Student Social Capital and Retention in the College of Engineering

Abstract

An investigation of relationships between student social capital and retention in the engineering program and the use of the concept of social capital as a framework to understand the retention of engineering students are discussed. The concept of social capital has been utilized in investigations of economic productivity and innovation of corporations, drop-out rates in high school, and academic performance both in high school and in college. For the purposes of this study, social capital consists of social networks, social norms, and the value of these networks and norms for achieving mutual goals. Previous research suggests that the peer group and faculty support are both important factors in student retention and academic success. It has even been suggested that the peer group is the single most influential factor on personal development in college. Student social capital was assessed in one-on-one and focus group interviews with both students that have left engineering and students that remain. The focus of the interviews was on student interactions with peers, faculty, and teaching assistants, and students’ integration and perception of the engineering culture. Student responses indicate that social capital does play a role in the retention of engineering students. Both students that remain in engineering and those that have left reported that positive interactions with peers, faculty, and advisors were important to retention. Both groups indicated that few opportunities exist in the lecture setting to interact with other students, but the dorms provide opportunities to develop relationships with other students. Both groups voiced frustration with mostly poor interactions with faculty and advisors. Similarly, both groups indicated that their sense of community in freshman engineering courses is low, and they are frustrated with the competitive norms in engineering. Only those students that left engineering voiced dissatisfaction with teaching methods that encourage plug and chug problem solving, characterized by little discussion or opportunities to ask questions about assumptions or approaches. Recommendations are made to address student concerns that include active and cooperative learning approaches, and the development of learning communities.

Introduction

In today’s technological society the need for engineers in the workplace is at an all time high. In the next ten years it is estimated that the United States will need to train an additional 1.9 million workers in the sciences [1], a significant portion of which will need to be engineers. Not only is it important to train larger numbers of engineers, it is also necessary to attract a more prevalent representation of women and minorities in the engineering workforce. Identification of this need is certainly not new or unique to this study, yet simply highlights the need to be interested in the retention of engineering students. Government agencies, universities, and private companies have invested heavily in not only attracting more engineers, but attempting to attract and retain a more diverse workforce in the engineering field.
Purpose of Study

The purpose of this study is to develop an understanding of why students leave engineering at Oregon State University, put forth a theoretical framework for understanding retention issues, and provide recommendations to improve retention.

Literature Review

The need for student academic and social integration into academic settings has been identified as critical to personal and academic success\cite{2,3}. Student involvement in the total academic environment has been identified as the single most important factor affecting the persistence of students\cite{4}. The three most important forms of involvement turn out to be academic involvement, involvement with faculty, and involvement with student peer groups\cite{5}. Astin further suggests that the single most important factor on student development is the student’s peer group\cite{5}. Specifically, both the characteristics of the student’s peer group and the extent of the student’s interaction with that peer group are correlated with student development. Seymour and Hewitt\cite{3} identify the lack of peer group study support as a relevant factor among students’ reasons for switching from science, math, engineering and technology (SMET) fields.

Tinto developed a longitudinal model of institutional departure that includes academic and social integration as key components\cite{2}. Positive integrative experiences have been found to reinforce persistence by increasing intentions and commitments both to completion and to the institution\cite{6}. In contrast, negative experiences serve to weaken commitments to the institution\cite{2}. In a description of modes of belonging to communities of practice, Wenger\cite{7} describes some individuals as marginal members, those individuals whose full membership is prohibited due to personal attributes, background, etc. Barriers to belonging exist in engineering communities potentially due to social forces and perceived differences.

It is clear from the literature that social integration into the community, both academic and extracurricular, is vital to both the personal development and retention of students in higher education. The concept of social capital serves to provide a theoretical framework for the nature and the value of this social integration. Tinto’s theory of student departure has gained much recognition from retention experts and universities. The theory of social capital has added value compared to Tinto’s theory in that it is related to innovation and productivity at the engineering workplace, relevant learning theories, and preparing students for a community-oriented workforce, all clearly important factors in engineering education.

What is Social Capital?

Social capital has gained much attention in fields ranging from sociology to economics and has proven to be a useful tool in analyzing social systems. Social capital broadly consists of social networks, social norms, and the value of these networks and norms for achieving mutual goals\cite{8}.

Social norms can be described as accepted behaviors in a specific social setting. Social norms range from trust and mutual respect to generalized reciprocity. Fukuyama posits that trust plays a vital role in the social and economic productivity of nations\cite{9}. Specifically, Fukuyama indicates that successful communities are “formed out of a set of ethical habits and reciprocal mutual obligations internalized by each of the community’s members”\cite{9}. In terms of economic
productivity, Fukuyama claims that a nation’s success is based on the level of trust inherent in the society. Coleman makes a similar claim in terms of group productivity when he claims that “social capital is embodied in the relationships among persons...a group whose members manifest trustworthiness and place extensive trust in one another will be able to accomplish more than a comparable group lacking that trustworthiness and trust.”

The network aspect of social capital refers to “relationships among social entities, and the patterns and implications of these relationships.” Putnam utilizes social connections, or relationships, as indicators of social capital, such as religious and civic participation, connections made in the workplace, and those made through informal community involvement, such as in community sports teams. Putnam also considers the normative aspect of social capital, i.e. reciprocity, honesty, and trust, and investigates the correlations between social capital and health, crime, and education levels.

In Table 1 below, social capital can be viewed as including both norms and networks; any specific community or group of people is only considered to have high social capital if it is high in trust (norms) and individual associations (networks). Brief descriptions of situations for each possibility are included. The literature documents the competitive nature of the first half of the engineering curriculum and its adverse impact on student interest and willingness to form cooperative study groups. Additionally, based on personal observations in labs, it has been found that students are unlikely to work together if they can accomplish what they need to without cooperating with other students. As Grootaert and Bastelaer summarize, “Both networks and norms must be assessed to obtain a valid estimate of the aggregate potential for collective action.” As an example, a group of people may display a large amount of interaction, but this may not necessarily include a high level of trust and the resulting cooperation that accompanies trust.

<table>
<thead>
<tr>
<th>Trust, reciprocity, mutual respect</th>
<th>Individual associations</th>
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<tr>
<td>High</td>
<td>Students work together with minimal barriers.</td>
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<tr>
<td>Low</td>
<td>Students work together but are leery due to factors such as competition.</td>
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Table 1 – The Normative and Network Aspects of Social Capital

Social capital can exist and be developed both inside and outside of the classroom, in the form of both networks and norms. As an example, a student’s peer network may consist of friends outside of their department or classes, through fraternities, military association, or clubs and organizations, and peers in the classroom. Although there may be overlap between these two groups, it is not necessarily the case. Similarly, a student may share specific values with
personal groups such as volunteer organizations, and these values may differ or even be in conflict with values of peers in their class. For example, a student may have a strong sense of trust and respect with friends in a church or military group. This sense of trust may not be present in interactions with engineering students, due to an individualistic, competitive climate.

The Value of Social Capital

Social capital has been researched in various settings and it has been found that the value, or capital portion, of the construct is evident. There are two settings that are most relevant for this research: 1) the workplace, specifically consulting and business and the value in innovation and knowledge sharing, and 2) educational settings, including teaching and learning, and retention and achievement.

Social Capital and Innovation

Economic productivity in engineering firms is a function of knowledge sharing and creation, “The competitive edge of many firms favors those that can create knowledge faster than their competitors” [15]. Knowledge creation can be in the form of product development, resource management, and production, and occurs as a result of information sharing between firms. Firms that are successful innovators have reciprocal agreements based on trust with other firms. More specifically, individuals in firms have trust-based reciprocal information exchange agreements with individuals from other firms. As stated by Maskell, “Social capital enables firms to improve their innovative capability and conduct business transactions without much fuss and has, therefore, substantial implications for economic performance.” [15]

Social Capital, Teaching, and Learning

The need and benefits of empowering and involving students in the learning process through social interaction is well documented and supported [16]. Teaching standards for K-12 teachers mandate that teaching include practices that engage students in authentic scientific discourse. Additionally, the practice of student-generated scientific discourse is advocated by reform documents such as Benchmarks for Science Literacy and the National Science Education Standards. Traditional teaching in college consists primarily of the professor talking and the student listening. Lemke [17] argues that in order for students to become scientists they must take part in scientific dialogue. Based on extensive analysis of science classrooms, it was found that classroom interactions were controlled by the teacher, and these interactions are not representative of scientific dialogue.

In addition to standards supporting the need for student engagement and community building, sociocultural learning theories are in alignment. The Vygotskian sociocultural perspective suggests that learners develop through interactions with the more knowledgeable members of the community [18]. It has been argued that scientific knowledge is socially constructed and takes on individual meaning for participants in a community of learners. Within such a community learning occurs formally, through written records and informally, through discussion. Brown [19] recommends that in light of this knowledge students advance their learning through collaborative social interaction.
Social Capital, Retention, and Academic Achievement

Coleman [20] conducted a study of high school students to investigate the potential relationship between social capital and high school dropout rates. Coleman found that a lack of student social capital contributed to high school dropout status. Following Coleman, several studies were conducted investigating potential relationships between social capital and both dropout status and academic achievement [21-25]. Carbonaro tested Coleman’s hypothesis in a new setting and found that social capital was positively related to dropout status and math achievement test scores [22]. Morgan and Sorensen similarly found that math achievement for 8th graders was positively correlated with density of friendship and parental networks [23]. In a study of university undergraduate students, Etcheverry [26] found that student perceptions of support from other students related positively to student self confidence and grade point average.

The number of retention studies in college math, science, and engineering is extensive. The relation between social capital, measured as networks and norms, and retention in engineering has not been investigated explicitly. However, several studies propose that social integration and the culture of engineering play important roles in the retention of engineering students. Seymour and Hewitt conducted a study to establish and rank factors that have the greatest influence on students leaving science, math, and engineering majors [3]. One of the most striking differences between students leaving engineering and students leaving math and science was the presence of competitive grading and a “weed out” culture in engineering which inhibited students’ abilities to develop collaborative study groups. Weed out cultures are characterized by student perceptions that a class or curriculum is designed to fail a portion of students that are not academically fit to survive. Tobias found similar results from students who claimed that there was no sense of community in the classroom and that students were not interested in forming study groups due to competitive grading schemes [13]. Astin proposes that students who have contrasting values and beliefs than the peers in their major are likely to leave that peer group in favor of one that has similar values and beliefs [4]. Referring to Table 1, this is an example of a low trust environment that is fostered by the social norms put in place through the competitive structure of the early engineering, science, and math courses. Magnifying this concern are Astin’s findings on the importance of the peer group in college. Astin [4] stated that, “the many empirical findings from this study seem to warrant the following general conclusion: the student’s peer group is the single most potent source of influence on growth and development during the undergraduate years.”

The occurrence of supportive interactions with faculty has been identified as important for both student success and retention. Both engineering students and students that have left engineering voiced frustration about poor faculty pedagogy [3, 13]. Seymour and Hewitt indicated that faculty are not supportive in one-on-one interactions during office hours or of in-class questions that are not perfectly aligned with the topic of the day [3]. Tobias reports that teachers discouraged classroom interaction and students found it difficult to interact with their classmates in this didactic environment. This provides further evidence that the development of productive interactions and relationships with faculty is discouraged and may adversely impact retention.

Minority students face unique retention issues. As stated by Chang, “African-Americans, Native American, and Latinos possess strong cultural values of group and community membership that are at odds with the perceived levels of individualism and competition.
associated with the sciences” [1]. Additionally, these groups face a lack of participation with fellow students. For example, minority students often express an interest and a need for a cooperative educational culture that is rooted in cultural values and norms. In a report published by the National Science Foundation minority students were found to possess strong cultural values of group and community membership that may conflict with the competitive nature of engineering education [27]. Seymour and Hewitt found that cultural identities and values can clash with engineering cultures. The lack of community in early engineering education may have a potentially adverse affect on retention of minority students.

The value of understanding and encouraging the development of student social capital extends beyond the retention of engineering students. Student social capital is related to academic achievement, personal satisfaction, teaching standards, and learning theories. Additionally, preparation of students for a workforce in which collaboration and information sharing are vital to the economic success of the companies for whom they are employed is essential. Although social capital is related to these important factors, the intent of this study is to investigate the relationship between social capital and the retention of engineering students. Specifically, the goals of this study are:

- Develop an understanding of why students leave engineering through an investigation of student social capital;
- Evaluate similarities and differences between students that have left engineering and those that remain of student perceptions of interactions with engineering peers, faculty, and advising, and the engineering culture, and
- Provide recommendations that have the potential to improve retention that are based on student feedback and the literature.

**Methodology**

The aspects of social capital that are relevant to retention of engineering students consist of relationships (networks) and values (norms). Relationships and interactions that students develop between peers, faculty, and advisors can impact the retention of engineering students. Collecting information on students’ relationships was done through student interviews. The interview protocol was developed to investigate student perceptions of interactions with faculty, teaching assistants, peers, and advisors, and of the engineering culture. The norms and values evident in the college of engineering were investigated in the interviews through questions about experiences in engineering courses and working with peers on engineering assignments.

Both students that are currently in engineering and students who have left engineering were interviewed. First, students were identified that had enrolled in any of the introductory engineering courses in Fall 2001, 2002, and 2003. From this list students that are currently declared as majors other than engineering were identified. This list was further refined by omitting students that had a grade point average below 3.0. This step was taken to ensure that these students would have gained entry into the second half (pro-school portion) of the program and been likely to succeed had they chosen to continue in engineering. This list consisted of approximately 400 students. All students were sent an email from the assistant dean requesting their participation in retention interviews. Approximately 40 students responded to this email.
The number of interviews conducted was chosen based on acquiring representative data. Overall, the intent was to conduct a sufficient number of interviews so that the results can be considered representative of the engineering population at OSU. This was accomplished by conducting interviews until a point at which student responses provide limited new information.

A total of 22 students were interviewed, including both focus group and individual interviews. Several ethnic groups were included in this group including Korean, Chinese, Hispanic, and Brazilian. Ten engineering students were interviewed including individuals from Mechanical, Civil, Industrial, and Electrical Engineering. Of this group of ten students, two groups of three students each were interviewed in focus group interviews, one group of male engineers and one group of female engineers. The remaining four students, two female and two male students, were interviewed individually. Twelve students that have left engineering were interviewed including students that are currently majoring in History, Political Science, Geology, Biology, and Business. In this population of twelve, one focus group interview consisting of five male students was conducted. The remaining seven students, four females and three males, were interviewed individually.

Results

The importance of student social capital in the retention of engineering students was confirmed by student interview responses. As a reminder, social capital consists of both networks and norms. Students reported on both the importance of social networks and norms as factors in retention.

Network Aspect of Social Capital

Students commented that positive interactions with peers, faculty and advisors was critical to staying in engineering. Both students in engineering (engineers) and those that have left (switchers) identified the peer group as essential to success in engineering.

Students made specific comments that it was difficult if not impossible to succeed in engineering without peer group support.

*Int (Interviewer):* Did you study with people when you were in statics?
*Female Business Switcher:* Yeah, had to, there was no way I was going to pass without it.
*Male Electrical Engineer:* You really can’t do it (engineering) on your own.
*Female Electrical Engineer:* Most of the help you get is from other students.
*Int:* How important were your peers in the early years?
*Female Industrial Engineer:* I would say they are very important. Those are the people that I studied with and did homework with and everything else and sat with in class so they were very important.

Although it is clear that peer group support is important to the success of engineering students, evidence exists to suggest that limited opportunities are provided to meet people in engineering courses:

*Int:* Is it easy to meet people in engineering classes if you didn't know anybody?
Male Electrical Engineer: I don't think so, most of the time you are just head down taking notes.

Int: Have they engaged you in any activities that help you meet people or work together with people?

Male Mechanical Engineer: No.

Male Electrical Engineer: Very seldom.

Male Civil Engineer: I've met very few people just through class cause you just kind of go in and they start talking and that is pretty much it, there is not much interaction there.

Although lecture appears to provide limited opportunities for meeting people, students commented that they did meet people in lab.

Female Industrial Engineer: Once I started working in the labs, I got to know the lab people very well, we all started hanging out together.

Int: Do you meet people in labs and in recitation?

Male Civil Engineer: Yeah, in labs.

Male Mechanical Engineer: I think labs are big yeah.

Int: Was it hard to meet people in the classes where you didn't know anybody?

Female Industrial Engineer: Not really, because in a lot of the classes we had labs and so you were paired up with some people, and those are the people that I tended to study with so since we were lab partners we would get together and study.

Int: Did the classes that you took in engineering help you get together with people?

Male Geology Switcher: The labs did.

Students also identified the dorms as a source for social integration.

Male Civil Engineer: I lived in the dorms right across from him so we studied physics together, we were going through it at the same time.

Female Industrial Engineer: I lived in Mcnary my first year and there were a lot of engineers on my floor and those were the people that I would always study with and had classes with up to my sophomore year. Those are the people that I studied with and did homework with and everything else and sat with in class so they were very important.

Male Wood Science Switcher: Just the dorms, that's how I met my engineering friends, was from the dorms, and a few from the department.

Int: Seems like a lot of friendships start over in the dorms.

Female Business Switcher: Yeah, it's nice. It's kind of nice and convenient because they're all right there. You just walk down the hall. It's a lot easier than like calling them up and saying hey what's up, you want to hang out.

Both engineers and switchers identified the importance of faculty interactions in retention. Unfortunately both groups also reported that their interactions with faculty were very few, and the interactions they did have were mostly negative. Students made explicit comments about improving retention by getting students more involved with faculty.

Int: If you could improve retention in the college of engineering what would you do?
Male Electrical Engineer: Get the students more involved with faculty.

Male Civil Engineer: Yeah, definitely.

In this particular case, the student identified a faculty member as being the sole reason for remaining in the engineering department.

Female Industrial Engineer: I think interaction with the professors is a big deal, its something that I didn't have and the only reason that I am still in engineering is because of my advisor, and I think at least in the (engineering department) we have incredible faculty, they work so well with the students and if you just get to know them they are incredibly inspiring and I think that interaction is incredibly important and should be encouraged.

Several students reported that they did not have much opportunity to interact with engineering faculty. It is important to note that both engineering students and students that have left engineering had similar reports with engineering faculty.

Int: During your freshman and sophomore years how much interaction did you have with engineering faculty?

Female Industrial Engineer: Hardly any.

Female Industrial Engineer: None unless you went out of your way.

When students did get an opportunity to interact with faculty they reported that faculty were annoyed when students had questions during office hours and more generally that interactions with faculty were poor.

Male Civil Engineer: Sometimes they are pretty good, other times it’s kind of irritating. I find a lot of times, even if it is during their office hours that some professors are irritated that you are using their time.

Male Mechanical Engineer: There’s a big separation between the teacher student integration. There have been instances where I have gone in and talked with the teachers in their office hours and they were, it seemed like they were rather irritated that I even had a question, or why didn't I understand this when I was in the classroom and why are you coming in and talking to me about it now. Type of thing where they just hurried you along so they could get back to whatever they were doing.

Male Biophysics Switcher: I'd say seventy percent of the reason I transferred out of engineering was overall interaction with faculty... it was just they had zero time for the students.

Female Civil Engineer: My friend and I took (engineering course) at the same time and she went to talk to the professor and he basically said that she should drop engineering right away because she was female and she wouldn't make it through the rest of the program. That was my first impression of engineering professors so I didn't go talk to them until my junior year. It turned me off enough to not talk to any of them. It was four years ago.

Although the majority of comments about the quality of faculty interaction were negative, in several cases, one specific faculty member was identified as having a very positive influence on students’ experiences in engineering.

Male Biophysics Switcher: Well, I’d say one of the greatest experiences I had was actually (engineering course) with (engineering professor). He was a great professor and really a refreshing change to the whole department that I had seen up to that point. He was there...
for the students, which he's the only professor in engineering that I ever found that knew what the students' names were.

Students did not report as many concerns about the importance of interactions with advisors on retention. However, some still felt these interactions were important.

Male Biophysics Switcher: I think I was assigned two different advisors then had to talk to another one or two for different stuff and no one was ever very encouraging of taking anything except for what they told me to take, and so advising was a big issue for me.

Similar to experiences with faculty during office hours, students reported both positive and negative experiences with advisors. It appears that early in the students’ careers they had poor experiences with their advisors, but as time wore on the experiences improved.

Male Political Science Switcher: I was having some problems freshman term and I went in and talked with him and thought he was really helpful giving me advice.

Male Mechanical Engineer: I've had a horrible experience with counselors until right now. This last counselor visit was the first time the counselor was nice to me and actually cared that I was there. Before that it was like yeah, take those classes, I don't care, now get out of here.

Male Electrical Engineer: My advisor had been pretty decent. It took me a while to get to the position I am in with her. She was just like with all the other teachers, like hurry up, get in and get out, let me get back to whatever I am doing, but I've worked with her for two and a half years now, so she kind of has a basic idea of who I am and I think that I have a decent rapport with her.

Students voiced some frustration with the large advising sessions.

Male Geology Switcher: And in engineering they see you once every three months and there are 500 people they see and its just did you meet this, did you meet this, did you meet this.

In general, it appears that students have some frustration with faculty in both academic office hour sessions and advising sessions. In both cases students are frustrated because faculty do not appear to have the time to answer students’ questions and rush them out of their office. Helping the students with coursework or with advising does not appear to be a priority on the part of the faculty. Although some students reported positive experiences with faculty outside of class, these reports were about isolated individuals. As an example, several students reported very positive interactions with two specific faculty, but overall students reported poor interactions with most faculty.

The importance of positive interactions with peers, faculty, and advisors to retention was consistent. Perhaps the most important pattern was that no significant differences in perceptions exist between engineers and switchers in terms of the importance of networking to retention.

Normative Aspect of Social Capital

Students also commented on norms in engineering that prohibited students from working together. The norms enforced and encouraged in the college of engineering are not conducive to student involvement in learning and forming cooperative study groups. As reported previously, students recognize the need to work together in groups, but as noted by one student the difficulty of the program appears to be the only factor that brings students together.
Recent studies have reported the competitive weed out culture and its adverse impact on student retention \cite{3,13}. Similar results were found in this study. Students reported that engineering students were pleased to outperform their fellow students, to the point of annoyance and discouraging collaboration, and that the goal of early engineering classes was to weed out a large portion of the students. Referring back to the discussion of social norms, this is an example where social capital is low due to factors such as low trust and lack of support that discourage student collaboration. These comments were consistent from both engineers and switchers.

Female Business Switcher: But then it was just kind of weird because she would always be like what'd you get, what'd you get, what'd you get and I'm like why do you want to know so badly? Does it really matter? But then she'd be like all excited when she did better than me, she wouldn't really be that happy when I did better than her, and I'd be like what's going on, I don't like this.

Male Biology Switcher: It was kind of discouraging. Why am I going to take this class where they want to fail me?

Female Civil Engineer: Who could handle the most BS, busy work and I don't think they cared about us at all, it was like you have to do this stuff and sit there and take it and if you pass you get to keep going.

Male Political Science Switcher: I sort of get the impression that they don't care if they retain a lot of their students, that they want to get rid of them. I don't know exactly what the philosophy behind that is.

Students also indicated that there was no sense of community or connection in engineering, which has been verified in other retention studies \cite{13}.

Female Industrial Engineer: It wasn't personal, it felt like they really didn't care about you, can you pass it, can you make it through, that type of thing.

Male Geology Switcher: There's no sense of community between engineers either, especially the first 2 years.

Female Electrical Engineer: Engineering is kind of like swim or die. It's like nobody cares if you don't, if you have 300 people whose going to notice that the one person dropped out.

Male Biology Switcher: You don't feel any connections with your department at all.

Male Political Science Switcher: Not only that there were like 300 people in the class, you could pick out faces but there was, just like he said, no community.

Students’ lack of a sense of support and a sense of community were consistent among both engineers and switchers. A non-caring impersonal climate does little to encourage collaboration and cooperation.

In Tobias’s investigation of student retention in science, students reported that early science courses are taught in a fashion in which information is presented as here it is and there’s only one way to think about it \cite{13}. Additionally she found that discussion was not encouraged in the classroom environment. Knowledge was presented as plug and chug, i.e. here is the equation, here is the situation, now plug in the numbers and get an answer. Students in this study reported similar results.
Female Business Switcher: I found more in engineering classes it was more like this is what it is and you write it down.

Male Political Science Switcher: It was a lot of the plug and chug teaching method and that just kind of turned me off.

Male Biology Switcher: You go to the next class and they say just do it and not why. I mean there's no explanation of what you are doing, why you are doing it or where you are going, its just do it.

Male Biophysics Switcher: It was very this is how you do things I don't want to talk about why, I don't want to talk about how, I don't want to talk about this, it's do it and that's it.

It would be inappropriate for faculty to suggest to students that engineering knowledge is absolute fact and that there is no time for questions. Engineering knowledge is certainly not static; if it were research universities would not provide value to society. Students have reported interest in the source of knowledge, assumptions, limitations of equations presented, and why something might be done in a certain way. If the norm in the classroom is to not ask questions about methods or concepts, minimal opportunities are provided for students to interact and discuss material. Most importantly, this runs contrary to teaching standards and learning theories discussed previously.

Both switchers and engineers commented on the competitive weed out culture and the lack of a sense of community. However, only switchers were frustrated with the plug and chug teaching methods.

Summary
Students perceive that social capital, in the form of networking with peers, faculty, and advisors, and pro-social norms, encouraging collaboration and trust among students, are important to student retention and success in the engineering department. Unfortunately, the evidence suggests that little is done to encourage the development of social capital. Classroom environments are seen as unfriendly, lacking a sense of community, and not conducive to discuss subject matter. Students feel that the purpose of the early years is simply to weed students out. Several engineering students reported that the early years were just to see who could handle the difficult environment with little support from faculty. Students are interested in acquiring a more in depth understanding of subject matter, an ideal situation, but questions are not encouraged either in or out of class. Although students made multiple positive comments about experiences in specific classes and with certain faculty, the consensus was consistent among both engineers and switchers that overall interaction with faculty was poor.

Perceptions of social networking and norms in engineering were consistent among both engineering and switchers. The only difference between the two groups was switcher’s frustration with the plug and chug teaching method. Based on the extensive similarities between the groups, it could be concluded that social capital is a concern for these students but does not play a role in retention. A question that arises is, what differences exist between switchers and engineers that allow them to cope with this chilly climate? It is likely that social capital is more important to some individuals than others, and it would be a mistake to assume that the chilly climate in engineering is conducive to keeping only the best engineers. The lack of frustration of engineers with the plug and chug teaching method is alarming. There are few that would argue
that we do want engineers that are inquisitive and question the source of knowledge and the assumptions of certain approaches. Two themes emerge; what are differences between engineers and switchers that result in differences in retention, and what can be done to change the chilly climate in engineering? The first question is a topic for future research, and the second is addressed below.

Recommendations

As it has been established that social capital is important to the retention of engineering students and that opportunities for students to develop social capital are minimal in the early engineering curriculum, the following recommendations will focus on successfully implemented practices that have been shown to increase several positive outcomes, most notable for this study, retention of engineering students, student social capital, perceived satisfaction with the program, and academic achievement. The number of available programs and practices found to increase student retention, in addition to the outcomes mentioned above, is immense. The descriptions of programs and practices below serves to provide an overview of potential programmatic changes. Described below are both in-class and out-of-class opportunities.

It is important to note that not all of these practices have been proven to improve retention. This may seem problematic at first. However, each of these practices, as mentioned above, is related to multiple positive educational outcomes and to increasing student interaction and student social capital. Also important to note is that the ability to positively link a specific program or practice with increased retention is very difficult in a complex social setting like higher education. Some programs have been shown to increase retention, including those at Purdue and Carnegie Mellon Universities. In both of these cases the changes made were expansive and multifaceted, and determining which aspects of specific changes actually increased retention would be difficult. The lesson to be observed is that to improve retention multiple changes must be made, with each change having the potential to impact a variety of students and each having the potential to have multiple positive outcomes.

In-Class Practices

Active and cooperative learning have been shown to have both positive academic outcomes and contribute to the development of group skills. Both concepts are briefly presented in the following with the intent of providing a description of what each entails and the benefits supported by research. Following the discussion of active and cooperative learning is a summary of research of teacher and student discourse in the classroom, including practical suggestions for increasing student learning and involvement in the classroom. In this discussion several recommendations for in-class practices are included, some of which have limited descriptions of specifics of implementation. However, references are provided for the reader to investigate these practices in more detail.

Active learning is characterized by a student’s direct involvement in the learning process. In active learning students are seen as active constructors of knowledge as opposed to passive receivers of information. Learning theories and learning experts have reached some consensus that students actively construct new knowledge based on previous understandings and experiences. A subset of active learning is cooperative learning. Cooperative learning has received significant attention both in practice and in the research, and is best understood when
compared with two alternate modes of learning, competitive and individualistic. It is important to note that cooperative learning is not simply putting students together in a group to work together. Specific characteristics of the group work must be present for it to be successful: positive interdependence of the group members; promotion of face-to-face interaction; individual accountability and responsibility to groups goals; use of relevant personal and small group skills; and group evaluation of group processing to increase the group’s effectiveness \[31\]. Cooperative learning has been implemented and evaluated extensively in the higher education arena. Perhaps the best example in engineering education is the Foundation Coalition, a group of six universities that have implemented innovative educational practices into the engineering curriculum. Cooperative learning has been shown to encourage the development of academically and personally supportive relationships that are vital to a number of important processes and outcomes, including pro-social attitudes and behavior patterns, perspective taking abilities, sense of belonging and connectedness with others, achievement, and educational aspirations \[32\].

Faculty can increase student interaction in the classroom through active learning exercises. Active learning exercises encourage discourse among students in the classroom. The role of student discourse in the classroom has been investigated extensively. Jones argues that within the framework of interactive teaching exists several teaching components and strategies that have been shown to positively impact learning of mathematics, including higher-order questioning, student presentation and discussion of mathematical ideas, and reflective discourse \[33\]. In addition, each of these strategies needs to be conducted in a supportive classroom culture, in which students and teachers can negotiate mathematical understanding and students can compare their conceptual understandings with accepted understandings. Additionally, the classroom culture allows students to propose and discuss mathematical issues and situations that are important to them. A barrier to the described culture is the power differential between teacher and learner. This barrier can be minimized through teacher behavior that guides, not controls, the discourse. Specifically, teachers can encourage student reflective discourse on relevant topics.

Van Zee \[34\] conducted an investigation of student centered discussions. The author concludes that two aspects of her practice tend to encourage discussion, distributed authority and quietness, and suggests that these practices may be used in classrooms to encourage discourse on inquiry. In a second article by van Zee \[35\], multiple case studies were conducted by a group of educators from grade school through college. The intent of the case studies was to investigate methods of speaking by teachers and students that encourages students to formulate insightful questions about science topics and share their own ideas during science discussions. The authors identified common aspects of both student and teacher questioning. Student questions were found to occur under four conditions: 1) when discourse structures were set up that explicitly elicited questions, 2) when students were engaged in conversations about contexts of which they are familiar and had made observations for a long period of time, 3) when discourse environments were comfortable and students tried to understand each others thinking, and 4) when small groups of students were collaborating with each other. Comfortable discourse environments were found to be created by appointing students to facilitator roles, describing to students how to converse, listening closely to what they said, and clarifying student contributions. Teacher questioning was characterized by eliciting student questions that developed conceptual understanding, and asking students to clarify meanings, explore various
viewpoints, and monitor their own thinking. Teachers were found to encourage discourse by practicing quietness and reflective questioning.

In the above, descriptions of educational practices focused at getting students more involved in the classroom learning experience were provided. In order to implement these practices, faculty must be willing to adopt changes in their teaching and be provided with the resources and training to do so effectively.

**Out-of-Class Practices**

Out of class experiences include service learning, learning communities, and a variety of out-of-class programs and experiences. As noted previously, providing a detailed description of all available programs is not within the scope of this project. However multiple resources are available. Most notable are the retention efforts undertaken by Purdue University, which are based on Tinto’s model of retention \[2\], and focus on increasing students social and academic integration and commitment to the college.

Service learning is characterized by community service work that is integrated into the curriculum, and is specifically related to learning objectives. The connection between the community service work and the curriculum occurs through written activities and discussions. Service learning has been shown to be correlated with student’s social involvement during and after graduating from college. A growing body of evidence “strongly suggests that when accompanied by proper preparation and adequate academic reflection, service learning can be a potent civic educator.” \[36\] It has been shown that a service learning experience “can achieve the goal of educating young people about their responsibilities in a democratic society, allowing them to think about what it means to be a part of the multiple communities in which they find themselves.” \[37\] Additionally, students involved in service learning have increased comprehension of course material and develop an awareness of their local community \[38\]. Perhaps the best example of service learning in engineering education is the EPICS (Engineering Projects in Community Service) centered at Purdue University that involves seven universities nationwide. Service learning has tremendous potential to help students develop subject specific knowledge, group skills, and a sense of civic duty.

Learning communities are established as part of efforts undertaken by the Foundation Coalition. Learning communities are established by placing small groups of students together in several pre-engineering classes during their first two years of school. These students then have the opportunity to meet people early in their academic career. These peers provide social support and study partners, both of which are essential for survival in the engineering curriculum.

The above described methods for encouraging the development of student social capital are just the tip of the iceberg for educational opportunities. They have been selected based on the extensive research done indicating that they can increase student academic socialization and achievement, both of which are related to retention.

**Summary**

The most important consideration in improving student retention in engineering is that a single change in practice is unlikely to have a substantial impact on the retention of engineering
students. Changes must be multifaceted and targeted at multiple groups. Both in-class and out-of-class positive experiences must be available. While this report has provided some recommendations on improving retention, the most valuable aspects are utilizing social capital as a framework for understanding and improving retention and developing an understanding of why students leave engineering. Improving student social capital, i.e. increasing opportunities for networking and social integration and enhancing pro-social norms such as trust and mutual respect, has the potential to not only improve retention, but to increase academic achievement, perceived satisfaction, and perhaps most importantly, to prepare students to be active democratic citizens and cooperative and innovative engineers.

Bibliography


