AC 2007-1603: MINORITY RETENTION AND SUCCESS IN ENGINEERING: DIVERSIFYING THE PIPELINE THROUGH THE DEVELOPMENT OF SOCIAL CAPITAL

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Minority Retention and Success in Engineering: Diversifying the Pipeline through the Development of Social Capital

Abstract

Diversity is a cornerstone to innovation in engineering problem solving. The retention and success of minorities in engineering is necessary for building diversity in academia and industry. The majority of engineering programs, however, suffer from a lack of minority students, particularly in graduate programs. A perceived individualistic and weed out culture of engineering, ethnic isolation, and a lack of interaction with faculty and the broader university are barriers which may inhibit minorities from matriculating through college and entering graduate studies. One mechanism for supporting minority students is the development of social capital which can help to eradicate these barriers. While universities have developed some programs and curricular opportunities to support minorities in engineering majors, student-run organizations are relatively untapped resources that can directly facilitate the development of social capital. Using survey and interview data from participants in a mentoring program of the National Society of Black Engineers, the authors demonstrate how student-run organizations can make the development of social capital a reality, and thus bolster the pipeline toward a diverse population of successful graduates for the workforce and academia.

Introduction

Innovation is the key to the future success of the United States and engineers and scientists are large contributors to that success. In Friedman's 2005 book *The World is Flat*, some of the key tenets are that perpetual innovation and adaptability are essential to the future success of the US economy and workforce[10]. Hargadon asserts that "innovation is driven by the convergence of diverse networks of people, objects, and ideas[16]. Similarly, research conducted by Crosby et al. indicates that a diverse workforce provides economic benefits because heterogeneous groupings bring different perspectives to bear on problems, thus helping to solve them creatively and effectively[7]. Based on these arguments it would seem that science and engineering, which are key factors for the innovation essential to US success, would benefit greatly from the diversity present in the current US population.

It is no secret, however, that engineering, along with science, technology, and mathematics, is suffering from "a diversity problem[5]". Data collected by the Engineering Workforce Commission, on engineering graduates for 2001, 2000, and 1999 were combined to obtain a three year average and then compared with college freshman enrollment averaged over the years 1996, 1995, and 1994. Computing the ratio showed the graduation rates of African-Americans as 41.8%, Hispanic Americans as 64%, and Native Americans as 50.7%. All underrepresented minorities were lower than the 73.1% average of other U.S. students, but only African-Americans fell below 50%[3]. This amounts to only 4.88% of the engineering degrees awarded in the United States landing in the hands of Black students. This lack of undergraduate representation, however, is only a piece of the diversity puzzle. In 2005, African-Americans were awarded only 4.6% of the Masters degrees and only 3.7% of the doctoral degrees conferred in engineering in the US, down from 3.8% in 2004[12]. In 2003, Black faculty at assistant professor

or higher level comprised 3.8% of the doctorates in science and engineering -- 42% of these faculty were not U.S. citizens. Further, in 2005, African-Americans composed only 2.4% of the tenured or tenure-track teaching faculty. Additionally, fewer African-Americans (and other minorities) are tenured or have earned full professorship status[25].

Here we see that the pipeline for Black engineering students is broken. We must explore ways, therefore, to ensure the academic achievement and future success of Black students. Many researchers (e.g., Zhou, Coleman, Stanton-Salazaar)[6, 24, 28] have shown how social capital can lead to academic success; therefore, it is powerful to determine ways to utilize it for the success of Black engineering students. The purpose of this paper is to show how social capital generated through involvement in student-run organizations such as the National Society of Black Engineers can bolster the pipeline of underrepresented minorities in engineering. Through surveys and interview data that reflect the experiences of members, the authors show how these organizations can make the development of social capital a reality, and thus create a diverse population of successful graduates for the workforce and academia.

Background

The pipeline for moving African-American students through engineering degrees and beyond is in need of augmentation to solidify the goal of diversity. Because undergraduates may become graduate students, who may eventually become faculty, this break in the pipeline creates a vicious cycle wherein future Black engineering degree hopefuls encounter barriers directly correlated with the dearth of other students, faculty, and staff lost in this breach. The question becomes, what exactly are these barriers? A myriad of correlates to this low retention rate have been cited, including adequacy of prior preparation, family background, individual goals, institutional experiences, financial assistance, lack of intervention programs, admission policies, lack of role models and support structures, engineering culture, and self-view[13, 19]. Covering all of these barriers is beyond the scope of this paper; however, below we cover those most relevant to this work.

To some, engineering typifies the American individualistic culture – a culture that is at odds with African-American students' need to feel as though they are helping others and the need for a cooperative educational culture[15, 21]. This perception affects both the tendency of Black students to choose engineering and often the ability of Black students to remain in engineering. For example, Powell[21] states that there is "considerable evidence that today's college students, particularly African-Americans and Hispanics, avoid majoring in science and mathematics because societal cultural traits support unfavorable images of scientist and make the attainment of a scientific career unrealistic." Surveys of college freshmen and high school juniors showed that African-American men expressed a greater interest in social service fields versus White men who preferred engineering disciplines[14]. Although these surveys were done in the seventies, there still remains a disproportionate amount of African-American college students in disciplines such as education and other humanities[13]. Additionally, Brown characterizes engineering as a weed out and individualistic culture with an undergraduate curriculum designed for students not to succeed[4]. The utilization of competitive grading schemes inhibits students' abilities to form collaborative groups. Here, we see a culture at odds with that of African-American students.

Acting in parallel with the force of the engineering culture are ethnic isolation and the lack of role models which may both be by-products of this perceived individualism.

Gentemann's research data suggests that even if minority students show high levels of academic satisfaction and success, they may feel socially and culturally alienated in some university settings[11]. These sociocultural alienation factors may contribute to minority students dropping out of an academic program or sometimes school entirely as described by Loo and Rolison[18]:

> …no matter how outstanding the academic institution, ethnic minority students can feel alienated if their ethnic representation on campus is small. Furthermore, unlike white students, ethnic students' retention rates may be just as much a function of sociocultural alienation as of academic factors. Attributions of intellectual inferiority, academic inferiority, or motivational deficiency to minority students who drop out or who are not performing optimally not only blame the victim but obscure the institutional and social context of the problem.

In a 2006 report on the future of engineering, it was suggested that lack of personal knowledge of actual engineers discourages many students from ever attempting to enter the field[23]. A study of high school students as cited by Anderson-Rowland showed that students with an engineering family member or friend tend to choose engineering as a field of study earlier than those without a role model[1]. Thirty-seven percent of the students with an engineering family member or friend had chosen engineering by their sophomore year in high school. Only 26% of the students who had no engineering family member or friend had done so by that time. A disproportionate amount of African-Americans tend to select occupations and pursue careers in which they had contact with successful role models[15]. In addition to choosing engineering as a major in the first place, quality interactions with engineering faculty can have a significant impact on a student's decision to pursue graduate education, since such interaction provides the student with effective role models and mentors. Minority students perceive the status and environment of these role models and use them to gauge how they themselves will be treated should they pursue degrees and employment in those disciplines[20]. Due to the scarcity of minority engineering faculty, minority students are also deprived of the psychological benefit of role models with whom they share common ethnic and cultural backgrounds[19]. This phenomenon can cause a breakdown in the mentoring cycle. Faculty members are responsible for the mentoring of graduate students in order to make them effective members of a research group, and those graduate students in turn are often responsible for mentoring of any undergraduate or more junior student members of the group[22]. Thus, the diversity of science is dependent on the quality of mentored research, and this experience is a key to attracting underrepresented groups to science.

It could be said, therefore, that the best way to encourage students to "be" engineers is by allowing them to "see" engineers. With current statistics showing the number of black and minority engineers and scientists are so low, the likelihood of a black or minority student "seeing" (or more importantly, interacting with) someone who looks like them is not very high. Even if students choose to enter the field of engineering, given the low number of African-American faculty in engineering related disciplines, finding role models and mentors once they are there is a challenge. Results include being unaware of career options, having limited

knowledge of the advantages of advance degrees, and lacking crucial support structures at the university level.

Generating Social Capital

Social capital is defined by Stanton-Salazaar as, "a set of properties existing within socially patterned associations among people that, when activated, enable them to accomplish their goals or to empower themselves in some meaningful way."[24] Utilizing this definition, the "goal" referenced for our purposes is attainment of an engineering degree. In what ways can generating social capital be beneficial to engineering students? Brown, et. al. present a framework involving cooperative learning and service learning to help universities incorporate curricular opportunities for students to develop social capital[4]. Further, they cite workplace readiness, innovation and productivity, involving students in the learning process, as well as retention and academic achievement as reasons why social capital is a necessity for engineering student success.

While Brown and others (e.g., Lee) have focused on top-down, external programs design and carried out through the university to better integrate students into the institution, the purpose of this paper is to point to the strength of bottom-up efforts[4, 17]. These bottom-up efforts, therefore, are seen as a compliment to rather than a replacement of more top-down efforts. For example, Daily, Eugene, and Prewitt[8], posit that social capital generated through involvement in student-run organizations can speak to the barriers mentioned above of an individualistic culture, ethnic isolation, and a lack of interaction with faculty and a broader university community (see Table 1).

Table1: Daily, Eugene, and Prewitt[8]

Construct	**Barrier Addressed**	**Kind of Capital**	**Application to Student-Run Organizations**
Interconnectedness and social closure	Individualistic and weed out culture of engineering	Bonding	Similar closeness and familial structure – establish norms and obligations
Ethnic Social Capital	Ethnic isolation	Bonding & Bridging	Strong culture grounded in mission statement and enforced by familial structure helps students develop positive achievement orientation and navigate outside world
Institutional Agent	Lack of interaction with faculty and broader university community	Bridging	Guidance in the development of relationships with these agents and access to invaluable information

The remainder of this paper is dedicated to detailing the National Society of Black Engineers – an exemplary student-organization that can serve as a model for how other organizations of this type can enable students to generate their own social capital.

National Society of Black Engineers

With more than 17,000 pre-college, collegiate, and alumni members, the National Society of Black Engineers (NSBE), is the largest student-managed organization in the United States of America. Upon its founding in 1975 by six African-American students at Purdue University, its mission was and continues to be "to increase the number of culturally responsible Black engineers who excel academically, succeed professionally and positively impact the community." More than thirty years later, NSBE has an international headquarters located in Alexandria, Virginia and is comprised of more than 270 chapters on college and university campuses, 75 Alumni Extension chapters, and 75 Pre-College chapters nationwide. Although the headquarters is not entirely comprised of students, its function is to support, rather than dictate, the daily functions of the organization.

Its mission in action takes the form of tutorial programs, group study sessions, community outreach programs, chapter, regional, and national conferences, technical seminars and workshops, career fairs, mentoring activities, and many other programs. These activities have been developed to stimulate as well as develop interest in engineering, encourage members to seek advanced degrees and professional registrations, establish mentoring relationships for blacks in engineering, and function as a representative body on issues that affect black engineers. Although many point to the success of NSBE as an organization and companies continue to pour hundreds of thousands of dollars into it, there has only been one study to date that has examined the impact of this organization on its members or the communities with which it interacts.[26]

There are so many programs that are a part of NSBE, discussing them all in detail would be beyond the scope of this paper. We focus, rather, on one excellent program called the Stratus Mentoring Program (SMP) which has been chosen for its ability to address the barriers of Table 1. To be thorough, we will present a summary of other valuable programs encountered in our research within NSBE that allow its members to develop social capital

A Sample NSBE Chapter Level Program: Stratus Mentoring Program (SMP)

The Florida Agricultural & Mechanical University-Undergraduate Program (FAMU-UP) - National Society of Black Engineers (NSBE) Stratus Mentoring Program was conceived in Summer 2001 by a student in the Electrical Engineering department of the Florida Agricultural & Mechanical University—Florida State University (FAMU-FSU) College of Engineering, Ms. Leila Merriweather. The idea behind the Stratus Mentoring Program was to help minority students adjust to college life and matriculate confidently through the Engineering curriculum. This ideology fit well with part of NSBE's mission: "To increase the number of … engineers who excel academically". The Stratus Mentoring Program utilized a systematic mentoring model for its operation as opposed to an informal arrangement between potential mentors and protégés (See Figure Below).

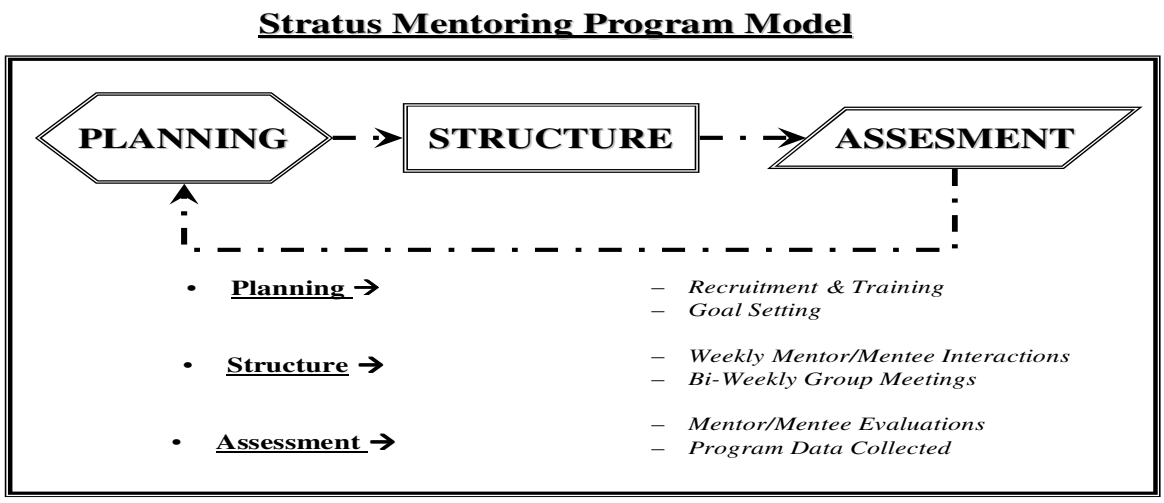

Figure 1. Adapted from Systematic Mentoring Model[2] to illustrate the structure and dynamics of the FAMU-FSU NSBE Chapter Stratus Mentoring Program

The incorporation of a systematic and well structured mentoring framework and the mission and principles of the National Society of Black Engineers had far reaching benefits to both the students who ran the program (mentors) and the students who participated (mentees) which we shall delineate in greater detail in the discussion section of the paper.

Research Methodology

Qualitative and quantitative research methodologies were used for this study.

Participants

Two sets of participants comprised the participant sample for this study (herein referred to as P1 and P2). The four interviewees for P1 were all part of the Stratus Mentoring Program, described earlier, for at least two years as both mentees and mentors. P2 consisted of four post-graduate Electrical engineers who obtained their degrees between 2001 and 2003. All were NSBE members with at least 2 years of experience in the organization. Both groups of participants were recruited via personal emails or phone calls.

P1 – Questionnaire and Interviews

A written questionnaire was used in addition to conducting a series of semi-structured interviews. Likert-scales were used in the questionnaire and open ended questions were used in both. The questions related to the mentoring program effectiveness, relationships established, involvement with NSBE, as well as general demographic and scholastic information.
Because chapter level programming represents the most direct type of student initiated "bottom-up effort" to better integrate students into the institution and foster their success it is necessary to examine the effectiveness of a specific example of NSBE chapter level activities and their ability to generate productive social capital. Thus, this method was chosen because of the need to examine the effects of chapter level social capital generation.

Because all participants were members of the same chapter of NSBE results may not generalize over the entire organization, and there may be other factors that contribute to the retention and success of these participants beyond the influence of NSBE.

The questionnaires were filled out via email and follow-up phone calls were made to elicit additional information from participants. Interviews lasted an average of about one hour and questionnaires could be completed in approximately half an hour.

P2 – Interviews & Observations

A semi-structured interview, lasting one to one and one half hours, consisting of Likert-scale and open-ended questions was used. The questions obtained information about involvement with NSBE, feelings of trust within NSBE, relationships within NSBE, and interaction with communities beyond NSBE as well as general demographic and scholastic information.

This method was chosen because of the need to obtain an accurate descriptive picture of social capital building within NSBE. Because all participants were members of the same chapter of NSBE, which recently won Chapter of the Year, results may not generalize over the entire organization. However, this limitation may also lay emphasis on the power of this type of organization in building social capital. Additionally, all participants were Electrical Engineering majors, so more research would have to be conducted to study the effects across the engineering disciplines.

Observation notes were also taken during the five-day annual conference in Pittsburgh, Pennsylvania. This included general sessions, involving the entire organization with guest speakers; regional meetings for conducting business and voting; individual workshops from the collegiate and graduate students tracks; and social events such as the closing gala. This method was chosen in order to gain a broader perspective of the organization as a whole since interviews are limited to personal experience. Interview and observation data were hand-coded to determine themes that emerged.

Results & Discussion

Using the results obtained from the groups of participants, we will paint a picture of the experiences of students involved in NSBE, again, highlighting students from SMP.

Fighting Individualism

A perceived culture of individualism is a barrier that NSBE confronts head on by establishing a familial type of environment. In this way, members of NSBE feel as though they have at least some of the support structures necessary to ensure their success. NSBE "Luv" *[sic]* is the idea that all members of the organization are experiencing similar trials that place them in similar positions and therefore they develop similar perspectives about the world. This notion serves as a basis for members to move beyond collegial interactions into more familial type relationships, often cited in the interviews (P1 & P2) and observed during the conference, and helps bonding social capital to form on the chapter level. One participant (P2) stated, "NSBE Luv creates a

family atmosphere." This was also evidenced in participants' tendencies to greet each other as "family."

The Stratus Mentoring Program strives to further develop this "luv" on a chapter level by involving mentors and mentees in more than just business-related events. Movie nights, bowling outings, poetry sessions, and other socially based events serve to establish the sort of bonding ties necessary to develop social capital. Additionally, because the relationships are viewed as "family-like," trust and reciprocity develop as norms. Interviewees (P1&P2) indicated spending the majority of their time with NSBE members.

Further supporting this tendency for SMP to draw people together, a respondent (P1) when asked if there were any additional comments she would like to give about the program said:

> In the end the mentors and all of NSBE became my family and I sincerely believe without a doubt had it not been for [them] I would have left, dropped out, given up, and cried way more than necessary in college. There were so many days I wanted to leave permanently. But I would remember all the seminars given, all the help available, all the socials to give your mind a break, spiritual gatherings to keep one right, and all the people I could call on who made themselves available to me. Even people who didn't know me like that but knew sometimes that's exactly what you need. So this journey was no longer mine, but as many of us minorities know, it became a journey representing more than just ones own self. For me to give up and say I couldn't take it would effect more than just myself. *[sic]*

Thus, the interconnectedness created within SMP lay the foundation for the bonding necessary for its members to achieve academically and subsequently remain in engineering.

Institutional Agents

Organizations like NSBE offer Black students a wide variety of opportunities to see, meet, and most importantly interact with Black students and faculty at every stage of the pipeline. These types of meetings and interactions can help foster a tiered system of social networks to help students succeed. Mentoring by minority role models can foster bridging social capital, and bonding social capital can be a consequence of productive interactions with peers (other NSBE members).

For example, respondents (P1) said that participation in the mentoring program had the greatest influences on their leadership capacity (M= 7.333) and on their ability to obtain jobs and/or get into graduate school (M= 7.333). Additionally, Role-modeling and peer group interactions were cited by several respondents as important outcomes of the program that they felt were critical to their eventual success. More than half of the respondents indicated that involvement in the program significantly enhanced their views of engineering and of themselves. Additionally, positive benefits to both mentees and mentors were noted and the interviewees (P1 & P2) all felt that the mentoring relationships and social capital developed as program participants were contributing factors to their achievement.

We believe that involvement in a student organization like NSBE can offset the type of sociocultural alienation which many minority students face. By providing students access to peer groups and role-models, NSBE promotes the academic excellence of its members as well as providing positive, culturally stimulating interactions. Some of the respondent's (P1) answers support these claims and demonstrate the various types of social capital generated in NSBE. For instance one interviewee stated:

> The mentors I was lucky enough to have let me know that undergrad was just the beginning. They introduced the idea of second and third degrees which had never entered my mind as being attainable. With one word I can open up a wealth of information and research capability. Fellowships and special programs is something the mentors always wanted to help us with. The mentors took pride in what we did with our lives, and still do to this day.

In addition to the obvious bonding social capital formed by a positive interaction with mentors, this mentee also benefited from the bridging social capital to access fellowship and program information that could make graduate school possible. Over half of the respondents (P1) who participated in the mentoring program later became mentors themselves and all were either currently employed as engineering professionals or attending graduate school, thereby increasing diversity in the sciences and bolstering the pipeline of black engineers. All respondents consider themselves active NSBE members.

Persisting and Moving Beyond

Participants (P2) mentioned explicitly that involvement with NSBE influenced their decision to stay in engineering. When asked, "What influenced your decision not to leave engineering," one participant stated:

> The people I met through NSBE… Misery loves company [chuckle] I figured that I could either switch majors and possibly end up fighting the same battle over again, except by myself this time or I could stay in engineering and at least fight with a team. I knew that I had people supporting me in NSBE that would help me get through it.

Echoing this feeling about NSBE, another participant (P2) stated, "[I decided not to leave engineering after I] went to my first [national] conference and came to the conclusion that there is no other major that is as important as engineering." These statements, along with others that relate to NSBE's norms suggest that participation in NSBE directly influences member's orientation toward academic achievement as well as their decisions not to switch majors.

We found that when students focus on positive values that are important to them they tend to be more successful. As one of the mentoring program participants (P1) indicated when asked about the influence of the program on him:

> [The Mentoring Program and NSBE] allowed me to set more specific goals for myself b/c I had a better idea of what I was after. Seeing my mentors' community [and]

organizational involvement, resumes, and work ethic gave me an excellent model for what I strived to be.

Beyond Stratus

As mentioned previously, there are numerous programs that contribute to the development of bonding and bridging social capital in the National Society of Black Engineers. The Table below summarizes a few of the other programs or events mentioned in interviews with participants.

Table 2. Programs in NSBE also contributing to its members' ability to generate social capital.

NSBE Program/Event	**Type(s) of Social Capital Involved**	**Contributions**
Chapter Level Programming - *Any program that support the ideals of NSBE that is conceived and managed by an individual NSBE Chapter (i.e. Stratus Mentoring Program)*	Bridging or Bonding	The outcomes will vary depending on the program a particular student chapter decides to implement, but in the case of the SMP, systematic mentoring activities led to both bridging and bonding social capital.
Achievers Plus- *Multifaceted academic program to promote student collaboration and success and increase GPA and technical excellence of NSBE*	Bonding	Positive interaction with peer groups who are focused on academic excellence and/or attaining graduate education could motivate students who might normally not be so inclined to pursue a graduate degree.
Graduate School Conference- *Mini-Conference to promote graduate education by providing information for undergraduates and showcasing current NSBE Graduate Student Research*	Bridging & Bonding	Meeting current graduate students can provide guidance and encouragement to undergraduates who are considering graduate school and support networks for other graduate students.
Workshops & Forums- *NSBE workshops, seminars, and forums held at each conference and convention to address student needs*	Bridging	The opportunity to get guidance from minority faculty members & professionals who have successfully completed advanced degrees can help students avoid many of the pitfalls that often hinder minorities from attaining graduate degrees such as the PhD.

Table 2 (cont.)

Career Networking Suites- *Series of Networking socials hosted by Corporate Sponsor Companies to promote interaction between NSBE student members and company engineers*	Bridging	Black engineering graduates who are currently working in industry can provide students with formal and informal advice about their own educational and career path, in order to help students plan early and effectively for career opportunities after graduation.

Conclusion

It is clear that the pipeline for African American students is broken; therefore, fixing it becomes the issue at hand. Top-down approaches are necessary; however, alone they can have potential drawbacks. Dasgupta and Asgari speculate that when women receive more support from faculty and staff that stereotypes of female dependency are strengthened and self-reported beliefs about leadership qualities in women are diminished[9]. We propose that a similar effect may be true for minorities. While top-down programs have been shown to increase success of African-Americans in engineering, an indirect effect may be of strengthening the perception that minorities cannot succeed on their own. We present this possible effect cautiously since it is speculative, however future research should be conducted in the future. In any case, bottom-up approaches can be seen as a direct compliment to these efforts.

As highlighted in this paper, the FAMU-FSU NSBE Chapter's Stratus Mentoring Program provided a wealth of benefits to the participants in addition to the social capital derived from a mentor-mentee relationship. This program provides an excellent example of how a "top-down" approach to improving student retention (such as a systematic and highly structured model of a mentoring program combined with strong institutional support) and a "bottom-up" approach actively involving students (such as a chapter-level NSBE initiative) can be combined to maximize the benefit to students.

Student-run organizations such as the National Society of Black Engineers utilize social capital as a vehicle to aid in the efforts to diversify the pipeline by improving the overall success of black students in engineering. The goal of minority retention and success in engineering is exemplified through interactions that NSBE provides with programs like Achievers Plus (see Table 2). It is shaped through the bonding developed through role models via programs such as the Graduate School Mini conference. These goals are further refined by the bridges of workshops and forums providing guidance to support retention, and they are carried out through chapter level programs, career networking suites and mentoring. Diversifying the pipeline of successful engineers through the development of social capital is the end result of NSBE's efforts.

Students who participate in collaborative learning and educational activities outside the classroom and who interact more with faculty members get better grades, are more satisfied with their education, and are more likely to remain in college[27]. Getting students involved in educationally purposeful activities increases the probability of them staying in school[22]. The National Society of Black Engineers is a remarkable example of an organization that actively

engages engineering students in ways that will aid in their future success by addressing such barriers as ethnic isolation, a weed out and individualistic culture, and providing access to institutional agents through the development and utilization of various forms of social capital. In the future, we would like to conduct more interviews from a greater pool of students as well as conduct longitudinal studies tracking students from Pre-College through PhD or Graduate school completion.

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