	.443	.074	.212
URM_Binary	2.113	.672	.189	.002*
UnifiedParentEd	0.148	.058	.167	.011*
Q117NUMBEROFBOOKSHELVES	-0.060	.195	-.020	.760
Note. *** sig. at the *p* < .05 level.**				

For the regression model predicting College of Engineering friendship network social capital resources, two variables—URM and unified parental education—significantly predicted such social capital at the $p < .05$ level. See Table 104.

Table 104. Unstandardized Coefficients for social capital variable 5: Sum Homework Network, college of engineering friends that you do homework with social capital resources.

	Unstandardized *B*	SE_B	β	Sig.
Constant	1.013	.262	-	.000
SELFTTBinary	0.015	.198	.005	.939
SELFTTLeaderBinary	0.157	.389	.027	.687
CTTEEEXPnew2	-0.096	.157	-.039	.542
CTTLDnew2	0.131	.209	.040	.529
SexNum	0.390	.137	.168	.005*
URM_Binary	0.324	.208	.094	.121
UnifiedParentEd	0.047	.018	.170	.009*
Q117NUMBEROFBOOKSHELVES	-0.070	.061	-.075	.247
Note. *** sig. at the *p* < .05 level.**				

For the regression model predicting College of Engineering homework network social capital resources, two variables—gender and unified parental education—significantly predicted such social capital at the $p < .05$ level. See Table 105,

Table 105. Unstandardized Coefficients for social capital variable 6: Sum College of Engineering Resource Utilization, college of engineering student services social capital resources.

	Unstandardized *B*	SE_B	β	Sig.
Constant	2.325	.614	-	.000
SELFTTBinary	0.194	.463	.026	.676
SELFTTLeaderBinary	0.510	.910	.035	.576
CTTEEEXPnew2	0.128	.368	.021	.727
CTTLDnew2	-0.724	.488	-.089	.139
SexNum	1.755	.322	.303	.000*
URM_Binary	2.595	.488	.301	.000*
UnifiedParentEd	0.061	.042	.089	.149
Q117NUMBEROFBOOKSHELVES	-0.118	.142	-.050	.405
Note. *** sig. at the *p* < .05 level.**				

For the regression model predicting utilization of College of Engineering student services social capital resources, two variables—gender and URM—significantly predicted such utilization at the $p < .05$ level. See Table 106.

Table 106. Unstandardized Coefficients for social capital variable 7: AugOrgSoc, socialization social capital reflecting back to first week in college of engineering

	Unstandardized *B*	SE_B	β	Sig.
Constant	2.052	.233	-	.000
SELFTTBinary	-0.075	.175	-.029	.668
SELFTTLeaderBinary	0.149	.343	.029	.664
CTTEEEXPnew2	0.019	.140	.009	.891
CTTLDnew2	0.329	.184	.115	.075
SexNum	-0.081	.122	-.039	.509
URM_Binary	0.597	.186	.194	.002*
UnifiedParentEd	0.027	.016	.113	.085
Q117NUMBEROFBOOKSHELVES	-0.062	.053	-.075	.248
Note. *** sig. at the *p* < .05 level.**				

For the regression model predicting perceptions of College of Engineering August socialization social capital resources, one variable—URM—significantly predicted such perceptions at the $p < .05$ level. See Table 107.

Table 107. Unstandardized Coefficients for social capital variable 8: ENOrgSoc, socialization social capital resources at the point of survey completion - November 2006 to March 2007.

	Unstandardized *B*	SE_B	β	Sig.
Constant	3.321	.243	-	.000
SELFTTBinary	0.117	.182	.044	.519
SELFTTLeaderBinary	-0.117	.356	-.022	.743
CTTEEEXPnew2	0.130	.146	.058	.375
CTTLDnew2	0.227	.192	.077	.237
SexNum	0.060	.127	.028	.638
URM_Binary	0.511	.194	.161	.009*
UnifiedParentEd	0.025	.016	.100	.128
Q117NUMBEROFBOOKSHELVES	-0.045	.056	-.053	.416
Note. *** sig. at the *p* < .05 level.**				

For the regression model predicting perceptions of College of Engineering socialization social capital resources during the first year of engineering study, one variable—URM—significantly predicted such perceptions at the $p < .05$ level. See Table 108.

Table 108. Unstandardized Coefficients for social capital variable 9: OrgSocSum, sum of socialization social capital trajectory from entry through survey completion

	Unstandardized *B*	SE_B	β	Sig.
Constant	5.373	.418	-	.000
SELFTTBinary	0.042	.312	.009	.892
SELFTTLeaderBinary	0.032	.613	.003	.958
CTTEEEXPnew2	0.149	.251	.038	.553
CTTLDnew2	0.556	.330	.108	.093
SexNum	-0.021	.218	-.006	.923
URM_Binary	1.108	.334	.201	.001*
UnifiedParentEd	0.053	.028	.121	.065
Q117NUMBEROFBOOKSHELVES	-0.107	.096	-.072	.263
Note. *** sig. at the *p* < .05 level.**				

For the regression model predicting perceptions of College of Engineering total socialization social capital resources during the first year of engineering study, one variable—URM—significantly predicted such perceptions at the $p < .05$ level. See Table 109.

Table 109. Unstandardized Coefficients for social capital variable 10: Q135, high school family and immediate social network support for studying engineering social capital resources.

	Unstandardized *B*	SE_B	β	Sig.
Constant	26.420	.886	-	.000
SELFTTBinary	-0.365	.612	-.025	.551
SELFTTLeaderBinary	1.891	1.395	.057	.176
CTTEEEXPnew2	0.111	.498	.009	.823
CTTLDnew2	0.819	.707	.048	.247
SexNum	-0.717	.459	-.060	.119
URM_Binary	1.281	.806	.062	.112
UnifiedParentEd	0.066	.059	.046	.263
Q117NUMBEROFBOOKSHELVES	0.345	.192	.073	.072
Note. *** sig. at the $p < .05$ level.**				

For the regression model predicting Q135 (family and immediate high school support network for studying engineering) social capital resources, no variables significantly predicted Q135 social capital.

CHAPTER 6

CONCLUSIONS, LIMITATIONS, AND SUGGESTIONS: SETTING THE STAGE AND TELLING THE STORY

This research project began as a handwritten diagram and set of questions scrawled on a piece of paper containing the agenda for a completely unrelated, but quite dull, meeting in 2003. I was a junior admissions office at a highly selective college of engineering and was deep in the process of reviewing candidates for admission. While attending that meeting I first drafted my initial research ideas. The topic of the meeting had little to do with me and was completely unrelated to my research project, but it offered a quiet opportunity for me to sketch out my thoughts.

That year, I had noticed a small groundswell of engineering admissions candidates who had participated in the FIRST Robotics program. Their descriptions drew my attention because more-than a few of these candidates submitted essay statements that were similar to this one:

> While of course I'm still working on my projects, one of the places in high school that I continue to work on engineering problems is my FIRST Tech Challenge robotics team. Sometimes I have trouble explaining to my friends why I devote so much time to robotics: lingering Saturday afternoons, evenings after tough cross country practices, and long nights before competitions tweaking code sequences to calibrate the robot millimeters right or left. During these long hours, I'm in my zone, and exactly where I want to be. I love the struggle of trying to make our robots *A path-finding algorithm more accurate and I love eventually uncovering creative solutions like using a computer's mouse's optical sensor to take better displacement readings. When the robot's arm just lifts the burdensome weight of a game piece, the gratification of "I made that real" makes it all worth it.
>
> At [engineering college] I plan to major in computer science and am considering minors in electrical engineering as well as business. I know that's a lot to accomplish. . . . When I visited this summer, I met some members of the [engineering project team], who were spending their whole summer working on the [technical team project]. Their enthusiasm and passion were just like the excitement I feel working on my FTC robot. This is exactly

the type of project I want to continue working on at [engineering college]. (Anonymous male first-year applicant, 1995)

This candidate, like other FIRST Robotics participants, spoke the engineering lingo. He talked of tying technology to creativity, working hard in the pursuit of innovation, and self-sacrifice, and demonstrated an inveterate devotion to problem-solving. He dangled his knowledge of an A* algorithm in front of the admissions committee like a blue-ribbon prize and described retro-fitting a computer mouse's optical sensor to meet his robot's needs. All other things being equal, clearly this was a compelling engineering school candidate that any engineering program would want to count as its own. Applicants with similar experiences reported having profound engineering experiences via FIRST Robotics and described these experiences in their applications in terms that resonated with engineering admissions committees. From my admissions position, I noted that candidates with these experiences tended to be male and from reasonably well-resourced communities and high schools. It seemed to me that they were using their FIRST Robotics experiences as "blue chips" in the admissions process, linking their experiences to what they might accomplish as students in our engineering program.

I was curious about other advantages the FIRST Robotics program might afford participants that went beyond nimbly retro-fitting optical sensors and making robots do remarkable things. It seemed to me that the FIRST Robotics participants *were* seeking an admissions advantage—but were there elements of these experiences, beyond the technical, that bestowed a specific set of other advantages on participants? It was this curiosity that led me to sketch my thoughts about my research project on the back of the meeting agenda and has been the touchstone for the project.

During the early stages of my work, I wanted mainly to know how technical team (TT) participants experienced undergraduate engineering when compared with non–TT participants. Were their grade point averages higher? Did they have more optimistic perceptions of their own success? Were they more involved as undergraduate engineers in conducting research, joining undergraduate project teams, and engaging in cooperative education? It wasn't until I began to think critically about how TT participation might play out across group classifications such as gender, ethnicity, and socio-economic status—how these types of experiences might reflect or reinforce existing social structures—that the research coalesced in earnest.

First Robotics as the Archetypal Technical Team Experience

While this project was not focused solely on the FIRST Robotics program, it represents an important element of the research context insofar as FIRST is, in fact, one of the world's premier robotics programs. The study's findings are therefore informed in part by the manner in which FIRST developed over time and by what it professes to accomplish, and in many respects does accomplish, for participants,. FIRST was founded in 1992 with 28 teams competing against one another in a basic robotics competition called the "Maize Craze." It was in the late 1990s and early 2000s that FIRST really began to gain national traction and gather momentum. In 2005, the year of FIRST's inaugural annual report, 465 teams from 19 countries involving 9,300 students had entered robots into the competition. That represents a 1,561% increase in the number of FIRST teams between 1992 and 2005. Between 2005 and 2015, the number of FIRST teams increased from 465 to 39,000, engaging 360,000 high school students from 80 countries. This represents an 8,287% increase in the number of teams participating in FIRST over the ten-year span between 2005 and 2015. This growth occurred despite the 2008 economic collapse. FIRST Robotics is a remarkable movement and its mass appeal is irrefutable.

What does FIRST profess to do that has led to such remarkable programmatic growth? The initial 1992 mission of FIRST has not changed and remains its backbone today: “Our mission is to inspire young people to be science and technology leaders, by engaging them in exciting mentor-based programs that build science, engineering, and technology skills, that inspire innovation, and that foster well-rounded life capabilities including self-confidence, communication, and leadership” (FIRST, 2017). The 2015 FIRST Annual Report takes the mission statement further, stating that “(k)ids who dream big, who like to tinker, who need a boost in self-confidence, who yearn for an inclusive, non-judgmental environment to discover their own talents, who want a chance to make something of themselves, need all of us working together. We believe that the opportunities offered by FIRST should be accessible to every student and belong in every school” (FIRST, 2015). A statement by FIRST founder, Dean Kamen, reinforces the notion that FIRST develops attributes in participants that will benefit them beyond the activity of building robots: “FIRST is more than robots. The robots are a vehicle for students to learn important life skills. Kids often come in not knowing what to expect—of the program nor of themselves. They leave, even after the first season, with a vision, with confidence, and with a sense that they can create their own future” (FIRST, 2017). FIRST and similar programs intend to affect their participants profoundly through character development to catalyze an interest in subjects related to science, technology, engineering, and math (STEM).

FIRST Robotics, perhaps the flagship TT program, is one of many STEM-related programs designed to incubate the next generation of technical talent. A recent Internet search yielded over ninety programs of varying scope and focus that resemble FIRST in terms of their professed missions. Reflecting the prominence of these programs, the National Science Foundation's fiscal year 2017 budget proposal to Congress earmarks $16 million dollars to continue growing its program, INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science). The goal of INCLUDES is to "produce, through alliances organized within a national network, rapid progress on changing the balance of diversity in science and engineering, have significant national impact for the participation of underrepresented groups, stimulate the community, forge new partnerships, and catalyze new approaches" (National Science Foundation, 2016).

The Story Continues: Key Findings from the Study

This study was initiated on the premise that socially created mechanisms, such as FIRST Robotics teams, have the potential to distribute benefits differentially based on the positions individuals occupy in the social hierarchy. The fundamental issue the study addressed involved understanding whether, or to what degree, the effects of TT participation on students were distributed *differentially* based on gender, URM status, and socio-economic status. In other words, do women, underrepresented minorities, and students from lower socio-economic strata experience TT differently from the ways in which male, majority, middle-class, or affluent students experience them?

The study analyzed the effects TT participation had on students' engineering-related social capital resources, self-efficacy skills, and confidence that engineering was a good fit for them. The refraction of each of these effects, as filtered by high school TT experiences, was measured and analyzed with the notion that students positioned at different points in the social hierarchy may manifest different responses to their TT experiences based, fundamentally, on positioning within the social structure. Finally, for the sake of discussion, and for future study, the question remains whether high school TT participation, perhaps unintentionally, reinforces rather than dissolves existing social structures that discourage students from specific backgrounds from pursuing STEM-related subjects.

Key Findings from Study 1: Confidence

Interesting Findings for the Variable Group Work

For the entire sample population, the study found a negative relationship between participating on a TT and perceptions of group work. The survey questions for the construct Group Work were designed to measure students' preferences for working in groups. The results indicate that those who reported participating on a high school TT actually prefer *not* performing within group settings. When disaggregated by gender, Group Work was uniformly rated negatively by males who participated on a TT across all four of the TT variables, while the results showed a negative relationship between participation and two of the four TT variables among responses by females. This suggests that males participating on high school TTs have a uniformly negative perception of Group Work while female perceptions of Group Work are mixed.

These results remained consistent when perceptions of Group Work were compared between majority and URM students. URM students associated all four of the TT variables with Group Work negatively while majority participants did so with three of the four TT variables.

Overall, that Group Work is negatively associated with high school TT participation is an interesting finding. This is particularly true given that undergraduate engineering programs incorporate curricular and co-curricular group work as foundational components. Additionally, high school TT programs commonly promote themselves by emphasizing camaraderie, communication, and team-oriented problem-solving skills as central to their mission. They advertise the social elements of TT participation—the group work—advertised as essential elements of most programs.

The results of this research suggest that the relationship between working in groups and TT experiences warrants close examination. This is not necessarily to imply that the results are wholly negative or indicate some failing of TT experiences. It is feasible that students who have participated on TTs have a more precise sense of the difficulties involved in working in a team setting, including those associated with managing personalities and reaching agreement and consensus on goals and how goals may be accomplished as well as the lack of individual autonomy and the presence of free riders. One participant voiced his frustration with having to do everything in a team. He suggested that all he really wanted was access to the tools the team possessed so he could do the work on his own, allowing his own creativity to drive what direction he took with his project. The team, he suggested, inhibited the fun he sought in developing his own robot.

Equally plausible, however, is a scenario in which TT participants had poor group experiences as a consequence of difficult team dynamics. Perhaps expectations of participating fully were not met. Or perhaps some TT participants were ostracized or pushed to the periphery of their teams. One female URM student who was in the first generation in her family to attend college described being relegated by her team leaders to the role of using a catalogue to order parts for the robot. She stated that dominant team leaders who were "hardcore" and who "took over" the team did not allow any input from other team members and that the bulk of the team members were marginalized to carrying out mundane tasks as a result. She described being allowed to bask in the fun of competitions with the robot, but never being allowed to actually touch the robot, let alone work on it.

Interesting Findings for the Variables Problem Solving Ability, Engineering Abilities, and Engineering Preview

For the entire sample population, the relationship between the three PFEAS confidence variables (Problem Solving Ability, Engineering Abilities, and Engineering Preview) and the four TT variables was almost uniformly positive. Problem Solving Ability is designed to measure a student's belief that he or she has the creative thinking and problem-solving abilities necessary to succeed in engineering. Engineering Abilities is designed to measure a student's belief that he or she has the capability traits of engineers. Finally, Engineering Preview is designed to measure a student's confidence that he or she knows what engineering is. For *each* of the three variables (Problem Solving Ability, Engineering Abilities, and Engineering Preview), two of the four TT variables showed a positive, statistically significant relationship and only one relationship was negative. The one exception was the Self TT Leader variable, which was negatively associated (not statistically so) only with the Problem Solving Ability variable.

For TT proponents, this is good news. A reasonable conclusion pertaining to the aggregated sample population is that high school TT participation has an overall positive impact by some measure, which can be demonstrated statistically, on these three important engineering-related characteristics or skills. TT participants are, in general, more confident in their problem-solving and engineering abilities and have a positive sense that they understand what engineering is. TTs are, in general, succeeding at reinforcing these skills and perceptions among their participants.

The story changes, however, when the analysis is disaggregated by demographic status. For majority students, the relationship between participating on a high school TT and the variable Problem Solving Ability remains uniformly positive. In fact, the relationship is strengthened, with three of the four TT variables showing a statistically significant relationship with Problem Solving Ability. For URM students, however, the inverse is true. While not rising to the level of statistical significance, the relationship between Problem Solving Ability and the four TT variables is uniformly negative in URM participants' responses.

This pattern remains consistent for the other two variables (Engineering Abilities and Engineering Preview). Among majority students, all four TT variables were deemed to have a positive relationship with Engineering Abilities. Additionally, two of the four

TT variables show a statistically significant relationship with Engineering Abilities. This pattern is reversed among responses of URM students, with three of the four TT variables showing a negative relationship to Engineering Abilities (although none of the relationships rises to the level of statistical significance). Finally, the Engineering Preview variable was positively correlated with all four TT variables by majority students, and two of the relationships were statistically significant. URM students judged that three of the four TT variables had a negative relationship with Engineering Preview (although, again, none of the relationships rises to statistical significance).

The difference between majority and URM students with respect to these variables suggests that TT experiences may be playing out differently for members of the two groups. While I cannot account for what might cause this due to the study design, the finding itself implies the need for further study. Many, if not all, high school TT programs are designed to diversify STEM-related fields. These results indicate that substantial gaps may be occurring that undermine the perceptions that URM students form of engineering while simultaneously bolstering the perceptions of majority students. Taking a deeper look at this possible dynamic across a broader cross-section of students would likely shed more light on this issue.

Interesting Findings for the Variables Perception of Work and Communication Skills

The variable Perception of Work measured student perceptions of the work that engineers do and of the engineering profession. Perception of Work was negatively correlated with three of the four TT variables in female responses (none of the findings was statistically significant). Among males, the same variable was positively correlated across all four TT variables. The inverse was true for the variable Communication Skills, which is one of the PFEAS confidence measures and is designed to measure students' confidence regarding a broad range of communication-related skills such as writing, speaking, and the use of computers in communication. The variable was of interest because the results were inverted based on gender. In male responses Communication Skills were negatively correlated with three of the four TT variables (none of the correlations was statistically significant). The inverse was true for females, among whom three of the four TT variables were positively correlated with the Communication Skills variable (in one case rising to the level of statistical significance).

These findings suggest, again, that TT experience has differential effects across distinct groups. Females' perceptions of the work engineers do (Perception of Work) may have been negatively affected by Tt experience. And yet, to participate in this study, students had to have intentionally enrolled in an undergraduate engineering program. Given that females suffer higher attrition rates in engineering than their male counterparts, this finding could have significant implications. If females who participated in high school TTs enter engineering with a negative view of the work engineers do, this could potentially contribute to increased attrition from engineering among women. At a minimum, this potential boomerang effect of TT participation on female participants bears closer scrutiny. If TTs intend to diversify engineering by enticing more women to enter the field, then everything should be done to ensure that TTs do not inadvertently counteract their intended purposes.

The results for the Communication Skills variable are less definitive. Communication plays an increasingly important role in undergraduate engineering curriculums, with the recognition that the communication of ideas by engineers is critically important and a skill that engineers are increasingly called on to master. Most undergraduate engineering programs devote a portion of the curriculum to engineering-specific communications. For example, the statement referring to completion of the technical writing portion of the curriculum at the engineering college under study states:

> Communication is an important way of acting in the world. And, because that world is constantly changing, professionals in engineering must be prepared throughout their career to learn to learn how to communicate. Consequently, the most important objective of the Engineering Communications Program (ECP) is to enable undergraduate engineering students to develop strategies for learning to learn how to act effectively and efficiently as communicators. (Cornell Engineering, 2017)

Similar curricular statements prioritizing engineering communication skills may be found at engineering colleges, schools, and departments across the United States.

That the Communications Skills variable yielded differential results based on gender and that males demonstrated a negative relationship between TT participation and confidence in their communication skills suggests that there is room for developing this area for all groups, but certainly in a more concentrated way for males. The finding is also somewhat confounding insofar as one might anticipate that participation on a TT would develop, not inhibit, communication skills regardless of gender.

These findings do pique curiosity, particularly so when the results for other variables are introduced. For instance, the relationship between the variable Group Work and TT participation was uniformly negative in the responses of males. Among females two of the four technical team variables were also related negatively to Group Work. It is plausible that there is some level of interaction between these results if one assumes that the capacity to successfully participate in group work may be premised on students' communication skills. If there is some interaction between these variables, then the results of this study generate additional questions. If modern engineering work is premised on accomplishing tasks in group settings, and if successful group work is premised on well-developed communication skills, then how might gender interact with these dynamics? This study unearths the question without satisfactorily providing an explanation for this interesting dynamic, as seeking plausible explanations for these specific findings is beyond the scope of this study.

Key Findings from Study 1: Self-Efficacy

Perhaps the most prominent finding relative to self-efficacy is that the analysis indicated that a negative relationship exists between three of the four TT variables and URM status. Among URM students' responses three of the four TT variables had a statistically significant, negative relationship with self-efficacy. This was not the case for majority students, among whose responses three of the four TT variables had a positive relationship with self-efficacy (although none rose to the level of statistical significance).

Based on this finding, one can infer that URM participation on a high school TT had a strong, negative relationship with the self-efficacy beliefs of these students. Recall that the self-efficacy data were collected on the first day of engineering undergraduate orientation; the students in the sample population recorded their self-efficacy responses on, quite literally, their first day as undergraduate engineers. This suggests that, contrary to commonly held beliefs that TT participation universally bolsters students' belief in themselves as budding engineers, TT participation may actually undermine the self-efficacy of URM students.

The finding is somewhat counterintuitive and surprises me; I anticipated that participation on a high school TT would bolster students' self-belief in their engineering abilities in ways that would propel them toward engineering. The interview data shed additional light on this finding that may offer insight. URM students who were interviewed described being on under-resourced high school TTs relative to teams comprising mostly majority students and majority students from more affluent areas. It wasn't until the URM students were in local, regional, or national competitions that they became aware of the resources other teams had that they did not. Based on the interview material, the differences in team resources were not lost on the URM students.

When URM students participated on TTs of which majority students formed the core, they also described being routinely assigned peripheral jobs or jobs involving no actual engineering or technically related tasks. Admittedly, it is difficult to assign causality to the self-efficacy findings (a range of factors beyond TT participation may lead to differences in self-efficacy between majority and URM students). However, it is worth considering the notion that the net effect of TT experiences may have played some role in eroding URM students' self-efficacy.

Key Findings from Study 2: Social Capital

Social capital lies at the heart of this study and ties directly to the original motive for conducting the research. One of the primary goals was to gain a clearer understanding of high school TTs as catalysts for engineering-specific social capital. In other words, do

TTs serve as conduits of information about engineering-specific skills, admission to engineering undergraduate studies, and undergraduate engineering resources that can be acted on instrumentally for advantages in engineering?

The results clearly show that participation on high school TTs connects participants to engineering-specific social capital resources. All four of the TT variables were statistically significantly correlated with high school engineering social capital. When the analysis focused on gender and URM status, a similar relationship between high school TT participation and engineering-specific social capital was found. Based on this result, it is apparent that TTs, as many suggest they do, connect their participants, including women and URM students, with people who are knowledgeable about engineering or who can provide tactical information about engineering.

I also measured social capital pertaining to engineering admissions. The goal was to gain a sense of the relationship between participation on a high school TT and people who could assist students in either accessing engineering admissions officers or in gaining admission to engineering undergraduate programs. For the total sample population, three of the four TT variables were statistically significantly related to the engineering admissions social capital variable. This implies that participation on a high school TT increases participants' social capital resources relative to gaining information about, or gaining admission to, undergraduate engineering programs.

This relationship plays out slightly differently for gender and URM status. Males' responses show the strongest positive relationship between TT experience and admissions social capital, with all four of the TT variables positively related to engineering admissions social capital and two of the relationships attaining statistical significance.

Among women, all four of the TT variables are positively associated with engineering Admissions social capital, but only one such relationship is statistically significant.

When the relationship is analyzed with respect to URM or majority status, the differences are slightly more pronounced. In majority students' responses, all four of the TT variables have a positive relationship with engineering social capital. While URM students also judged all four of the TT variables to have a positive correlation with engineering social capital, only two of these relationships rise to the level of statistical significance. In terms of engineering admissions social capital, majority students positively correlated all four of the TT variables with admissions social capital. Two of the four TT variables were statistically significantly related to engineering admissions social capital. The two statistically significant variables in majority students' responses were the TT leadership variables. This suggests that being a leader on a TT may play a role in the activation of social capital networks.

Three of the four TT variables were positively correlated by URM students with engineering admissions social capital and one TT variable was negatively correlated with engineering admissions social capital. None of the relationships was statistically significant. Taken as a whole, this would suggest that, relative to engineering admissions, majority students who participated on a TT have more robust engineering admissions social capital resources than their URM peers.

From these results I would infer a tiered set of engineering admissions social capital benefits being activated by students. Majority male students reported the strongest relationship between TT experience and engineering admissions social capital, followed by women, who are followed by URM students. This suggests that engineering admissions social capital benefits derived from TT participation may be unevenly distributed or activated based on gender and ethnicity.

The social capital variable measuring students' engineering homework networks was designed to quantify students' social capital relative to engineering friends (first-year through Ph.D. students) with whom students routinely work on their engineering homework. Three of the four TT variables were related negatively by URM students to TT participation and homework social capital. None of the relationships rises to the level of statistical significance. The inverse was true for majority students, who related three of the four TT variables positively to these variables. Again, none of the relationships rises to the level of statistical significance.

At a basic level, these two findings support two primary tenets of social capital theory. This first is that URM students tend to form dense social networks with few bridges to broader social capital ties. Majority students, and particularly those occupying positions of socio-economic privilege, tend to use a broad array of weaker social ties that provide them with more robust sources of information. Given the critical importance of successfully completing homework as undergraduate engineers, and given that engineering course content is generally considered academically challenging, the engineering homework social capital differences between URM and majority students is an important finding.

The regression models offer additional insight. For high school engineering social capital resources, the two TT leadership variables and the variable measuring socio-economic status (combined parental education) statistically predicted high school engineering social capital. This suggests that being a leader on a high school TT and being from a family with parents of higher educational achievement increases high school engineering–related social capital resources. This dynamic holds for high school engineering admissions social capital for both of the TT leadership variables, while the parental education variable no longer offers predictive value. This supports the correlation analysis, which indicated that being a leader on a high school TT is related to engineering admissions social capital resources.

Perhaps two of the most interesting regression analysis findings involve the relationship between URM students and specific engineering college social capital variables. The engineering student services social capital variable measures the scope of students' utilization of the full suite of engineering student support services available in the engineering college. The variable measures the number of times students visited the following engineering student service offices during their first year in engineering: Engineering Admissions, Engineering Advising, the Learning Initiatives Office, Career Services, Diversity Programs in Engineering, and the Engineering Registrar. The variable for URM was the only variable in the regression model that had a statistically significant relationship to the engineering student services social capital variable.

Relatedly, the variable measuring engineering social network social capital was also statistically related to only two variables. The engineering social network variable data indicate the number of first-year engineering-through-Ph.D. friends students had and was designed to measure, or quantify, the engineering-specific friendship social capital of the study participants. Both the URM variable and the socio-economic variable measuring parental education levels were statistically significantly related to the engineering social network variable.

These two findings related to URM students are interesting because they suggest, for URM students, a blossoming of engineering social capital that occurs during the students' first year in engineering college. Once they become first-year engineers, and regardless of prior TT experience, URM students' engineering-specific social capital expands to a point where a statistically significant relationship can be detected.

The corollary question is "Why does this occur?" While it is beyond the scope of this study to provide a fully tested answer to this question, a plausible explanation may involve a programmatically contrived engineering social capital network. The Diversity Programs in Engineering Office (DPE) works with URM students intensively during their first year in engineering. The DPE's goals involve the support and retention of URM students and much of their programming involves connecting URM students to their peers, faculty, and staff in the engineering college. It is feasible that their work develops and reinforces substantial engineering-specific social capital for URM students.

Synthesizing the Findings

Taken individually, each of the findings from this study is interesting and offers some insight into ways that high school TT participation may be related to how students from a range of backgrounds experience undergraduate engineering. There is value in each of the results considered independently. Taken collectively, however, the results offer a more compelling story that reflects the original purposes of the study.

Based on the results of the study, the effects of high school TT participation do not appear to be distributed equally across gender and ethnicity. Women and URM students perceive their TT experiences differently. Self-efficacy and confidence levels differ based on URM and gender status as well as social capital resources relative to high school TT experience. Even basic social capital resources are distributed differentially based on gender and URM status.

The results taken as a whole suggest a complex set of relationships, but due to the study design they do not establish causality. In other words, this study does not in itself warrant stating that participation on a high school TT leads to lower levels of self-efficacy for URM students. The relationships uncovered in this study are merely that: relationships that should catalyze further study.

Implications for Theory

The results of this study can be understood from the vantage point of the social capital theorist, and they also reinforce several propositions of social capital theory described in earlier chapters. Lin (2001) perfectly describes social capital as an "*investment in social relations with expected returns in the marketplace*" (p. 19; emphasis in original). He describes social connections that privilege members of specific networks with information that provides advantages within specific social hierarchies or structures. Indeed, the location of individuals within a social hierarchy defines their access to network resources, such as information, as well as their understanding that activating network resources may provide them with specific advantages (DiMaggio, 1979; Lin, 1981; Stanton-Salazar, 1997). Social capital, then, is about individual actors' ability to access specific networks of other individuals that will provide them with tactically important information in the competition to retain positions within or gain advantages within the social hierarchy.

Granovetter (1973, 1983) introduced the “strength of weak ties” principle of social capital, suggesting that individuals with robust social networks of weak ties are better able to collect important information across multiple networks than are those with strong ties. Conceptually, weak ties provide access to information in ways that more closed, or dense, networks do not. From a practical standpoint, this gives actors who realize the importance of cultivating a broad, loosely coupled social capital network a “my cousin in Silicon Valley knows a person who is best friends with the vice president of Google” type of advantage. The advantage of having weak tie lies in a network’s capacity to afford access to varied information from multiple and disparate social networks.

Homophily in social networks is, in many regards, the opposite of the “strength of weak ties” principle (Mouw, 2006). Homophily is the tendency of individuals to limit their social networks to people who are similar to themselves. Homophily may also not be a conscious choice individuals make, but rather a function of their status within the social hierarchy or a manifestation of their culture or immediate social milieu. Individuals whose behavior exhibits homophily have a propensity to be insular and have dense social networks that inhibit access to broader information resources. Homophily has been shown to be more pronounced along lines of race and gender (McPherson, Smith-Lovin, and Cook, 2001).

It is not enough merely to have access to networks of key information. While information access may be important, information may also be ineffectual unless it can be used for strategic purposes. Positioning oneself to control the flow of information and then activating networks for individual gain is a basic tenet of social capital theory (Burt, 1997; 2000; Reagans & McEvily, 2003). Social capital may also be used as a source of power to reinforce social positions while excluding outsiders from important information and resources (Portes, 1998). In this light, social ties inherent to a robust network can be tactically presented as a form of credential that validates the access of individuals possessing such ties to organizations (Lin, Cook & Burt, 2001). In these circumstances, social ties offer recognition that the holder of such ties is a member of a particular group.

This study confirmed many of the basic principles of social capital theory. TTs proved to be conduits of information, providing connections to individuals who are positioned to provide either information or resources associated with the field of engineering. TT leaders may have been best positioned to use their experiences for advantages in the admissions process. While it is beyond the scope of this study to suggest that this specific dynamic occurred, the findings do indicate that being a TT leader had a statistically significant relationship with engineering admissions–specific social capital. It is conceivable that high school TTs serve as the "structural holes" Burt (1997, 2000) describes. Relatively privileged majority students use TTs as a way of accessing critical information that provides some measure of advantage as they move toward becoming engineers. Participants' descriptions of this phenomenon in interviews are consistent with Delamont et al.'s (1993) definition of habitus as an almost unconscious set of behaviors, defined by one's position within the social hierarchy. The behaviors reinforce, and protect, the individual's position within the social structure. Majority students, for example, are socialized to seek opportunities that provide discreet advantages. High school TTs not only provide information about engineering, they also provide training in the language, dispositions, and behaviors of engineers.

The TT then is a structural hole, connecting participants to engineering-specific social capital. Structural holes, however, do TT participants little good without the recognition that they provide a source of diverse opportunities through which individuals can gain advantages over their peers. Habitus is the sociological trigger that signals individuals to use their experiences to capitalize on or actualize their advantages. This is the case for majority students and the results of the study illustrate this notion. Alternatively, but just as importantly, the habitus of URM students makes it more difficult for them to use TT experiences to gain an advantage. URM students' social capital resources that emerge from TT experiences appear to be less robust or positive than those of as majority students. This dynamic was underscored by an interview with an African American engineer who had participated in an all-URM FIRST Robotics team in high school. The team was sponsored by the President of the Coca-Cola Corporation, whom the student periodically still met with as a college student. Yet even though the student maintained a relationship with the company's president, he seemed either unwilling to use the connection to gain opportunities or oblivious to the potential advantages the relationship with the president of Coca Cola presented. When pushed by me to describe specific opportunities the president may have offered the student, he seemed genuinely perplexed.

Lin (2000) describes capital deficit in terms that resonate with this study. In short, capital deficit occurs when there is a shortage of resources for one group when compared with another. When the relationship between URM and majority students was examined in this study, majority students displayed more robust social capital resources. The corollary question is whether capital deficit can be artificially constructed for groups that suffer from such a deficit. The portion of the study that illustrated the blossoming of engineering–specific social capital resources for URM students provides some minor justification for asserting that building social capital where a deficit exists is possible.

Based on the results of this study, it is reasonably clear that high school TT experience provides participants with engineering-specific information resources that are well developed relative to those of their peers who had no TT experience. It is also clear that these resources play out differently based on URM status and gender. The study confirms, however, what social capital theory describes: that social networks provide information that offers advantages and, in this instance, the advantages may play out in cultural recognition that TT participants are moving through the process of enculturation whereby they are learning the codes, language, norms, and behaviors of engineers. The study also makes it clear that the TT enculturation process does not always yield positive perspectives on or perceptions of engineering.

Implications for Practice

The results of the study have several clear and practical implications for policy and practice for groups involved in almost all aspects of high school TTs with an interest in seeing their participants succeed in engineering at the college level.

Implications for organizers of technical team competitions

Adults organizing and managing TT competitions should recognize that teams may, in fact, reflect existing social structures and hierarchies. Policies should be implemented to ensure that teams from all levels of the social hierarchy are able to access resources equally. TTs from relatively affluent areas may have access to more abundant and higher caliber resources than teams from less affluent communities or communities where there are high concentrations of URM participants. The goal should be to level the playing field so that the results of TT competitions reflect individual teams' capacity to build a technical end-product rather than reflecting the position on the social structure where teams are located.

Ensuring that all TTs, but especially teams in which women and URM students predominate, have networks of engineers connected in engaging ways is important. The goal here is to provide all TTs with opportunities for members to learn from engineering mentors while also using such relationships in the pursuit of engineering education.

Implications for adult organizers of individual technical teams

Adults involved in organizing individual TTs must focus on the organizational make-up of their teams to ensure that URM and women participants are fully able to become involved in the technical aspects of the team process. URM and women students should not be relegated to fringe jobs that push them to the periphery of the core engineering work of their teams. Women should not be relegated to interpreting the rule book or ordering parts. URM students should be actively involved in the hands-on, intellectual exercise of building a robot. They should not be relegated to designing t-shirts or fundraising for the team. Policies and practices should be put in place by organizers that ensure that these students have bona fide opportunities to participate in building the technical products as well as developing relationships with the adult engineers involved in the projects.

Additionally, adult organizers of TTs with URM and female students should plan activities that artificially build engineering-specific social capital relationships into their team schedules. It is important to make explicit the importance of engineering social capital so that students who traditionally have not capitalized on these resources begin to understand how to do so.

Additionally, the negative relationship between group work and TT participation merits some level of response at the team level. Team organizers should consider the risk that participants may be less confident in their ability to work in groups after they have had a TT experience. The group dynamics of TTs should be addressed in ways that reduce the potential that participants view group work in a negative light. A range of strategic methods could be deployed to counteract negative perceptions of group work. These may include team-building exercises, regular job rotations within teams, leadership development, and mentorship programs.

Implications for engineering admissions officers

Perhaps the most critical implication of the results of this study for engineering admissions officers is to realize that TT experiences may play out quite differently based on factors such as gender and ethnicity. TT participants may have the ability to associate their experiences with engineering, but the quality of those experiences may vary widely by population. This dynamic should be considered consciously by admissions officers, particularly when reviewing female and URM engineering applicants. While this study has not found definitively that the quality of the TT experience is determined by gender and ethnicity, the study produces reasonable evidence that the quality of technical team experiences can vary substantially for women and URM students. It is a fallacy that technical team experiences are uniform across populations; furthermore, it seems likely that TT experience for women and URM students may, in fact, corrode their perceptions of engineering as well as their capacity to succeed as engineering students.

In addition, applicants from relatively privileged positions within the social structure who describe TT experiences in their applications should be looked at both contextually and with a critical lens. This is not to say that they should be disadvantaged in the admissions process because they have Tt experiences. Rather, their experiences should be perceived in light of a broader understanding that students from unequal positions on the social hierarchy activate the benefits of TT participation in differential ways. Maintaining a critical perspective will inform the weight that such experiences may be given within the full admissions review process. Because the listing of TT experiences, and rich descriptions of these experiences, tends to add weight to an applicant's admissions viability, it is important that admissions officers have a clear sense that TT experiences often mirror intrinsic advantages of positioning within the social structure.

So what should admissions officers do when they encounter TT experience listed on engineering applications? Like most things in life, there is no "one-size-fits-all" answer. The study provides reasonable evidence that TT experiences may vary based on factors such as gender and ethnicity. The study also suggests that the social capital benefits of TT experiences may vary based on the same factors. When reviewing applicants who describe these experiences in rich and textured terms, it is important to maintain a fundamental awareness of these differences and not dispense advantages by default.

Implications for students and their parents

The most fundamental implication for students participating on high school TTs involves realizing that the quality of their experiences will likely vary within their teams and may very well be at least in part a function of their gender or ethnicity. This suggests that student vigilance and parental advocacy may be important elements of a high-quality TT experience. Students should also be fully aware of the possibility that TTs are hubs of information that may provide them with distinct advantages if they are interested in pursuing technical fields such as engineering. The TT may bridge networks and offer access to a range of loose network ties rich in information and abundant in the activation of social capital.

Limitations of the Study and Directions for Future Research

This study is, in almost all respects, a preliminary study. As such, it is subject to several limitations. The findings are exploratory and, while they provide clues and interesting points, the results are in no way definitive. The main weakness of the study is that it attempts too much at once. Exploring, analyzing, and interpreting results premised on self-efficacy, confidence, and social capital is a highly complex set of tasks. The very breadth of the study imposes an inherent set of limitations on the results. Where complexity exists, the potential for error is increased and the possibility of misinterpretation is ever present.

The study is also premised on correlation and not causality. As a result, the study uncovers interesting, sometimes fascinating, relationships, but never unearths which dynamic, behavior, pattern, or result causes another to occur. Thus the study's findings are truly preliminary; correlation does not imply causality.

The study sample also represents a substantial limitation. The sample was drawn from a highly selective engineering college. Participants comprise a pool of carefully vetted students representing the top 3% to 8% percent of students from across the nation. The results likely reflect this skew, very likely compromising the generalizability of the results. In the future, it will be important to expand the representation of the participant pool to include a broader range of students from a wider range of engineering colleges.

A final limitation worth noting is my own boundaries as a researcher. I am, by nature, more qualitatively than quantitatively inclined. For the purposes of this study, I learned statistical analysis and data storage and manipulation via SPSS. Admittedly, my proficiency in both of these areas remains rudimentary. The results of the study must be approached with the cautionary note that the researcher has forged a careful, but novice, path through the sea of data collected for this study and the borderline Byzantine range of elements that were scrutinized. Any and all errors are mine and mine alone.

Where, then, does this study lead? Perhaps the first direction it leads is that it encourages an increasingly critical perspective on TT programs as panaceas for the dearth of engineers the United States has been experiencing for the last forty years. While Tt programs, such as FIRST Robotics, certainly have an important and valuable part to play in engaging young people in engineering, they are likely not as magical as they are described to be. At the foundation of this notion is that distinct groups participating in the same overall program, or even within the same TT, can have remarkably different experiences. Pursuing the causes of the differences is a logical next step for research in this area. What leads women to be technologically marginalized on teams where males are present? What catalyzes a TT participant's instrumental activation of engineering social capital resources and why do URM students build less engineering-specific social capital than their majority peers? Perhaps most importantly, what treatments might eliminate such dynamics? Many avenues for future research emerge from this study. In fact, the study may have introduced more questions than answers.

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APPENDIX 1. APPLICATION INTEREST STATEMENT OF A TECHNICAL TEAM PARTICIPANT

The following is excerpted from an application for first-year admission to an undergraduate engineering program. The excerpt is a candidate's academic interest statement. The candidate participated on a high school technical team.

My involvement in FIRST (For Inspiration and Recognition of Science and Technology) last year was one of the most rewarding and unforgettable learning experiences in my high school career. Contrary to popular belief, being on a robotics team is beyond just designing and assembling robots: it involves strategic planning, precise documentation of progress, community outreach, fundraising, and even entrepreneurship. Spending upwards of fifteen hours a week side by side with highly experienced engineers, I was captivated by the inventive, exciting nature of their work. From the second week in January through late March, I worked extensively with electrical and mechanical engineers from Johnson and Johnson. Aside from instructing me on (the) basics of electrical circuitry, and providing the team with a wealth of technical knowledge, the engineers were beside me, guiding me along, every step of the way. For the first time, I experienced what it genuinely feels like to be an engineer. Although our robot's performance could not live up to the team's expectations at the national championship event last spring, I cherish every moment of my FIRST experience; it provided me with an inside look into various aspects of engineering, and inspired me to further explore this field not only as an area of personal interest, but also as a potential career.

APPENDIX 2. HUMAN SUBJECTS COMPLIANCE FORMS

August 5, 2004

UCHS Administrator
Cornell University
115 Day Hall
Ithaca, NY 14853

To Whom It May Concern: Sarah Dero

Please accept this letter as acknowledgement that I have discussed Scott Campbell's proposed dissertation project with him in full detail. I have given Scott permission to survey and interview current undergraduate engineering students under two conditions:

1. That the study remains consensual, with students having the option to withdraw from the study at any point.

2. That students have the option to leave questions blank that they are not willing to answer.

Scott will also have access to the College of Engineering's archival admissions and registrar data under the condition that the identity of student participants remains anonymous in any final findings, reports, or publicly published material.

If you have questions or concerns, please contact me.

Sincerely,

Susan Murphy
Vice President for Student and Academic Services
Cornell University

SM
cc: SMC

Scott Campbell, PhD student
Dept of Education, Cornell Univ.

CORNELL

Cornell University
115 Day Hall
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Telephone: 607 255-5138
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University Committee on Human Subjects

NOTIFICATION OF EXPEDITED APPROVAL

Protocol ID# 04-08-014

To: Scott M. Campbell

From: Elaine Wethington, UCHS Chair *Elaine Wethington /s*

Date of approval: August 26, 2004

Project(s): ***Impact of Extracurricular High School Technical Team Participation on Student Success in Undergraduate Engineering***

As Chairperson of the University Committee on Human Subjects, I have reviewed and given an expedited approval to the above referenced project as far as the use of human subjects is concerned. **This approval shall remain in effect for a period of one year.**

The terms of Cornell University's Federalwide Assurance (FWA) with the federal government mandate the following important conditions for investigators:

1. All consent forms, records of study participation, and other consent materials **must** be held by the investigator for **three years** after the close of the study.
2. Investigators must submit to UCHS any **proposed amendment** to the study protocol, consent forms, interviews, recruiting strategies, and other materials. Investigators may not use these materials with human subjects until UCHS has reviewed them. For information about study amendment procedures and access to the Amendments application form, please refer to the UCHS website: http://www.osp.cornell.edu/Compliance/UCHS/Approval_Requests.htm
3. Investigators must promptly report to UCHS any **adverse events** involving human subjects. The definition of prompt reporting depends upon the seriousness of the adverse event. For guidance on recognizing, defining, and reporting adverse events to UCHS, please refer to the UCHS website: http://www.osp.cornell.edu/Compliance/UCHS/Adverse.htm.

If the use of human subjects is to continue beyond the assigned approval period, federal requirements mandate that the protocol be re-reviewed and receive an updated approval. **You may not continue to use human subjects beyond the stated approval period without an updated approval**. Please note that the terms of our FWA with the federal government do not allow for an extension of this period without review. Continuing without an updated approval constitutes a violation of University policy and federal regulations. Research funds administered by the Office of Sponsored Programs will not be released to any project that does not have a current UCHS approval.

Two months before the expiration of your approval, you will be sent a notification of pending expiration, and an explanation of the renewal process. Applications for renewal of approval must be submitted sufficiently in advance of the expiration date to permit the UCHS to conduct its review before the current approval expires. Please allow at least two weeks for the review.

****If you do not plan to renew your protocol approval at the end of the year, you must provide the UCHS with a Project Closure form. A link to the Project Closure form can be found at http://www.osp.cornell.edu/Compliance/UCHS/Approval_Requests.htm.**

c: John Sipple

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NOTIFICATION OF EXPEDITED APPROVAL

Protocol ID# 04-08-014

To: Scott M. Campbell
From: Elaine Wethington, UCHS Chair Elaine Wethington /s
Date of approval: August 5, 2005
Project(s): ***Impact of Extracurricular High School Technical Team Participation on Student Success in Undergraduate Engineering***

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Two months before the expiration of your approval, you will be sent a notification of pending expiration, and an explanation of the renewal process. Applications for renewal of approval must be submitted sufficiently in advance of the expiration date to permit the UCHS to conduct its review before the current approval expires. Please allow at least two weeks for the review.

****If you do not plan to renew your protocol approval at the end of the year, you must provide the UCHS with a Project Closure form. A link to the Project Closure form can be found at http://www.osp.cornell.edu/Compliance/UCHS/Approval_Requests.htm.**

c: John Sipple

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NOTIFICATION OF EXPEDITED APPROVAL

Protocol ID# 04-08-014

To: Scott M. Campbell
From: Sarah J. Demo, UCHS Coordinator *Sarah J. Demo*
Date of approval: August 11, 2006 (If you are using a consent form, enter this date at the bottom of it now.)
Project(s): ***High School Technical Team Participation as a Potential Pathway to Success in Undergraduate Engineering***

A member of the UCHS has reviewed and given an expedited approval to the above referenced project as far as the use of human subjects is concerned. **This approval shall remain in effect for a period of one year.**

The terms of Cornell University's Federalwide Assurance (FWA) with the federal government mandate the following important conditions for investigators:

1. All consent forms, records of study participation, and other consent materials **must** be held by the investigator for **three years** after the close of the study.
2. Investigators must submit to UCHS any **proposed amendment** to the study protocol, consent forms, interviews, recruiting strategies, and other materials. Investigators may not use these materials with human subjects until UCHS has reviewed them. For information about study amendment procedures and access to the Amendments application form, please refer to the UCHS website: http://www.osp.cornell.edu/Compliance/UCHS/Approval_Requests.htm
3. Investigators must promptly report to UCHS any **adverse events** involving human subjects. The definition of prompt reporting depends upon the seriousness of the adverse event. For guidance on recognizing, defining, and reporting adverse events to UCHS, please refer to the UCHS website: http://www.osp.cornell.edu/Compliance/UCHS/Adverse.htm.

If the use of human subjects is to continue beyond the assigned approval period, federal requirements mandate that the protocol be re-reviewed and receive an updated approval. **You may not continue to use human subjects beyond the stated approval period without an updated approval**. Please note that the terms of our FWA with the federal government do not allow for an extension of this period without review. Continuing without an updated approval constitutes a violation of University policy and federal regulations. Research funds administered by the Office of Sponsored Programs will not be released to any project that does not have a current UCHS approval.

Two months before the expiration of your approval, you will be sent a notification of pending expiration, and an explanation of the renewal process. Applications for renewal of approval must be submitted sufficiently in advance of the expiration date to permit the UCHS to conduct its review before the current approval expires. Please allow at least two weeks for the review.

****If you do not plan to renew your protocol approval at the end of the year, you must provide the UCHS with a Project Closure form. A link to the Project Closure form can be found at http://www.osp.cornell.edu/Compliance/UCHS/Approval_Requests.htm.**

c: John Sipple (jws28)

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Notification of Amendment Approval

Protocol ID# 04-08-014

To: Scott M. Campbell
From: Sarah J. Demo, UCHS Coordinator *Sarah J. Demo*
Date of approval: August 14, 2006
Project(s): ***High School Technical Team Participation as a Potential Pathway to Success in Undergraduate Engineering***

The UCHS has reviewed and approved the following amendment(s) to the above referenced project.

8/11/06 amendment to add a self-efficacy section, consisting of ten questions, to the overall survey.

If you requested modifications to a consent form(s):
- Use only the modified form for additional subject enrollment.
- Include on the form the date of this notification for the revised UCHS approval date.

If you submitted revised/final versions of interview guides, questionnaires, or debriefing scripts, you have approval to use these materials immediately.

All other study procedures/instruments are to remain unchanged from the original submission and UCHS approval.

UCHS approval for this project expires on **August 10, 2007** .

c: John Sipple (jws28)

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NOTIFICATION OF AMENDMENT APPROVAL

Protocol ID# 04-08-014

To: Scott M. Campbell
From: Sarah J. Demo, UCHS Coordinator *Sarah J. Demo*
Date of approval: November 8, 2006
Project(s): ***High School Technical Team Participation as a Potential Pathway to Success in Undergraduate Engineering***

The UCHS has reviewed and approved the following amendment(s) to the above referenced project.

10/3/06 amendment to administer two additional surveys-- "Resource Generator" and "Organizational Socialization"--to a subsample of participants who completed the initial EME survey.

If you requested modifications to a consent form(s):

- Use only the modified form for additional subject enrollment.
- Include on the form the date of this notification for the revised UCHS approval date.

If you submitted revised/final versions of interview guides, questionnaires, or debriefing scripts, you have approval to use these materials immediately.

All other study procedures/instruments are to remain unchanged from the original submission and UCHS approval.

UCHS approval for this project expires on **August 10, 2007** .

c: John Sipple (jws28)

Cornell University
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NOTIFICATION OF AMENDMENT APPROVAL

Protocol ID# 04-08-014

To: Scott M. Campbell
From: Sarah J. Demo, UCHS Coordinator *Sarah J. Demo*
Date of approval: March 29, 2007
Project(s): ***High School Technical Team Participation as a Potential Pathway to Success in Undergraduate Engineering***

The UCHS has reviewed and approved the following amendment(s) to the above referenced project.

3/15/07 amendment to 1) conduct 20 interviews with Cornell first-year engineering students, and 2) invite all Cornell 1st-year engineering students entered in the Internal Transfer Division to complete a questionnaire.

If you requested modifications to a consent form(s):

- Use only the modified form for additional subject enrollment.
- Include on the form the date of this notification for the revised UCHS approval date.

If you submitted revised/final versions of interview guides, questionnaires, or debriefing scripts, you have approval to use these materials immediately.

All other study procedures/instruments are to remain unchanged from the original submission and UCHS approval.

UCHS approval for this project expires on **August 10, 2007** .

c: John Sipple (jws28)

APPENDIX 3. RESOURCE GENERATOR SURVEY INSTRUMENT

First Name (required): Middle Initial: Last Name (required):

We ask for your CU ID and CU net ID so that your responses can be linked to future survey and interview responses, admissions data and Cornell academic records. Once a link has been established, your CU ID and CU net ID ***will*** *be permanently deleted and replaced with a unique numerical identifier that will guarantee your confidentiality.*

Cornell Identification Number (required):

Cornell Net Id (required): @cornell.edu

General Directions:

Section (A) contains questions about people you knew when you were in high school that helped you learn about engineering. These might be family members, friends, or acquaintances, but they do not include friends of friends or people that you are not ***personally*** in contact with. **Section (B)** contains questions about people that you know now that you are a Cornell engineering student. Both sections will ask if you personally knew – or know - someone with a particular skill or resource. For example:

			Contact Boxes						
Other than your high school teachers, when you were in high school, did you have access to someone who...?	**No**	**Yes**	**Immediate Family**	**Wider Family**	**Friend**	**Teammate**	**Mentor**	**Neighbor**	**Acquaintance**
...could show you how to fix a car	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

STEP 1. Please check the 'yes' box if you had access to someone in high school with this particular skill, or 'no' if you did not.

STEP 2. If 'yes', then please place a check in the column(s) corresponding to the **person** or **people** you would have likely approached in high school if you needed that particular skill or resource. You can refer to an individual **more than once throughout the questionnaire. You may also check multiple contact boxes for each question.**

STEP 3. Check the 'yes' box only if the person, or people, you checked in the contact box took action, or did something, to help you.

Are you a: ○ Freshman ○ Sophomore ○ Junior ○ Senior

Did you participate on a technical team in high school? ○ Yes ○ No

Did you participate on a FIRST Robotics team in high school? ○ Yes ○ No

(Section A) When you were in high school did you personally know anyone with the skill or resource listed below that you were able to gain access to within one week if you needed it?

Please answer all these questions, even if you possess the skill or resource yourself or if you have never needed to ask for it before. **If 'yes', you may check more than one contact box.**

Other than your high school teachers and guidance counselors, when you were in high school, did you have personal access to someone who...?	No	Yes	Immediate Family	Wider Family	Friend	Teammate	Mentor	Neighbor	Acquaintance
1 ... could teach you how to build a robot	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
2 ... could teach you about engineering	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
3 ... taught engineering at a college or university	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
4 ... taught you engineering-specific words	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
5 ... worked as a professional engineer	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
6 ... was an engineering undergraduate student	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
7 ... was an engineering graduate student	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
8 ... worked on a team that built an engineering-related product	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
9 ... could help you get an engineering internship	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
10 ... could help you get the parts necessary to build a robot	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
11 ... could show you what it means to be an engineer	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
	No	Yes	Immediate Family	Wider Family	Friend	Teammate	Mentor	Neighbor	Acquaintance
12 ... had technical skills	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
13 ... had a job at an engineering company	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
14 ... could write you a letter of recommendation for admission to an undergraduate engineering program	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
15 ... could give you tips on getting admitted to engineering schools	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
16 ... was an engineering admissions officer	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
17 ... could help you make your engineering application more appealing to engineering schools	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
18 ... could help you develop a *tactical plan* that would improve your chances of being admitted to selective engineering schools	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
19 ... personally knew engineering admissions professionals	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes

	No	Yes	Immediate Family	Wider Family	Friend	Teammate	Mentor	Neighbor	Acquaintance
20 ... was an alum of an engineering college where you were applying for admission	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
21 ... could influence engineering admissions decisions	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
22 ... helped improve the academic interest statement on your application for admission	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
23 ... told you to write about your engineering experiences in your application	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
24 ... contacted engineering admissions offices on your behalf	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
25 ... helped your parent(s) or guardian(s) understand the engineering admissions process	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
26 ... told you how to get an advantage in the engineering admissions process over other applicants	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
27 ... told you to write about your FIRST experience in your engineering application	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes

(Section B) ***As a first-year Cornell engineering student*, do you personally know anyone with the skill or resource listed below that you are able to gain access to within one week if you needed it?**

Please answer all these questions, even if you possess the skill or resource yourself or if you have never needed to ask for it before. If 'yes', you may check more than one contact box.

IMPORTANT – PLEASE NOTE: The following section asks for information about the people you know now who are associated with the **College of Engineering**. The listings in the contact boxes have changed.

Now that you are a student in the College of Engineering, do you have personal access to someone who...?	No	Yes	Faculty	Engineering Graduate Student	Upper-class Engineering Student	First-year Engineering Classmate	Engineering Staff	Cornell Engineering Alum	Professional Engineer
28 ... can help you find an engineering research position on campus (paid or volunteer)	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
29 ... can help you find an internship with an engineering company	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
30 ... can help you get an engineering co-op job	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
31 ... can tutor you in calculus, physics, chemistry, or computer science	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
32 ... can help you join study groups for your engineering courses	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
33 ... can give you the "inside track" on succeeding as an engineering student	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
34 ... is a member of an engineering student group	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
35 ... is a member of an engineering technical team (FSAE, CUBESAT, etc.)	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
36 ... can help you with your problem sets	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
	No	Yes	Faculty	Engineering Graduate Student	Upper-class Engineering Student	First-year Engineering Classmate	Engineering Staff	Cornell Engineering Alum	Professional Engineer
37 ... can teach you engineering-specific words	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
38 ... can help you meet upper-class engineering students	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
39... can help you solve a problem with your engineering course schedule	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
40 ... can show you how to use MATLAB and/or Java	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
41 ... can help introduce you to a Cornell Engineering alum	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
42 ... can help you get an engineering job after you graduate from the College of Engineering	○ No	◉ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes

43. Approximately how many friends do you have *that are engineers* in each of the following categories:

		None	1 to 3	4 to 7	8 to 11	More than 11
a.	First-Year	○	○	○	○	○
b.	Sophomore	○	○	○	○	○
c.	Junior	○	○	○	○	○
d.	Senior	○	○	○	○	○
e.	M.Eng.	○	○	○	○	○
f.	MS	○	○	○	○	○
g.	Ph.D.	○	○	○	○	○

44. Approximately how many of these friends do you routinely work with *on your engineering homework*?

		None	1 to 3	4 to 7	8 to 11	More than 11
a.	First-Year	○	○	○	○	○
b.	Sophomore	○	○	○	○	○
c.	Junior	○	○	○	○	○
d.	Senior	○	○	○	○	○
e.	M.Eng.	○	○	○	○	○
f.	MS	○	○	○	○	○
g.	Ph.D.	○	○	○	○	○

45. ***Approximately*** **how many times have you visited the following Engineering Student Services offices since August 19th, 2006?**

		None	1 to 3	4 to 7	8 to 11	More than 11
a.	Engineering Admissions	○	○	○	○	○
b.	Engineering Advising	○	○	○	○	○
c.	AEWs and Undergraduate Research	○	○	○	○	○
d.	Co-op and Career Services	○	○	○	○	○
e.	Diversity Programs	○	○	○	○	○
f.	Engineering Registrar	○	○	○	○	○

46. How many engineering-specific clubs are you currently a member of?

None	1 to 3	4 to 7	8 to 11	More than 11
○	○	○	○	○

47. How many engineering-specific clubs are you currently a member of where you are an officer?

None	1 to 3	4 to 7	8 to 11	More than 11
○	○	○	○	○

48. Are you a member of any of the following Cornell Engineering project teams:

		Yes	No
a.	Advanced Interactive Discovery Environment (AIDE)	○	○
b.	AguaClara	○	○
c.	Autonomous Underwater Vehicle (CUAUV)	○	○
d.	Concrete Canoe	○	○
e.	CUSat (Nanosat-4)	○	○
f.	DARPA Urban Challenge	○	○
g.	Engineers for a Sustainable World	○	○
h.	Formula SAE (FSAE)	○	○
i.	Mini Baja	○	○
j.	Odysseus	○	○
k.	Phoenix Society	○	○
l.	Programming Contest	○	○
m.	Snake Arm	○	○
n.	Solar Decathlon	○	○

49. Are you participating in engineering or science research?

	Yes	No
	○	○

50. The following diagram represents the College of Engineering.

People occupying Position 6 understand all spoken **and** unspoken roles, behaviors, norms and language that are **unique** to the College of Engineering; they are the College of Engineering's insiders.

People occupying Position 3 have a general, but not entirely clear, sense of the spoken and unspoken roles, behaviors, norms, and language that are unique to the College of Engineering; they are rookies or novices.

People occupying Position 1 are almost completely unsure of the spoken and unspoken roles, behaviors, norms and language that are unique to the College of Engineering; mostly, they feel like outsiders.

50.A. Think back to your first two weeks as a student in the College of Engineering. Where would you locate yourself on this diagram **when you entered the College of Engineering** as a first-year Cornell Engineering student in August, 2006?

Center	6	5	4	3	2	1	Outside
	○	○	○	○	○	○	

50.B. Consider for a moment your experience as a first-year Cornell Engineering student, where on this diagram do you fit **at this moment?**

Center	6	5	4	3	2	1	Outside
	○	○	○	○	○	○	

Thank you for your participation - please click 'Submit Form' below.
Please click the button only once, submission may take a moment.

Submit Form