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To the Graduate Council:

I am submitting herewith a thesis written by Sara Noel Abdulla entitled "Analysis of Information Networks of Freshman Engineering Students." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

Denise F. Jackson, Major Professor

We have read this thesis and recommend its acceptance:

David J. Icove, Dongjoon Kong

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Dongjoon Kong

Acceptance for the Council:

Anne Mayhew
Vice Chancellor and Dean of Graduate Studies

(Original signatures are on file with official student records.)

Analysis of Information Networks of Freshman Engineering Students

A thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville

Sara Noel Abdulla
December 2006

Dedication

This thesis is dedicated to my parents, Farid K. Abdulla and W. Faye Abdulla, who have provided for me, guided me, and believed in my capabilities. To my granny, Mildred McCall, my aunts and uncles, Mary and Roy Gamble and Farouk and Betty Abdulla, and to Reem and Mark Provinsal, who have selflessly supported and continuously encouraged me.

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I would like to thank God for giving me the strength and the resources to complete this project. I also thank Him for the encouraging friends and family he has put in my life.

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Without those professors and teaching assistants who allowed me to interrupt their classes to gather data I would not have been able to complete this work; I thank those who have been most helpful.

Last but not least, I would like to thank all of my family and friends for their patience and support throughout my time in graduate school.

Abstract

The main purpose of this study was to determine if social interaction within the University of Tennessee, Knoxville college freshman engineering classrooms correlates with academic performance. Also of interest was whether the interactions between genders had a significant affect on academic performance. Better academic performance is cited in the literature as improving retention and graduation rates; therefore, if factors that affect academic performance can be understood measures can be taken to help students perform better.

Five UT freshman engineering classes were surveyed to determine their level of involvement with the rest of the members in their class. Academic performance of the class as a whole and of each gender was retrieved from the class's instructor at the end of the semester.

The demographic information revealed that there are significantly fewer females in engineering than males, however, the percent enrolled is consistent with that of the national average. Social networking analysis of the interactions within the class revealed that the women have a higher percent of interaction within the class than males do. However, classes overall do not have that much interaction.

The relationships did show that social interaction within a class could have an affect on student's academic performance. While there was no significant relationship between the overall class grades and overall class density, strong relationships were revealed between overall class grades and gender-to-gender interaction and gender grades with respect to gender-to-gender interaction. A significant positive relationship was made between receiving A's and an increase in male-to-female interaction ($p = 0.038$). As the A's within a class increase, other grades will decrease; and thus, the class's academic success rate increases. A weak positive relationship was made between the percent of males receiving A's and the amount of male-to-female interaction; however, given a larger dataset, there may have been statistical significance.

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Introduction

1.1 General Introduction

For decades, the top priority of America's higher education leaders has been to encourage more and more students to go to college. High school guidance counselors, college recruiters, news programs, and TV commercials tell students that if they want to go to college it is possible, for everyone. This generally means that students who may not be able to afford the financial cost of college can still attend college by borrowing money from the government at a lower interest rate and not make payments on it until they have graduated. And for those who finish college and find a job, it is well worth the price of the loan. Although enrollment in college courses is increasing, significant proportions are not graduating. In 1997 just fifty-four percent of students entering four-year colleges had a degree six years later (Associated Press [AP], 2005). "Now the question of what to do about the country's unimpressive and stagnate graduation rates is on the agenda, from college presidents' offices to state houses" (AP, 2005).

Important factors that lead to the successful retention of college students have been studied for decades. Several factors that researchers agree contribute to a student's academic success are "high standards for academic learning and conduct, meaningful and engaging pedagogy and curriculum, professional learning communities among staff, and personalized learning environments" (Klem & Connell, 2004, p. 262). In addition, some researchers have recognized that social integration is also an important factor to academic success (Hosen & Solovey-Hosen, 2003; Thomas, 2000: Tinto, 1975 & 1997).

Social integration within a classroom allows peer-to-peer interaction. Students are able to build social capital, which "consists of social networks, habits or cooperation and bonds of reciprocity that serve to generate benefits for members of a community" (Hosen & Solovey-Hosen, 2003, p. 84). Students are willing to share information within their network, issues out of the class and issues in the class. However unfortunately, "the classroom has not played a more central role in current theories of student persistence" (Tinto, 1997, p. 599).

While social networking within a community or a class is becoming more recognized as an important factor for the academic success of students, it has been difficult to study this attribute (Thomas, 2000). However, as satisfaction with college and academic success have been shown to be attributable to teachers, class curriculum, gender, and social integration, it is important to understand how these factors correlate with each other in order to provide and encourage productive and successful environments for college students. An understanding and effective planning based on these attributes should lead to greater academic performance and persistence for college students.

1.2 Purpose of the Study

Amongst graduating high school students the number of students interested in engineering is declining; and, of the students that enter engineering, only fifty percent graduate in engineering (French, Immekus, & Oakes, 2005). The SME majors have "the highest defection rates among undergraduates [and] the lowest recruitment rates" (Lee, 2002, p. 350). The number of students leaving the engineering curriculum would not affect the numbers so "severely if there were compensating inflows [of students] along the way; however, the dominant flow is outward" (Lee, 2002, p. 350). Education columnist, Jay Matthews (2006), deduced from other people's studies "Five Weird Ways To Graduate College" and number five on the list was "don't major in engineering." Unfortunately, it seems that engineering students feel this way as well and are choosing to switch majors or dropout of college entirely.

As engineering programs are particularly vulnerable to defection, one of the goals of the college of engineering at the University of Tennessee, Knoxville has been to improve the retention and graduation rates of engineering freshmen. The freshman Engage Engineering Fundamentals Program was developed at UTK in order to help increase the retention rate; this study will focus on the Engineering Fundamentals program.

As academic performance is a huge indicator of whether students will continue in engineering, the purpose of this study was to determine the extent to which various

classroom factors correlate with a student's academic success in engineering. The attributes studied are the student's (1) degree of social information networking within the class environment, (2) gender, and (3) academic performance. Academic performance was limited to the grades received from the classes studied.

1.3 Terminology

The terms as used by this research are described below:

1. Academic failure – receiving a grade of a D or F
2. Academic performance – a students letter grade at the end of the course
3. Academic success – receiving a passing grade of an A, B, or C
4. Actor – social entity within a network, such as a person, organization, etc.
5. Association/adjacency network – matrix (or graph) representation that shows the relationships or connections among people and organizations. A one is entered to indicate that two nodes are connected (adjacent) and a zero is entered to indicate that two nodes are not connected.
6. Connectivity – connections within a set of actors
7. Defection – dropping out of Engineering and switching majors.
8. Degree – number of connections an actor/network has
9. Density – proportion of all possible ties that are actually present within a network
10. Directed – ties are not necessarily reciprocated, as in, one actor may consider another to be a friend, however, the other actor may not reciprocate the feeling of friendship
11. Group – collection of all actors with ties in a network
12. Isolate/Isolated point – actor that has no ties to its network
13. Link/Edge/Tie/Arrow – symbolizes a relationship among actors
14. Network - an interconnected system of things, entities, or people
15. Node – points in a graphical display which represent actors or objects being studied
16. Persistence/Retention – a student remaining in Engineering until graduation
17. Social information network – who shares information (any type of information) with whom within a set of actors

18. Social network – finite set or sets of actors and the relation or relations defined on them (Wasserman & Faust, 1994)
19. Undirected – ties within a set of actors are all reciprocal

1.4 Background

1.4.1 Engineering Student Retention

The academic success and retention of engineering and other science and mathematics students has become a major concern. In 1995 a national movement was underway to recruit and retain more college students into the science, mathematics, and engineering (SME) majors. In 1993 the SME majors suffered a relative student loss rate of 40 percent between their freshman and senior years (Seymour & Hewitt, 1997). Engineering has one of the highest defection rates; the loss rate for engineering students alone was 40 percent and, as for careers, engineering lost 53 percent of their entrants into the workforce (Seymour & Hewitt, 1997). Therefore, engineering student retention has become a central issue as "the demand for qualified engineers threatens to outpace the number of graduating engineers" (French, Immekus, & Oakes, 2003, p. T2A-19).

The initial barrier to a student entering their first year of engineering is getting accepted into the program. Being accepted into most engineering colleges generally signifies that the student has the intellectual background and aptitude to be in engineering. However, success in engineering school is another story. The next barrier for most entering engineering students is adapting to the new material and style of teaching, coming from high school to college. At a time like this, it would be advantageous for these freshman students to make connections with other students in their engineering classes as well as form relationships with their instructors; unfortunately however, many entering freshmen are introverts, based on the Myers-Briggs Type Indicator (Felder, Felder, & Dietz, 2002). This means that most entering engineering students are shy people who tend not to socialize too much. Which may be one of the reasons that sometime during the first year many students are lost; they choose to switch majors or quit school. Many defectors thought when they entered engineering that they would succeed because they felt they had a strong background in math and

science in high school (Seymour & Hewitt, 1997). However, everything that the engineering major entailed, i.e. difficult material, lengthy study session, complex homework and projects, became too challenging for them to handle.

In order to recruit and retain students in engineering, and college in general, more focus needs to be put on what factors contribute to students experiencing academic success and satisfaction. Many studies have shown that "grade performance is the single most important factor in predicting persistence in college" (Tinto, 1975, p. 104). Studies also suggest that social integration leads to academic success, better understanding of class material and therefore persistence (Tinto, 1975 & 1997). Therefore, social networking should influence how the students perform and in turn whether students choose to continue their studies or transfer to another major.

1.4.2 University of Tennessee, Knoxville's Engage Engineering Fundamentals Program

"Due to the demanding curriculum, retention and graduation rates for engineering students have traditionally been lower than those of other academic disciplines" (Cowart, 2002). The goal of the freshman Engage Engineering Fundamentals Program (EF) is increasing student's academic success and the engineering retention and graduation rates. EF encourages students to learn by having the students work in team environments and interact with others to create solutions. This introduces to the students the life of an engineer and provides the students with realistic experience as practicing engineers because many professional engineers must work as effective members of a team, especially as the "complexity of modern engineering tasks" increase ("Engage", 2006). The teamwork style in the EF courses promotes team member communication, problem solving, and working together to meet the desired end goal.

Some of the students in the freshman engineering courses also have chosen to live in the Engage Community, in which one floor of a UT campus residence hall is dedicated to students enrolled in the engage program. This offers an environment in which students who are taking the same core classes may integrate more easily, share notes, receive help, form study groups, and so on. The combination of a community atmosphere and team

skills development the engage program offers are geared to prepare students for success in their courses as well as in their careers.

During the first two-year phase of the EF program, 1997 and 1998, data on student academic performance and retention were collected. In 1997 a pilot group of 60 students were enrolled in the EF program and 254 students remained in the traditional freshman engineering curriculum, the control group. In 1998 150 students were enrolled in the “transition” group while 244 remained in the traditional freshman engineering curriculum, the control group. Comparisons between each year’s EF and traditional groups were made based on student’s academic performance and graduation rates.

Student’s academic success was evaluated by their grades on two exams that both the EF and traditional groups had to take. The first exam, the statics exam, showed that between the 1997 and 1998 classes, the EF groups performed an average of 13 percent better than the control students. The second exam, the dynamics exam, showed that the EF groups performed an average of 6 percent better than the control students. An additional goal of the EF program was to better prepare students for entry into their future engineering classes. In order to measure this goal student performance in their first departmental course was evaluated. The results showed that the EF students outperformed the control students.

The average time to graduate engineering from UT is over five years; therefore, a six-year analysis would be necessary to get a complete picture of the graduation rate of the EF students versus the control group. The study only tracked the class of 1997 students through their first five years and the class of 1998 students through their first four years. The 1997 EF group had a 43.3 percent graduation rate compared to 25.5 percent of the control group. The 1998 EF group had 17.9 percent graduation rate compared to a 6.1 percent of their control group (Parsons et al., 2002).

After the first four years the program was initiated with all freshman students, Dr. Roger Parsons, the program’s director, stated that freshman retention results have improved by 15 percent and engineering graduation rates have increased by 10 to 15 percent (Cowart, 2002). The analysis shows that the EF curriculum and educational

approach is achieving its goal of helping students academically succeed and improving engineering freshmen retention and graduation rates.

1.4.3 Gender in Engineering

Engineering has traditionally been a male dominated major. Many people feel that engineering, and other science, math, and technology related fields, are meant for men. While women make up 50 percent of college undergraduates, women only make up 20 percent of engineering (Trimbath, 1998). Some fear an engineering shortage, due to "a) the fact that engineering is not favorably perceived and b) students are shying away from math and science" (Arabe, 2005). However, without the representation of both genders in the field engineering and the products and ideas produced do not reflect society. Therefore, there has been much focus on what factors may help recruit, motivate, and retain students in engineering, especially females. Many colleges are spending more time and resources to attract women into a field that traditionally has a difficult time with female recruitment and retaining.

1.4.4 Social Networking

Communication creates social information networks between the people or organizations involved in the interactions. A social network is a set of actors, within the network being studied that may have relationships with one another. Social networks are found wherever there are relations between two or more people, for example, within families, schools, communities, organizations, and so on. What makes a social network successful is: sharing similar interests; associating social boundaries, a network may be accepting of people who claim certain affiliations; and arranging activity within the network, meetings and phone calls. In a classroom, the social network is made up of all of the students in the class and the relationships between each of them. The common bond they all have is that they are all taking the same course, learning the same material, completing the same homework, and taking the same tests.

A great deal of value can be gained through appropriate information networking inside and outside of the college classroom. Within a classroom if students network they

are able to collaborate with each other when they need help or have questions about the class. Networking allows for brainstorming and sharing of ideas. Effective networking is important for everyday life, not just in the classroom. For instance, within an organization, if an employee needs information or expertise about a situation through his daily interactions with workers he has networked and learned from whom he should seek guidance. Useful networking can also be viewed between organizations. Consider that organization A is planning to purchase a new hip simulation machine. Instead of relying solely on catalogues and sales representatives' information, organization A should also research customer satisfaction. They should be able to network with a similar organization that uses similar products to determine whether the machine is the right machine for them. Networking can occur through contacts already established at another organization, through local and national conferences, through on-line forums, and so on. While the importance of networking for success may be clear, what may not be quite as obvious is the extent to which networking can improve a school, or even a community or organization.

In a college class there is continuous interest in determining the type of setting and instructional style that promotes class involvement, satisfaction, and achievement. If social networking within a class is attributable to greater persistence, it may be a link that should be further exploited within engineering classes to provide a better experience and higher academic performance, which would lead to more student persistence. This research addresses the issue of what class factors contribute to academic success in freshman engineering college classes. The aim is to determine which students interact within their class's social network and whether there is a correlation between class social interactions, class gender composition, and academic performance. Understanding how the network is connected may provide information explaining why a network may have success or vice versa.

1.5 Problem Statement

In order to stop the trend of college freshmen entering engineering and switching majors or dropping out of college, more focus needs to be directed at what is happening

in the classrooms. Student's gender, interactions, and their relationships to the academic setting and academic performance need to be understood. While knowledge that peer-to-peer interaction and gender are accepted as factors in a student's commitment to engineering, little research has been done to actually study student's social networks, thereby, how information is shared and discussed within the class, and how this interaction affects academic performance. As more research is recognizing the importance of retaining and graduating engineering students of both genders, especially the females as they are so underrepresented, it is important to study whether social networking and gender composition within a class may actually have an affect on the student's performance

Thus, the problem addressed is determining whether there are correlations in freshman engineering classes between social networks, gender, and academic performance.

1.6 General Approach

This research effort involved using a questionnaire to determine the Spring 2006 freshman engineering class's social information networking data. This data will allow the class's social networks to be understood and from this correlations can be made to determine whether social integration plays a significant role in the overall class's success. The research questions that will be addressed are:

1. Is there a correlation between the overall density of the class's social network and the class's overall academic performance?
2. Is there a significant relationship between the density of gender-to-gender social interactions and the class's overall academic performance?
3. Is there a relationship between the density of gender-to-gender social interactions and each gender's academic performance?

1.7 Organization of Thesis

This thesis is composed of five chapters including this introductory chapter, introducing the importance of understanding what affects a college student's academic

performance. Chapter 2, “Literature Review,” provides a review of previous studies on understanding what can aid in students academic achievement, factors that lead to retention, and what factors enhance student’s perception of their class and school. Chapter 3, “Methodology,” describes the method used to administer a questionnaire, collect data, and perform social network and statistical analyses. Chapter 4, “Results,” presents the outcome of the analyses and Chapter 5, “Conclusion,” summarizes the conclusions about the research, its implications, and discusses future research for this topic.

CHAPTER 2

Literature Review

As the numbering of entering college freshmen is on the rise, so is the number of engineering students choosing to switch majors or dropout of college entirely. Therefore, there is a need to bring about greater success from engineering students to encourage persistence. In order to know how to increase student's success, there needs to be knowledge on the major factors influencing engineering students. As academic success is the number one attribute in student's persistence, it is important to know what factors influence student's academic performance.

2.1 Retention of Engineering Students

As students enter the college of engineering they have proven themselves, through their high school academic performance, standardized testing scores, and extracurricular activities, to be potentially capable of attending their college and graduating. Although getting accepted can be tough, it is only the first part of the process. The next step is for the students to succeed in their chosen majors in order to complete the goal of graduating. Unfortunately, the college dropout rate in the U.S. is quite high at fifty-four percent, especially that of engineering majors at forty percent (AP, 2005). This leaves questions as to what factors are contributing to the high rate of engineering dropouts and defectors. Past research shows that several important individual characteristics that contribute to dropout are: family background, faculty involvement, characteristics of the individual himself, pre-college educational experience, and personal expectations and goals (Tinto, 1975).

Research shows that the student's family background, the socioeconomic status, is inversely related to dropout. Meaning, students from families with lower socioeconomic status have higher rates of dropout than students with from higher status families. There are also findings that students who have quality relationships with their parents and whose parents are more educated tend to have higher persistence rates (Tinto, 1975).

Research shows that support from teacher's influences the level of engagement a student has toward his school and this is linked to academic performance (Klem & Connell, 2004; Tinto, 1975 & 1997). Teacher support is perceived as a teacher that is involved and invested in the academic life of their students. For instance, the students that feel their teacher knows and cares about them, wants them to learn and understand the material and it relevance, continues to care that they progress, and provides structure and equality, regarding class expectations and conduct. Therefore, there is engagement with the faculty both inside and outside of the classroom. Regardless of socioeconomic status, if students are engaged in school they are more likely to perform better, earn higher grades and have lower dropout rates. And vice versa, students that have lower levels of engagement are less likely to earn higher grades and are more likely to have negative consequences, such as, low motivation, "disruptive behavior in class, absenteeism, and dropping out of school" (Klem & Connell, 2004, p. 263).

The student's individual characteristics are viewed as even more important to a student's persistence than their family background. Individual characteristics that play a role are measured ability based on pre-college academic performance, personality and attitudes, and the student's gender. Students that showed better academic performance in high school have higher persistence rates, probably due to the fact that their work and success in college will somewhat mimic that of high school because they are adjusted to the requirements of the educational setting (French et al., 2003; Tinto, 1975). Student's personalities and attitudes have been noted to distinguish persisters from dropouts because dropouts tend to be "lacking in any deep emotional commitment to education" (Tinto, 1975, p. 101).

Past educational experiences are also major factors that may contribute to whether a student chooses to continue to remain in college. Students that have stronger educational backgrounds, due to the quality of their high school, its facilities, curriculum, educators, and atmosphere, play an important role in a student's achievement in college.

The student's goal commitment is often paramount in his success and persistence in college. If a student is motivated and committed to completing college in his selected major, most likely, despite hardships, an individual will continue on their path and

graduate. And vice versa, if a student enters without much drive or commitment, the rigors of college life will most likely cause withdrawal or academic dismissal (French et al., 2003; Tinto, 1975).

However, pre-college factors and individual characteristics are not the only contributing factors to a student's success and persistence in engineering. Other factors associated with persistence are college academic performance, gender, and social integration (French et al., 2003 & 2005; Tinto, 1975 & 1997). These factors will be discussed in more detail in the following sections.

2.2 Academic Performance

As suggested earlier, many students that enter the field of engineering are accepted because they have proven through their performance in high school that they have the intellect and fundamental background to enter as an engineering student. However, during their freshman year many feel overwhelmed with the amount and difficulty of the work and are either forced out for academic reasons or choose not to continue in engineering due to the stress.

One of the single major predictors of persistence within engineering is academic achievement (French et al., 2005). Academic achievement is associated with a couple of main factors, acquisition of knowledge, intellectual development, and development of skills. In general, most students with poor academic competence either voluntarily leave engineering or leave because of academic dismissal. When studying how to retain engineering students, this raises the question of what factors influence academic success. For, if academic success can be achieved, the number of students defecting or being dismissed from the engineering program would decrease.

There is a consensus in literature of the conditions that lead to the most student success, they include: "high standards for academic learning and conduct, meaningful and engaging pedagogy and curriculum, professional learning communities among staff, and personalized learning environments" (Klem & Connell, 2004, p. 262). Setting high standards for academic quality and academic performance aids the student in several ways; they are challenged by the curriculum in order to help fully develop their academic

skills and critical thinking skills, as well as worldly survival skills. Expecting high quality teachers is obviously necessary for the success of the students in order to provide the students with appropriate guidance. The concept of teachers networking together is also essential in order to share ideas and experiences to make sure they are utilizing the best methods to educate the students. While there is much emphasis placed on the quality of the faculty and faculty interactions, studies are also showing a relationship between a student's social integration with peers and academic success.

2.3 The Role of Gender in Engineering

There has also been a significant correlation between gender and college dropout rates. There are a higher percentage of female dropouts than male dropouts, however, a greater proportion of the women tend to be leave by choice whereas a greater portion of the men leave on academic dismissal (Bottomley, Rajala, & Porter, 1999; Felder, et al., 1995; Lee, 2002; Tinto, 1975). The loss of qualified females results in a loss of talented students (Lee, 2002).

Up until the 1970s there was a small percent of women enrolled in engineering. Most women were either not interested, or did not think that they should be or would be allowed to be engineering, as it was viewed as a man's world. In the 1980s, however, the percent of women entering engineering began to rise. Even though there has been an increase of women in engineering, the number of females in engineering is still not staggering. In fact, although women make up roughly 50 percent of the population (Felder, et al., 1995), schools do not come close to 50 percent female enrollment in engineering. There is a significant gender gap; "fewer than 20 % of engineering graduates are women" (Wadhwa, 2006).

There is a bias that men are more inclined to be engineers due to the intense math and science required and the industrial job setting. In the 1970s and 1980s books were published suggesting "that males are innately superior in certain mathematical reasoning and visual-spatial abilities," however, further analysis lends little credibility to this conclusion and shows that this may be due to a multitude of other factors (Felder, et al., 1995).

Due to the low number of graduating female engineers, Felder et al. (1995) performed an analysis studying academic performance and attitudes of males and females in engineering. The study followed men and women in chemical engineering for five semesters. After assessing the students attitude and academic performance prior to beginning their courses and at the end of five semesters, the females, on average, entered engineering with credentials equal to or higher than that of the males, but "exhibited erosion relative to the men in both academic performance and confidence" by the end of the five semesters (Felder et al., 1995).

The females who participated in Felder's et al. (1995) study began their first engineering course with greater anxiety and lower confidence than the men, even though their pre-college performance was equal to or better than the males. The females also began their first course with higher expectations of themselves and had better study skills. But by the midpoint of their first chemical engineering course, their views changed and they were less motivated; this continued throughout the curriculum. The males', on the other hand, assessment of their abilities increased as they proceeded through their courses.

Based on surveys the students filled out before graduation, more women than men attributed poor performance to lack of ability whereas more men than women attributed it to a lack or hard work or being treated unfairly (Felder et al., 1995). However, when asked about success, more men attributed it to their own ability and more women were associated success with getting help from others. As engineering is geared toward males, there are gender barriers that make "women feel ill at ease, wonder whether they belong, become intimidated, and lose much of their self-confidence" (Lee, 2002).

By the student's sophomore year, the percentage of women who dropped out of engineering for any reason was twice that of the males. By their senior year, the percentages were closer; however, many men that dropped out did not continue their education whereas most women remained in college and switched to a major outside of engineering.

According to Felder et al. (1995) likely causes for women's lower academic performance and lower confidence levels could be due to many factors besides inherent

gender differences. Likely causes may be due to: (1) women not feeling like they belonged in engineering; (2) differences in learning styles between women and the way the teachers teach; (3) discrimination as a minority; (4) women not feeling like they have a voice when working with the men; (5) discounting by males; (6) lack of female role models; and (7) emotional differences between males and females as women tend to place more focus on personal relationships. Other major impediments are isolation and exclusion from networks (Shull & Weiner, 2000).

According to Rayman and Brett (1995), "females often prefer a more interactive environment," including interaction with peers as well as faculty. As engineering colleges tend to be less nurturing this affects the formation of social relationships and as women have a strong need for personal, supportive relationships, girls' future in engineering is vulnerable (Lee, 2002). In a study by Amenkhienan and Kogan (2004) it was found that female students at one University found it beneficial to have connections and interaction with other females whenever possible. This offered social and emotional support, as well as academic support, to the females. In this same respect, single-sex colleges have been recognized as being successful at contributing more to young women's persistence in science than coeducational colleges. This is most likely due to the fact that at an all woman college, the females can interact with each other and feel comfortable approaching and working with each other. In a coeducational college, there are not many other females to seek encouragement from due to a low enrollment of females students and because there are not many female faculty role models.

Due to the relatively small percent of females entering engineering, women tend to feel lonely and isolated. As the "persistence rates for women in science-related fields … are significantly lower than those of their male peers," there is strong evidence that gender plays an important role in academic performance, retention, and graduation from engineering (Bart, 2000). In order to increase student retention, factors that affect male or female success should be addressed.

2.4 Social Integration Between Students

In addition to individual characteristics, pre-college factors, and the role that gender plays on academic performance and retention rates in engineering, studies also show that peer-to-peer interactions play an important role as college dropout rates appear to be related both to academic performance and insufficient integration. Social integration, or social networking, involves peer-to-peer interaction that can occur through study groups, extracurricular activities, and interaction with faculty and administrative personnel. The interaction provides the students with a support group, whether it is academic or just social friendship. Numerous studies have discussed that involvement matters in student's persistence (Amenkhienan & Kogan, 2004; Hosen & Solovey-Hosen, 2003; Lee, 2002; Thomas 2000; Tinto, 1975 & 1997). High levels of involvement have been associated with learning gain, therefore, better academic performance, increased persistence, and more class enjoyment and self-confidence. Low levels of involvement generally result in lower levels of achievement (Lee, 2002).

After decades of research on retention on college campuses, two theoretical perspective models have emerged. The first is Bean's Student Attrition Model, "which emphasizes the role that external forces play in the persistence process," and the second is Tinto's Student Integration Model (SIM), which "places a greater emphasis on the role of within institution peer cultures" (Thomas, 2000, p. 591). Both models are similar in that they both predict that peers' attitudes and pressure affect student's commitment to the institution. Essentially, both models suggest that with a higher level of social integration there is more encouragement from peers and there will be a greater sense of commitment to the institution and persistence.

Academic integration involves students who interact and share similar educational experiences, for instance, they are in the same class, in the same major, have taken similar courses, and so on. Academically integrated students are able to form a support group. They are able to understand the struggles of a rigorous college program, give each other guidance, work together toward a common goal, and share learning experiences. While working together they are able to help each other; students who do not understand are able to get further clarification and those students who do understand are learning

more because they are learning and retaining information as they teach. In an article by Tinto (1997, p. 611) a student stated,

> You know, the more I talk to other people about out class stuff, the homework, the tests, the more I'm actually learning, … and the more I learn not only about other people but also about the subject, because my brain is getting more, because I'm getting more involved with the students. I'm getting more involved with the class even after class.

In *An Engineering Student Survival Guide*, Felder (1993) discusses ways for students to survive and improve in the engineering curriculum. Several of his recommendations include working together with others or consulting experts. Therefore, he encourages students to network with one another for several reasons: (1) when working in groups students are less likely to just give up; (2) different people may introduce alternative ways to solve a problem; and (3) students learn more by teaching.

Due to the realization that peer-to-peer networking is essential to students' success many programs have integrated collaborative learning into their courses. Collaborative learning involves more interaction from the students, putting students into teams to work on class assignments. This promotes networking skills, team-working skills, and actively engages the students in the course material. By making the class more interactive and student driven this would also encourage the development of social capital. Hosen and Solovey-Hosen (2003) describe social capital as consisting of "social networks, habits of cooperation and bonds of reciprocity that serve to generate benefits for members of a community" in that they promote trust and cooperation (p. 84). By working in collaborative environments, students build social capital rather than staying isolated and have more meaningful learning experiences than working in the traditional individual manner. "College students learning cooperatively perceive greater social support (both academically and personally) from peers and instructors than do students working competitively" (Johnson, Johnson, & Smith, 1998).

Jurkowski, Antrim, and Robins (2005) also support learning as a social activity. They noted that there are many ways to involve and encourage student interaction that will not only help them learn more and gain further understanding of the topic, but they

may also enjoy it more, and employ what they have learned. Jurkowski et al. (2005) encourage that students delve into the complexities of a topic by doing their own researching and exploring and then sharing that knowledge with each other. Students that have more social contacts within a course are at an advantage because "students learn best when interacting with others" (Jurkowski et al., 2005, p. 200). Regardless of the type of class, traditional, online, interactive, interaction is important for learning to occur. This could be attributed to several factors such as: (1) students feel more comfortable, less threatened or apprehensive about asking a fellow classmate for guidance; (2) most professors have limited extra class time for office hours to address questions; (3) students tend to prepare more conscientiously when they know that their group or classmates are counting on them.

Many researchers agree on the importance of social integration in college as it can be correlated with commitment to the institution, and persistence (Thomas, 2000). Thomas (2000) found that "students with a greater proportion of ties outside their subgroup perform better academically and are more likely to persist. Second, similar benefits accrue to those students who develop ties with other students who themselves have broader ties" (p. 604). Those students with broader ties are reaching out of their individual subgroup reaching more parts of the overall network.

Such integration should increase the rate of persistence, as "voluntary withdrawal rarely occurs as a result of … excessive social interaction," unless the interaction is negative, i.e. interactions with underachievers, or unproductive, i.e. excessive interaction that detracts from school work, to learning (Tinto, 1975, p. 108). Thomas (2000) warns that too much connectedness can be a bad thing due to an over abundance of relationships. Therefore, as interaction can both detract and assist in college academic performance and persistence, higher social integration within the students in a course may be more attributable to higher academic performance and persistence in engineering than outside social networks.

The concept of interaction and collaboration is not only important for the classroom, but the life of an engineer virtually revolves around working in teams. This brings together many different ideas to lead to the best end result. In fact, many major

achievements in modern society would be impossible without collaborative efforts. As James Watson, a co-discoverer of the DNA double helix, stated, “ ‘Nothing new that is really interesting comes without collaboration’ ” (Johnson et al., 1998).

2.5 Verification of Procedure

As exhibited, some models to determine how to achieve better academic performance and retention and graduation rates involve learning about the student’s social life outside of the classroom and involvement with the school as a whole. There has also been literature discussing the importance of student’s gender and social interaction as key components to affecting the academic success of engineering students and persistence and graduation rates.

Tinto (1975) noted that despite the large volume of research on college dropout rates there have been few studies that allow a good understanding of factors individual affects. This study will only focus on the main factors associated with persistence in order to try to gain a better understanding of the individual affects. Therefore, the affect of gender and social interaction on academic performance will be addressed.

Academic performance has been measured in past studies by student’s class grades and overall grade point average (Johnson et al., 1998; Felder, et al., 1995 & 2002; Tinto, 1975 & 1997). Grades are related to the probability of dropping out (Tinto, 1975), therefore, academic success is considered to be one of the most influential factors on whether students persist in college. As grades tend to be the most visible form of reward in college, the higher a student performs the more committed he is to completion (Johnson et al., 1998). Therefore, in this study the students’ course grades will be used to judge academic performance. A grade of an A, B, or C will be considered academic success and a grade of a D or F will constitute academic failure. However, students’ receiving a grade of an A is most desired. As academic performance is highly attributed to persistence, this study will focus on the factors that may influence academic success and in the long run contribute to increased persistence and graduation rates in engineering.

Felder et al. (1995) studied the academic performance of engineering students based on gender differences. He collected data based on students attitudes of themselves and their education and how on the student's grades to determine how each gender felt throughout their engineering coursework compared to how they performed academically and their graduation rates. This research will also look at the performance of each gender in a class to determine if there are any significant differences between performance levels which may lead to higher retention and graduation rates of one sex.

Felder et al. (1995) also found that both men and women viewed performing group activities very positively. In fact, high percentages preferred to work with a partner because they enjoyed the social interaction and felt they were able to learn more. However, there were differences between the males and females responses to how the group work benefited them. The men felt that they had to explain the material more often in their groups, which benefited them because they were able to learn and study the material as they explained it, while the females felt they were more likely to have the material explained to them and therefore enjoyed the benefits of group work more. Therefore, it is important to understand the affects of the female and male social networks to understand what factors may cause increased academic success and, therefore, retention of each gender.

The importance of social integration at school has been addressed in past literature. It has been reported that a student's individual perception of his social integration and friendship network is the most important decision in dropping out (Tinto, 1975). In fact, Thomas (2000) performed a study on a college freshman class that looked at each individual's closest ties in a social network in order to determine the student's subgroup integration within the whole network of college freshmen. Thomas (2000) concluded that studying students' social networks are an important, although difficult to measure, and overlooked dimension, when determining what conditions promote persistence.

While there is an agreement that student integration and involvement is important, "we have yet to explore the critical linkages between involvement in classrooms, student learning, and persistence" (Tinto, 1997, p. 600). The affects of social integration within

the classroom have "not played a more central role in current theories of student persistence" (Tinto, 1997, p. 599). Understanding the role of student integration within a specific class is important because classmates are the people that can best support, encourage, and help someone in need, especially in engineering classes where the coursework can be rigorous.

Little literature has been published addressing student's academic performance with respect to a student's actual social network within that specific class. However, the necessity is there; "we would be well served by supplementing…path analysis to study the process of persistence with network analysis and or social mapping of student interaction patterns" (Tinto, 1997, p. 619).

In this research, social network analysis is used to map and understand the relationship of students in freshman engineering classes. The social networking data will provide a true description of the student's interactions with other students instead of just a student's perception of integration. Data will also be obtained on gender in order to relate gender interactions within the class to academic performance.

2.6 Social Network Analysis

Social Network Analysis (SNA) has been used since the 1930s in the social and behavioral sciences. The field progressed slowly until about 1990 when interest in SNA began to grow. Some of the major goals of SNA are to "discern fundamental structure(s) of networks in ways that (1) allow us to know the structure of a network and (2) facilitate our understanding of network phenomena" (Carrington, Scott, & Wasserman, 2005). With the increase in interest in SNA research has recognized that it has important applications in organizational behavior, inter-organizational relations, epidemiological studies, the diffusion of information, and criminal organization.

Social networks can be generally defined as a group of inter-connected individuals. As different people make up different networks, the patterns within different networks, such as channels of information exchange, also vary. When beginning to study a particular network, it is important to determine the kind of data that should be gathered. The two most common types of data used in social analysis are attribute and relational.

Attribute data relates to the attitudes, opinions, and behaviors of actors. Relational data are the connections that relate and connect actors to each other. Relational data is the best type of data for SNA whereby the relations displayed by linkages between the agents. Regardless of the type of data used, there is nothing specific about the methods of data collection (Scott, 1991).

There are several methods of collecting data. The method that collects the most information and will be used in this study is the full network method that requires collecting information about each actor's ties with all other ties in the network (Hanneman & Riddle, 2005, Ch. 1). For example, all of the people in a class would report on all of their friendships within the class. This method provides a complete picture of the relationships within a population and is more advantageous to have when studying a network.

Sources of data can come from questionnaires, interviews, observations, and texts (documentary). When studying friendships, the most common method of obtaining data is using questionnaires. In the questionnaire participants are asked to identify their friends. While a participant could list all of the people they are friends with, an alternative approach is giving each participant a chance to see a roster of everyone within the network. This is generally more accurate because a participant may not remember to list all of their friends; however, offering an entire list allows them to remember everyone within the network being studied. Observations may be performed when trying to track who meets with whom, such as in a criminal network. And texts may be used when trying to determine relationships from past events.

The density of a network describes the general level of linkage among actors. In a network in which all actors are connected to each other the network is complete. However, such completion is very rare, even in smaller networks. "The concept of density is an attempt to summarize the overall distribution of lines in order to measure how far from this state of completion" the network is (Scott, 1991, p. 73). An isolate, or isolated point, in a network is one that has no connections to any other actor. Because density measures the completeness of the network, the more isolates present within a network the less dense the network because it is not offering any ties. While every

network is made up of different actors, situations, relationships, etc., in a study focusing on similar attributes and sizes, density can "play a powerful role in the comparative study of social networks" (Scott, 1991, p. 79). A network with many ties versus a network with fewer ties indicates that the social interaction between the individuals is very different. There is less communication between the actors, therefore, less sharing of diverse information.

Social Network Analysis uses two kinds of tools (based on mathematics) to represent the network compactly and systematically and to determine information about patterns and ties among social networks: graphs and matrices.

2.6.1 Social Network Analysis: Graphs

Using Social Network Analysis software, graphical representations of the social relations can be produced. The graphs produced can be helpful for visualizing the networks social structure based on what is to be determined, such as: who is connected to whom, who is in a subgroup, which characters have many or few ties, and so on. The graphical displays consist of nodes, each of which represents a set of actors or objects, connected by lines or arrows, representing ties between the objects.

An example of such a graph is shown in Figure 1. The network represents the social connections of a fictional set of students in a class. The nodes represent the individual actors and the arrows represent friendship ties recognized between the actors.

The graphical representation in Figure 1 represents binary data. A tie, or a connecting line with arrows, represents a yes or no type relationship (represented by zeros and ones in a matrix). For example, in asking, "do you consider this person a friend," or if graphing whether there is any interaction between actors in a network, the choice is binary: each person considers or doesn't consider the other a friend or there is or is not any interaction between two nodes.

The direction of the arrow indicates who is directing a tie at whom. For instance, in Figure 1 there is a single-headed arrow (blue) from Ali to Kim; however, there is not an arrowhead pointing from Kim to Ali. The translation is: Ali is reporting a friendship with Kim; however, Kim is not reporting a friendship with Ali (non-reciprocated tie). A

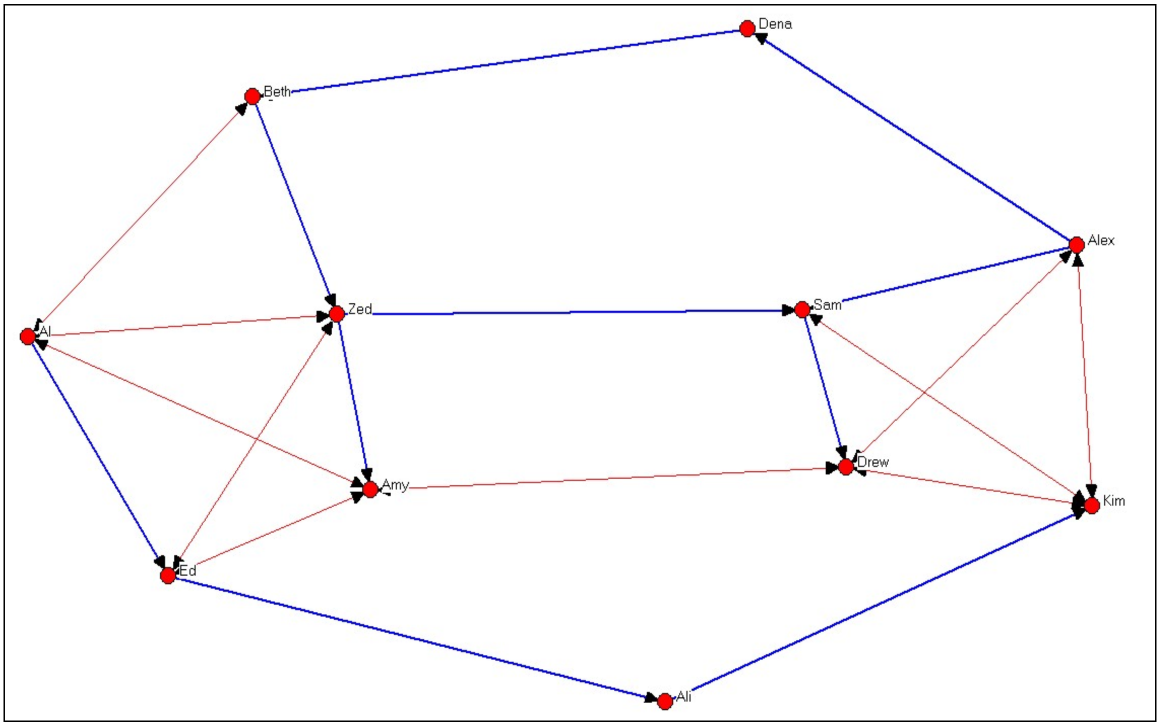

Figure 1. Fictional directed network displaying class friendships using NetDraw.

double-headed arrow (red) represents a reciprocated tie between two nodes. In Figure 1 the double-headed arrow between Alex and Kim means that both Alex and Kim report a friendship with each other.

Graphs can represent either directed or undirected networks based on the ties represented within the network. A graph is directed, as in Figure 1, when not all ties between two nodes are reciprocated. A graph is undirected when all nodes are reciprocated.

2.6.2 Social Network Analysis: Matrices

SNA utilizes network information mathematically to determine information about the network. While the graphs are a convenient way to view the network, as the size of a network increases, the difficulty of analyzing its graph intensifies. Therefore, SNA utilizes the network information represented in matrix format, and applies mathematical

and computer tools to summarize and identify patterns and knowledge that is otherwise difficult or impossible to see by merely looking at a graph.

"A social network is a set of n actors and a collection of r social relationships that specify how these actors are related to one another" (Carrington, et al., 2005, p. 148). In a network based on a single relationship, such as reporting interaction with someone else in the network, and assuming that the relational ties take on just two values, such as binary, $r = 1$. The set of actors in the network is denoted $\mathcal{N} = \{1, 2, \ldots, n\}$, and $\mathcal{X}$ denotes the particular relation between the actors. Therefore, "$\mathcal{X}$ is a set of ordered pairs recording the presence or absence of relational ties between pairs of actors" (Carrington, et al., 2005, p. 149). The association matrix, X, is square, n x n, and can be represented as:

$$x_{ij} = \begin{cases} 1 & \text{if } (i, j) \in x, \\ 0 & \text{otherwise} \end{cases}$$

Where X and its elements are assumed to be interdependent based on the individuality of the social processes that form the social network (Carrington, et al., 2005).

As the association matrix is square, the rows, i, represent the actors in the network being studied; and the columns, j, represent the same set of actors as in Table 1. The cells represent information about the ties between two actors. An association, such as friendship, phone calls, meetings, and so on, between two actors is most easily represented as binary data where ones and zeros represent that presence or absence of a tie. If an association is present, a one is entered into the cell; if there is no association, a zero is entered into the cell. Self-ties, such as when $i = j$, are ignored because that would report that a person recognizes a relationship with themselves. Therefore, zeros are entered along the main diagonal, for example, into $X_{1,1,} X_{2,2,\ldots,} X_{n,n}$. Every row vector describes whether actor i reports a tie with actor(s) j. Every column vector describes who reports a tie with actor j.

An association matrix can either be classified as undirected or directed. An undirected matrix, also known as symmetric, represents ties that are always reciprocated between two actors in a network. For example, if the matrix was representing meetings between two people, then if actor A meets with actor B, person B meets automatically

Table 1. Matrix of the fictional directed network displaying class friendships. (Graph displayed in Figure 1).

Actors	Al	Alex	Ali	Amy	Beth	Dena	Drew	Ed	Kim	Sam	Zed
Al	0	0	0	1	1	0	0	1	0	0	1
Alex	0	0	0	0	0	1	1	0	1	1	0
Ali	0	0	0	0	0	0	0	0	1	0	0
Amy	1	0	0	0	0	0	1	1	0	0	0
Beth	1	0	0	0	0	0	0	0	0	0	1
Dena	0	0	0	0	1	0	0	0	0	0	0
Drew	0	1	0	1	0	0	0	0	1	0	0
Ed	0	0	1	1	0	0	0	0	0	0	1
Kim	0	1	0	0	0	0	1	0	0	1	0
Sam	0	0	0	0	0	0	1	0	1	0	0
Zed	1	0	0	1	0	0	0	1	0	1	0

with person A. Therefore, each entry in the $X_{i,j}$ cell would be the same as the entry in the $X_{j,i}$ cell.

A directed matrix, or an asymmetric matrix, represents ties that may or may not be reciprocated between two actors as in Table 1. The rows represent the source of directed ties and the columns are the targets of those directed ties. For example, if a set of actors is asked to identify the relationship between other actors in the network actor A may consider actor B a friend; however, actor B may not consider actor A a friend. Therefore, as is represented in Table 1, each entry in the $X_{i,j}$ cell is not necessarily the same as the entry in the $X_{j,i}$ cell.

2.7 Summary

The review of literature pertinent to college courses, and specifically engineering courses, demonstrates that academic performance is an important predictor in persistence and graduation. The question is, to what degree do certain factors affect academic performance? Academic performance influencing factors chosen for this study are gender and social interactions within the class.

The next chapter presents a description of the methods used to obtain and analyze the data, followed by a description of the findings, and a discussion along with future recommendations.

CHAPTER 3

Methodology

3.1 Introduction

Social Network Analysis (SNA) is the primary tool used in this research. The methodology included:

a) Collecting data from college classes at The University of Tennessee, Knoxville.
b) Performing an analysis on the social networks.
c) Correlating the data

3.2 Research Design

The study was designed to correlate and discover any relationships between the densities of freshman engineering class interactions with measurable attributes of the student and their academic experience in the class.

1. There will be positive correlations between the median of a class and its overall social density. Therefore, as the social interaction within the class increases the academic performance of the class overall will increase.
2. An increase in all gender-to-gender interactions will result in a positive correlation with the class's overall academic success. Therefore, the amount of A's will increase with an increase in social interactions.
3. While the density of gender-to-gender relationships will show a positive correlation with each gender's receiving an A, the females will be most affected by interactions with either sex whereas the males will be most affected by interactions with other males. As females' interactions with males and other females increase, there will be a positive correlation with receiving an A. And as males' interactions with males increase there will be a positive correlation with A's.

Data for the class's social network density will come from a questionnaire administered to the students to discover and understand the class's information sharing

network. Academic performance will be measured by looking at the final class grade performance. Academic success includes an A, B, or C and academic failure will include a D or F. The data will then be statistically analyzed by correlation analysis and multiple regression analysis to determine the relationships, if any.

3.2.1 Variables

For this study, the variables are: the overall density of a class's social network; the degree of interactions between each gender in each class; percent of students passing with an A, B, or C; percent of students failing with a D or F; percent of males and females passing with an A, B, or C; percent of males and females failing with a D or F; and the median grade of each class.

3.2.2 Assumptions

Assumptions that underlie the study are:

1. Respondents to the questionnaire and class evaluation provided accurate and honest information.
2. The questionnaire developed for the study adequately captures the connection and social interactions within the class.
3. The connections students recognize are positive influences.
4. Students who did not participate do not heavily influence other students.
5. As social networks may change, because the questionnaire to undercover each class's social network was distributed toward the last half of the semester, the social networks did not change throughout the end of the semester.
6. The variables selected for correlation reflect important aspects to the learning experience.
7. The students will all be enrolled in the same class; therefore, all classes will be learning the same information (no difference in content or difficulty), in the same type of class setting, and class teaching style.
8. The teaching instructors will offer the students the same opportunities. The students will be taught and assigned the same material, they will have similar

access to outside help and resources, and they will be given the same opportunities to participate in class surveys.

3.2.3 Constraints

The research design imposed delimitations that defined the parameters of the current study. The constraints enforced throughout this study were:

1. Only classes that had several sections taught using the same curriculum and format were studied in order to limit variability between classes that are more difficult, exciting, have teachers with different grading scales, and so forth.
2. Only classes whose instructors would allow the interruption for the survey and would be willing to provide the necessary data at the end of the semester were studied.
3. Classes had to have at least 20 students enrolled. A larger class enrollment is necessary in case students do not show up for class on the day the initial survey is given, or, because the study is voluntary, many students choose not to participate which may leave a large gap in the social connectivity.
4. Only classes that were taught on UT's campus that offered face-to-face interaction with the students and the instructor were considered for this study. No classes that incorporated any on-line or distance education components were studied.
5. Students had to attend class on the day the questionnaire was administered in class in order to participate.

3.2.4 Limitations

The current research was subject to seven limitations. These limitations were circumstances that might adversely influence the results or generalizability of the research.

1. Not all classes had many students willing to participate.
2. Not all course instructors would allow their class time to be interrupted in order to administer the questionnaire.

3. Few classes had several sections that are taught with the same exact information and format.
4. Amount of data that could be collected and methods of collection from the students was limited due to Internal Review Board regulations.
5. All surveys were subject to the interpretation of the respondent.
6. The population of the survey consisted of a course in the Engage Engineering Fundamentals classes at the University. It was the only course that fit the above constraints.

3.3 Selection of Sample Population

When studying a social network it is rare to draw on samples. Most often, a population so be studied is identified and a census is conducted on the entire network. The census may be a survey, observation, or documentary. For example, an analyst may study all of the people in an organization or all of the people in a neighborhood.

Studying an entire network means focusing on the relationships among all of its actors, therefore actors cannot be sampled independently. If one actor is studied then the ties of the original actor must be included as well. Therefore, network studies tend to study whole populations rather than just samples of populations.

The populations do have boundaries, however. In the case of a class analysis, being in the class imposes the network boundary. Other examples of similar networks with imposed boundaries are neighborhoods, companies, and clubs. These networks are naturally occurring and have natural boundaries. By studying several populations comparisons can be made (Hanneman & Riddle, 2005, Ch. 1).

3.3.1 Population

The population for this study consisted of students enrolled in the same computer Freshman Engineering College courses offered at The University of Tennessee, Knoxville in the Spring of 2006. The Office of Research Internal Review Board approved the project methodology and participants used. The classes were chosen based on the style of the course and class size. All classes met regularly and students had face-

to-face contact with the teacher (or teaching assistant) and classmates; therefore, no internet-based, distance education, or independent study courses were selected. Each class chosen had at least twenty students enrolled. As participation in the survey was completely voluntary, choosing to survey classes with at least twenty students helped guarantee that enough students would be willing to participate in the survey. Also, due to the nature of most college classes, there is no guarantee that the entire class will attend the day the survey is distributed. While several classes throughout different engineering classes offered at UT were examined, there were few engineering classes that offered several different sections of the same course and of those it was impossible to gather all of the necessary data from several classes. The only complete data came from one of the Freshman Engineering courses; therefore, only that courses sections could be examined.

3.3.2 Freshman Engineering Courses

Five different sections of the same computer Freshman Engineering class were surveyed. Although this class was held in Spring 2006, the course is a co/pre-requisite for other engineering courses. Therefore, although the students may have been at UT for a semester or more, this is the student's first semester actually in the engineering program. Of the five engineering courses that provided complete data, there were 161 students. Of the 161 students, 116 students (72%) chose to participate in the study.

3.4 Instruments Used

The data retrieved for this study was obtained from: (a) an initial social network questionnaire and (b) the professor who compiled and provided the final course grade data. Each of the components is described below.

3.4.1 Class Surveys

An initial survey was administered to determine the extent of each classroom's social information network. Each student participant in the classroom receives an index card with a different assigned number written on it. The students are instructed to write their name on the index card. Then, one by one, each student stands up in the class and

calls out the number written on their index card. As instructed, the other students in the class write down the standing student's number on their own index card if they consider this person to be a friend, or someone that they would have a conversation with and share information with, such as classroom information, within a week's time; this requires a conversation between the two individuals, more than merely saying hello. This interaction could take place either inside or outside of class. Then, the next person in class stands up and calls out their number; and, they continue this process until the whole class has gone.

In order to determine the correlation between academic successes, a median grade of C or higher, and the amount of A's with respect to social interaction, final class grade data was collected from the professor. The Engage Engineering Fundamentals program keeps track of the students grades in order to evaluate the program, therefore, the professor was able to provide the median grade of the students who participated in the class, the percentage of A's, B's, C's, and D's or F's as well as the percentage of A's, B's, C's, and D's or F's for each gender.

3.5 Data Collection

Prior to entering and collecting data from class participants, the researcher complied with the University of Tennessee's Office of Research human subjects requirements and filed Form A, Certification for Exemption from IRB Review for Research Involving Human Subjects. Once approval was received, surveying began on classes in which the professors were willing to allow their classes to take the time to participate.

Prior to administering and beginning the social network survey in each class, the entire class received a written consent form that was also presented to them orally. The consent form stated that participation was voluntary; information retrieved from participants completing the survey would have no negative affects on them; and that participation in the study is completely confidential, no one will have access to their data other than the investigators. At this time, if any students chose not to participate they

were asked to step out into the hall until those students that were willing to participate completed the survey.

Once the semester was over and the final grades were completed for each class; the professor provided the final grade data including the participants of the questionnaire.

3.6 Overview of Class Network Analysis

The data obtained from each class's social networking questionnaire will be used to create a graphical representation of each network and to determine the social interaction densities within each network. This will be performed using social network analysis (SNA) software packages that map and measure the flow of relationships within a network.

3.6.1 Graphical Representation

Once the data from each class's questionnaire is collected it was formatted into a program and a graphical representation was produced using the software tool NetDraw version 4.14. NetDraw produces two-dimensional images of networks. The software allows for a visual analysis of several key attributes of network data such as isolates and actors with relationships to each other. The program also allows different transformations of the graph in order to display different features about the network. For example, NetDraw can produce a circle layout of the network that is commonly used to visualize which nodes are most highly connected due to the density of lines surrounding them (Hanneman & Riddle, 2005, Ch. 4).

3.6.2 Matrix Data

The density of a network is determined by calculating the percent of all possible ties that are actually present in a network. The maximum number of ties which could be present in a directed network is equal to the total number of pairs the network contains, $n(n\text{-}1)$. Therefore, the density of the network is determined by dividing the number of actual ties present (l) by the number of ties that could be present (Equation 1).

$$\textbf{Equation 1.} \quad Density = {}^{l}\!/\!\left(n(n-1)\right)$$

The matrix is then partitioned into groups based on gender. By grouping certain nodes together based on similar characteristics, a partition is created in the matrix. This is called "blocking the matrix" because each partition represents a new block, or a group of similar nodes with differing characteristics to those in the other block(s). This is taken one step further when computing the density of the matrix. Now, a block density matrix can be produced that shows all of the proportion of ties within a block that are present (Hanneman & Riddle, 2005, Ch. 5). This divides the number of ties present within the block by the number of ties possible within the block (ignoring self-ties).

Using the same network as in Table 1, the matrix has been grouped based on gender with all of the males together and all of the females together, therefore, creating two blocks. The matrix in Table 2 represents a block density matrix that shows the density of male-to-male interactions, male to female interactions, female to male interactions, and female-to-female interactions. Therefore, 33% of all possible interactions between the males are present, 26.7% of all possible female interaction with males are present, and so on.

UCINET version 6.0, SNA software, will be utilized to perform the analysis on the matrix in order to determine the density of the connections within each class and the density of connections between each gender.

Table 2. Block density matrix of fictional data set representing the proportion of gender-to-gender interactions.

Gender	Males	Females
Males	0.333	0.333
Females	0.267	0.1

3.7 Overview of Statistical Analysis

In the current study we used Pearson's Product Moment for correlation analysis and Step-wise Regression analysis. Sampling procedures were unnecessary since this research incorporated the entire population of each class surveyed. JMP version 6.0 was used to perform the statistical calculations.

The questions addressed through this research are:

1. Is there a correlation between the overall density of the class's social network and the class's overall academic performance?
2. Is there a significant relationship between the density of gender-to-gender social interactions, male-to-male; male-to-female; female-to-male; and female-to-female, and a class receiving an A.?
3. Is there a relationship between the density of gender-to gender social interactions and each gender's academic performance?

3.7.1 Correlations

This study focused on the correlations between the overall class interaction densities, gender to gender density interactions, overall academic performance, and gender academic performance. The attributes were analyzed using the Pearson Product Moment Correlation. Pearson's correlation reflects the extent to which values of two variables are linearly related to each other. Given two variables and n pairs of data, $(y_1, x_1), (y_2, x_2), \ldots, (y_n, x_n)$, Pearson's correlation, Equation 2, is used to determine the strength of correlation.

Equation 2. $$r = \frac{S_{xy}}{\sqrt{\left(\sum_{i=1}^{n}(x_i - \bar{x})^2\right)\left(\sum_{i=1}^{n}(y_i - \bar{y})^2\right)}} = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$$

Where *r* represents the correlation coefficient and *S* represents the sum of the cross products of the two variables *x* and *y*.

3.7.2 Step-Wise Multiple Regression

Linear regression is a statistical analysis that allows the relationship between two (or more) variables to be expressed algebraically. This allows an equation to be developed that represents the relationships between the dependent and independent variables. This equation will predict the expected change in Y given a change in *x*. Studies with one dependent variables and one independent variable are referred to as a simple linear regression. The dependent variable is the response variable that is related to one independent, or regressor, variable. Equation 3 represents the equation for a simple linear regression.

Equation 3. $Y = \beta_o + \beta_1 x_1 + \in$

In this equation, Y represents the dependent variable, β_0 and β_1 are regression coefficients, *x* is the independent variable and e is the random error term that captures the effect of all omitted variables.

In studies with more than one independent variable, there is a possibility that the variables may be intercorrelated and their interactions may affect the dependent variable. Therefore, multiple regression analysis can be used to analyze separate effects of two or more independent variables on a dependent variable. Using this procedure, an equation is produced based on one dependent variable and n independent variables as shown in Equation 4.

Equation 4. $Y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \in$

In this equation, Y represents the dependent variable, the response variable, and it is related to the *n* independent variables, the regression coefficients.

When accepting a linear regression model several assumptions for the data must be met. If the assumptions are not met the results may not be trustworthy. Those assumptions are normality, linearity, independence, and constant variance. It is assumed in regression analysis that the data is normally distributed because non-normally distributed variables can distort relationships and significance tests. Regression analysis also has an assumption of linearity, meaning there is a straight line relationship between the independent variables and the dependent variable. A goodness of fit test is performed to check that the data is normal.

As the aim is to determine if there is an optimal combination of class density factors that would predict the success of the class, multiple regression analysis will describe a relationship between the variables if one exists.

3.8 Summary

One overlying research question guided this study, are there possible correlations between class social networks, gender interactions, and academic performance?

The data was collected using a social networking questionnaire and from he course instructor. The questionnaire gave the results to determine each class's social interaction and the instructor provided the modified class data, based on student performance. The population consisted of 116 students in the Engage Freshman Engineering Fundamentals Program.

The data's social network information was analyzed using UCINET and graphical displays were produced using NetDraw. JMP was then used for statistical analysis of all of the attributes. The statistical analysis included correlation analysis and multiple regression analysis. The next chapter will display and discuss the results.

CHAPTER 4

Results

The purpose of this research was to investigate the relationship between the make-up of the social interactions as reported by a class and factors of academic success in a Spring 2006 engineering fundamentals course. The responses from 5 classes with a total of 117 participants were analyzed. This chapter will report the results of: (1) the population and questionnaire response rate; (2) the demographic profile of the participants; (3) the social network analysis; (4) the results of each class's academic performance; and (5) the analysis of the research questions.

4.1 Population and Questionnaire Response Rate

As discussed in chapter 3, the participants in this study were taken from an Engage Engineering Fundamentals course at the University of Tennessee. Students who attended class and chose to participate took the social networking questionnaire during their class period. Class 1 had 58.8% participation, class 2 had 67.9% participation, class 3 had 84.8% participation, class 4 had 72.7% participation, and class 5 had 75.8% participation. The overall participation for all five classes was 72%.

4.2 Demographic Profile of Respondents

Of the 116 students that participated in the survey, 17 were females and 99 were males. Therefore, there were significantly more males in the class as the females only represented a total of 17 percent of the population. The percentage of male and female participants in each class is provided in Table 3.

4.3 Social Network Analysis

The questionnaire data was input into matrix format and Social Network Analysis was performed. Graphs were produced in NetDraw for each class to give a visual

Table 3. Percentage of male and female participation.

Class	% Participants Male	% Participants Female
1	80	20
2	94.7	5.3
3	89.3	10.7
4	83.3	16.7
5	80	20

representation of the interactions amongst class members and the matrices were analyzed in UCINET in order to determine the social density of each class.

4.3.1 Graphical Analysis

The questionnaires were used in order to determine the social network of the class. By analyzing the responses, the density of each class's social interactions was determined. Figure 2 through Figure 6 display circular graphical representations of the class's social networks (additional graphical representations are displayed in Appendix A). They are graphs of the ties between each student in each class's social network produced by NetDraw. Using the circular lay-out makes it easier to see which nodes have more connections due to the density of the lines around a node, which nodes create a hole, or a break, in the class connections, and, because the nodes that are placed closer to each other have similar connections, which nodes share similar ties. By comparing the circular graphs it becomes clear which classes have more integration throughout more members of the class.

The red ties represent reciprocal relationships and the blue ties represent one-directional ties. The black nodes represent the females and the red nodes represent the males. Looking at Figure 2, it shows that all but two of the students (nodes 19 and 20) in class 1's network are connected to at least one other student in the network; however, most of the students do not have too many connections to others. Also, several of the students are peripheral, such as nodes 17 and 18, because their only connection is node 15; however, they do not reciprocate the tie with node 15. The connections between the

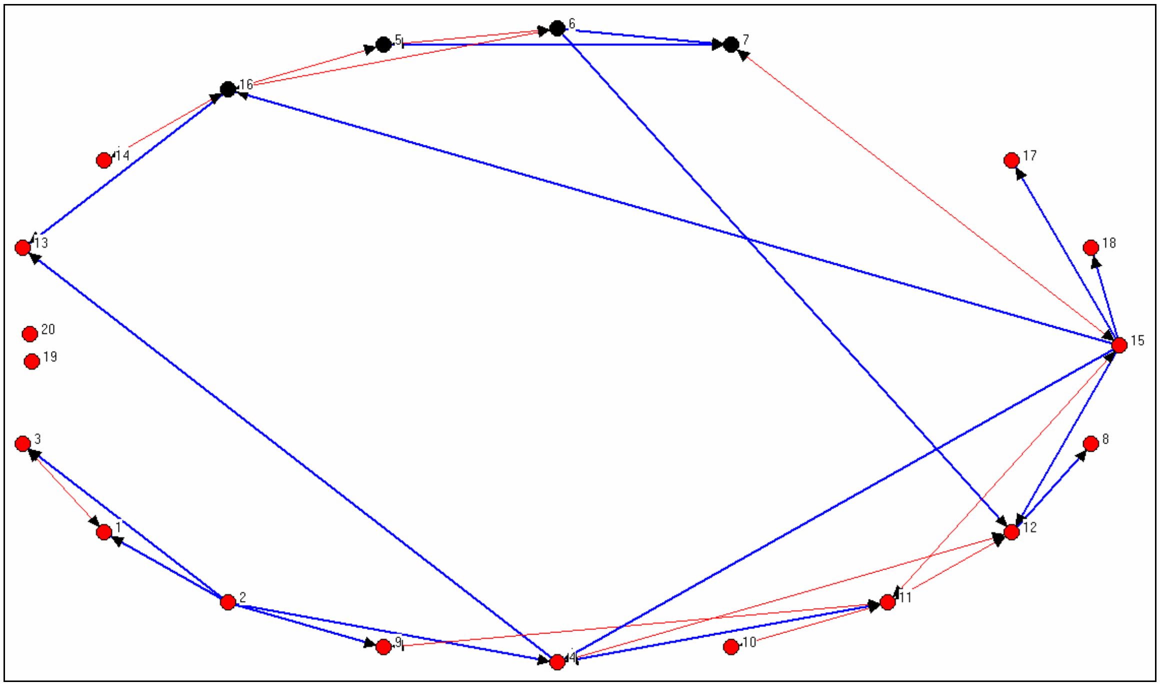

Figure 2. Circular display of class 1's social network.

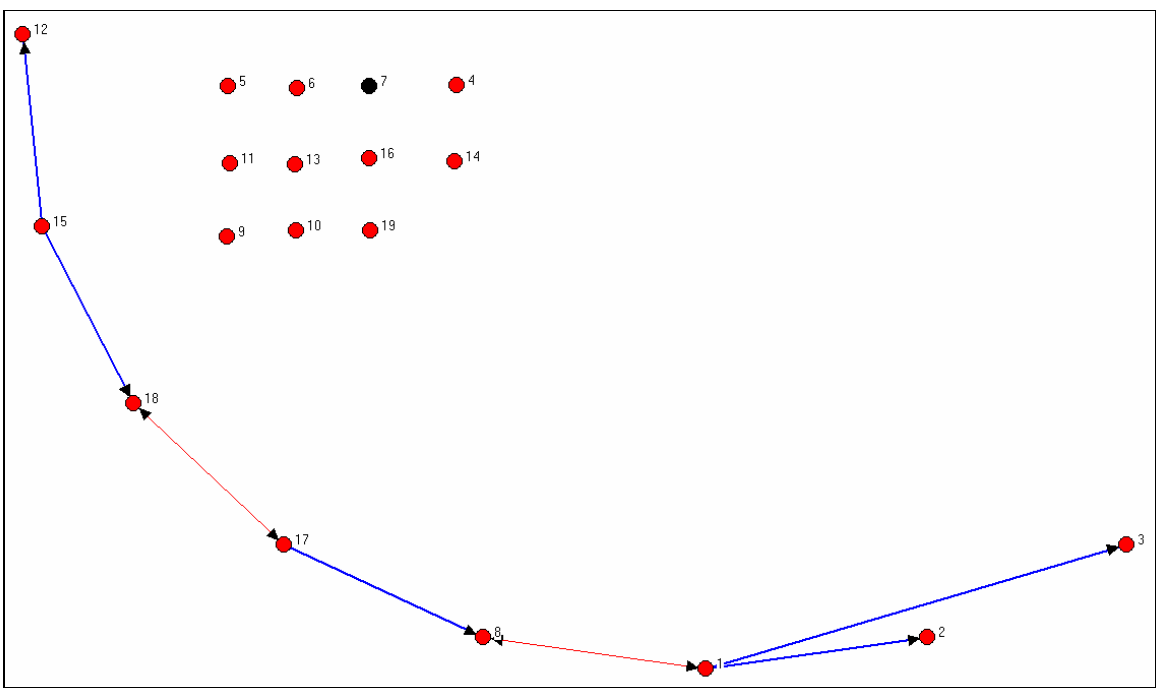

Figure 3. Circular display of class 2's social network.

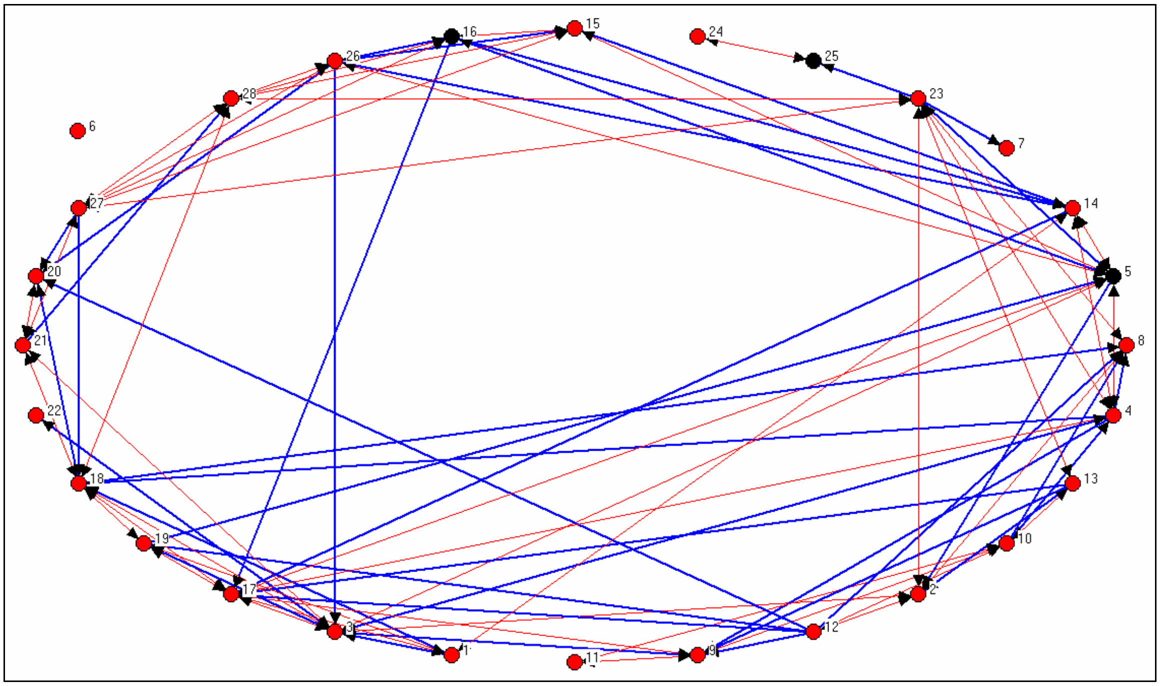

Figure 4. Circular display of class 3's social network.

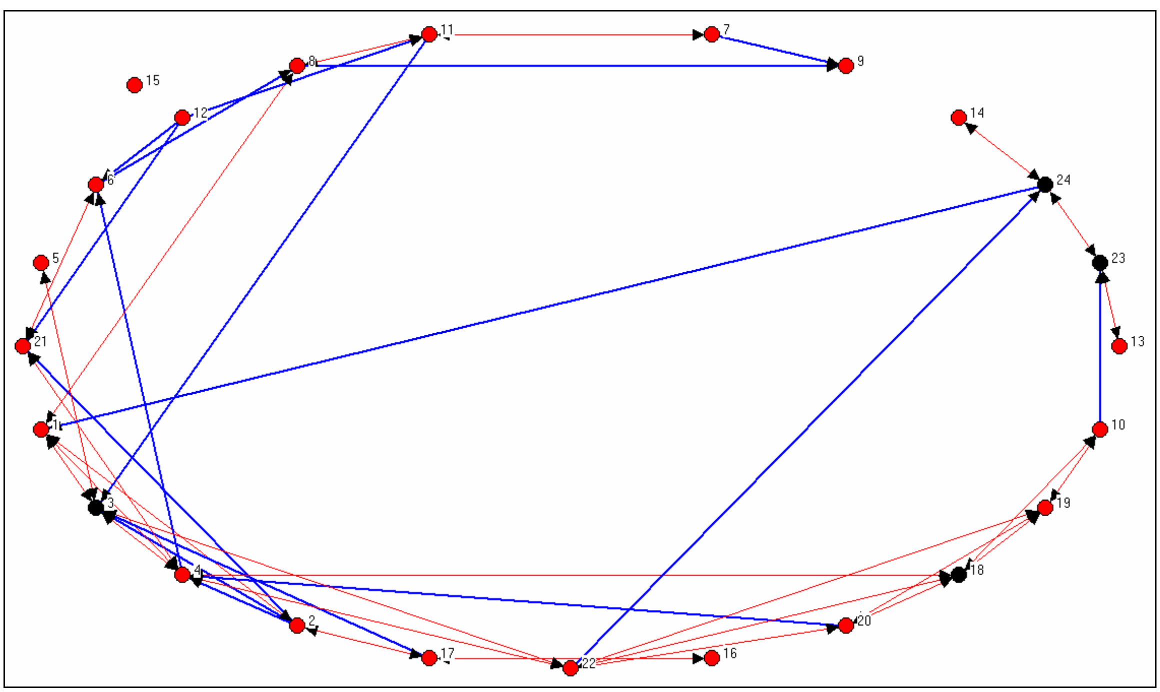

Figure 5. Circular display of class 4's social network.

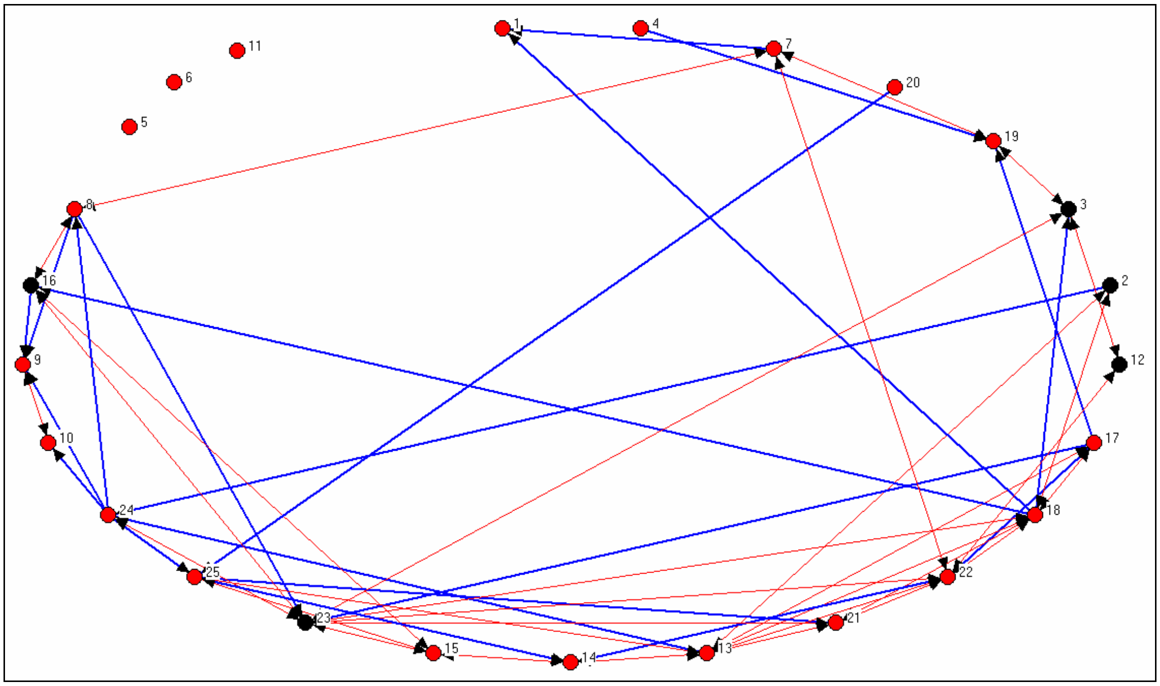

Figure 6. Circular display of class 5's social network.

females seem to show that three of them have some interaction with at least 2 out the 4 females however they do not have too many connections to the males.

Figure 3 shows a very sparse network, as a large number of students in class 2 are not connected to anyone in the class. There are very few students in that class that have any connections and those that do have very few contacts. Figure 4 shows the network for class 3, which, due to the large amount of ties between the nodes, appears to have a much higher number of connections than the other classes, therefore, a higher density of interactions. There is one outlier in this class; however, most of the students have more than just two or three contacts. Figures 5 and 6 display similar data to classes 1 and 3, each have outliers, however, the rest of the network is connected, although there doesn't appear to be quite as much connectivity as that in class 3 as most students do not appear to have more than two or three connections.

4.3.2 Matrix Analysis

As the graphs are helpful tools to initially visualize the networking occurring within the class, it is also evident that as a network gets larger and there are more connections it is harder to have a more detailed understanding of the connections. Therefore, analyzing the data in matrix format allows more specific information to be determined about the networks.

The social network questionnaire data was analyzed in UCINET to determine the social density of the class network overall; then, a block density matrix was formed based on gender and the density of interactions between genders was determined. The results provided in Table 4 show the total density of interactions of all students in the class as well as the density of male interactions with the rest of the class and the female interactions with the rest of the class. Table 5 displays a breakdown of the male and female interactions. The density of each gender's interactions with each gender is displayed.

As predicted from analyzing the graphs, Class 3's overall density is much higher signifying that much more social interaction occurs between those students than in the other four classes and Class 2 has very little social interaction. The other three classes are fairly close in overall density. In Table 4 it is apparent that the females have more interaction than the males do. It also appears in Table 5 that, although there are significantly more males in each of the class's, males do not interact with a high percentage of other males in the class; in fact, in most classes, the males have a higher percent of interaction with the females. The females, on the other hand, appear to have moderate to high interaction between other females in two of the classes; however, in the other two they have almost equal interaction with the males and with the females. This is to be expected as "females … prefer a more interactive environment" (Rayman & Brett, 1995) and because as the 2001 Society of Women Engineers President, Gail Mattson, stated " 'women work well in team environments' " (Cowart, 2001). A higher percentage of female-to-female interaction would be expected based on research that many women feel more comfortable interacting with one another and need to have female role models.

Table 4. Density of interactions within each class.

Class	Total Class Density (%)	Total Male Interactions (%)	Total Female Interactions (%)
1	10	9.1	15.8
2	2.63	2.8	0
3	17.06	16.9	18.5
4	12.32	11.7	15.2
5	13.5	13.1	15.9

Table 5. Total density of each genders interactions with each gender.

Class	Male-to-Male Interaction (%)	Male-to-Female Interaction (%)	Female-to-Male Interaction (%)	Female-to-Female Interaction (%)
1	9.6	4.7	6.3	66.7
2	2.9	0	0	N/A*
3	16.8	17.3	18.7	16.7
4	10	20	15	16.7
5	12.4	15	13	30

*This result is non-applicable because there was only one female in the class.

4.4 Academic Performance

The class professor provided the academic performance data. The data, displayed in Table 6, only included those students who participated in the social networking questionnaire. Academic success is defined by a grade letter of C or higher. With an A being most desired. And failure is defined as a D or F therefore those results could be grouped together. The median grade of each class was used to represent the class's overall academic performance. The percentage of the entire class's grade distribution is shown in Table 6; Table 7 shows the grade distribution based on gender.

The median grade for each class is fairly consistent; however, the grade distributions are not quite as consistent. No females performed poorly, whereas several males did receive failing marks. This is consistent with the notion in literature that social interaction has an influence on grades. The women had overall higher densities of social interaction. This may be attributable to their higher academic success.

4.5 Statistical Analysis

This study proposed three research questions in order to investigate the relationship between social networking in a class and academic performance. While analyzing the five data points, we found that Class 2 might be a potential outlier. A study was run using the raw data with five data points. In order to avoid confusion, actual results of the study have not been inserted, but rather a brief overview of what was inferred is discussed. Performing regression analysis on these data points, there was strong evidence stating that Class 2 is an outlier in terms of Cooks D and Hat diagonals. Hence, this data was removed from the dataset to prevent it from producing unreliable results. It was later discovered that Class 2 was somewhat of a transient class, in that students would attend that section if they could not attend their scheduled class session that week. Due to the fact that there were often students in the class that were not actual students of the class, the dynamic of the class was different than that of the others most likely resulting in the major differences within Class 2. Results of the initial analysis were Class 2 was an outlier and the overall dataset was too small. Section 4.5.1 and further on represent final analysis performed using the four acceptable data points.

Table 6. Each class's grade distributions.

Class	Median Grade	A (%)	B (%)	C (%)	D or F (%)
1	86.56	20.0	70.0	5.0	5.0
2	84.57	21.1	47.4	21.1	10.5
3	86.86	35.7	42.9	17.9	3.6
4	86.72	37.5	33.3	16.7	12.5
5	84.54	28.0	40.0	24.0	8.0

Table 7. Academic performance for each class based on gender.

Class	Gender	A (%)	B (%)	C (%)	D or F (%)
1	Males	18.8	75.0	0.0	6.3
	Females	25.0	50.0	25.0	0.0
2	Males	22.2	44.4	22.2	11.1
	Females	0.0	100.0	0.0	0.0
3	Males	36.0	48.0	12.0	4.0
	Females	33.3	0.0	66.7	0.0
4	Males	40.0	30.0	15.0	15.0
	Females	25.0	50.0	25.0	0.0
5	Males	30.0	35.0	25.0	10.0
	Females	20.0	60.0	20.0	0.0

4.5.1 Research Question One

Is there a correlation between the overall density of the class's social network and the class's overall academic performance? In order to determine whether the overall density of the class's social network has an affect on the class's overall academic performance, Pearson's correlation analysis was performed (Table 8). Pearson's correlation, *r*, measures the strength of the linear relationship between two variables. There are no significant correlations found. Moderate positive correlations were seen with A's (r = 0.6614) and C's (r = 0.6322). This would suggest that as the total interaction within a class increases the percent of A's and percent of C's in the class would both increase.

A single linear regression analysis was performed to determine whether a model could be used to predict the percentage of each grade for a class. The simple regression was run for the factors using an alpha=0.05 significance level (probability of making a Type I error).

After performing the regression analysis, the relationships between overall class density and academic performance were non-significant (Table 9). These results were not consistent with the hypothesis of a relationship between class density and class grades as literature cites that academic performance correlates with frequency of social interactions. However, there are many other factors that could be influencing the students. Also, this may be due to how the grades were distributed to the students. If the students received grades that they truly earned, or whether there was some degree of curving the class's grades.

4.5.2 Research Question Two

Is there a significant relationship between the density of gender-to-gender social interactions, male-to-male; male-to-female; female-to-male; and female-to-female, and the class's overall academic performance? To determine if a correlation exists between the overall grade of the class and the density of gender-to-gender social interactions, Pearson's correlation analysis was performed on the density of male-to-male (MMI),

Table 8. Correlation, *r*, between grades and the overall density of class interaction.

Grade	Density
A	0.6614
B	-0.5572
C	0.6322
D/F	-0.3245
Median	0.444

Table 9. Regression of grade with a regressor of overall density of the class.

Dependent	R^2	$F_{1,2}$	p
A	0.437	1.555	0.339
B	0.310	0.900	0.443
C	0.400	1.332	0.368
D/F	0.105	0.236	0.676
Median	0.002	0.004	0.956

male-to-female (MFI), female-to-male (FMI), and female-to-female (FFI) interactions and the percentage of A's, B's, C's, and D's and F's in the class. The correlation matrix in Table 10 shows the correlation between the density of gender to gender interactions, and the percentage of A's, B's, C's, and D's and F's, and median in the class. The data shows strong correlations between most of the independent X variables of density; therefore, a reliable regression equation cannot be predicted. In order to account for the correlation between the independent variables, a step-wise linear regression was performed to remove the redundancy in the data.

The correlation matrix of just the overall class grades and the gender-to-gender social interaction densities within the class has been extracted from Table 10 and is displayed in Table 11. The correlation shows a strong positive correlation with MFI (r = 0.9619) and FMI (r = 0.9140) and strong negative correlation with FFI (r = -0.9611). Indicating that if the male to female, or female to male interactions increase there should be an increase in the number of A's. However, if the number of female interactions increases the number of A's will decrease.

There is a strong negative correlation between the percent of B's and MFI (r = -0.9765), FMI (r = -0.8117), and a strong positive correlation between FFI (r = 0.9458).

There are moderate to strong positive correlations between the percent of C's and density of the class overall (r = 0.6322), MFI (r = 0.7590), FMI (r = 0.6496) and a moderate negative correlation with FFI (r = -0.7770). Social interactions will have no effect on the amount of D's or F's.

Beyond the correlation analyses, the research included a step-wise multiple regression analysis to see if the grades could be viewed as an outcome based on the different gender-to gender density relationships. Due to the high correlation between the independent variables, a step-wise regression analysis was performed on the data so the redundancy between the independent variables would not interfere with the regression model. Both the probability to enter and the probability to leave were set at 0.05 and the direction was mixed. The step-wise regression was run for all the factors using an alpha=0.05 significance level (probability of making a Type I error).

Table 10. Correlation values, *r*, of densities and class grades.

	MMI	MFI	FMI	FFI	A	B	C	D/F	Median
MMI	1	0.397	0.761	-0.543	0.445	-0.312	0.475	-0.572	0.057
MFI	0.397	1	0.89	-0.986	0.962	-0.977	0.759	0.52	0.013
FMI	0.761	0.89	1	-0.952	0.914	-0.812	0.695	0.077	0.14
FFI	-0.543	-0.986	-0.952	1	-0.961	0.949	-0.777	-0.373	-0.026
A	0.445	0.962	0.914	-0.961	1	-0.881	0.578	0.418	0.28
B	-0.312	-0.977	-0.812	0.949	-0.881	1	-0.85	-0.598	0.191
C	0.475	0.759	0.695	-0.777	0.578	-0.85	1	0.293	-0.602
D/F	-0.572	0.52	0.077	-0.373	0.418	-0.598	0.293	1	-0.135
Median	0.057	0.013	0.14	-0.026	0.28	0.191	-0.602	-0.135	1

Table 11. Pearson's correlation data, *r*, on the percent of each grade and the median grade and the interaction between the students (extracted from Table 10).

Grades	MMI	MFI	FMI	FFI
A	0.4446	0.9619*	0.9140*	-0.9611*
B	-0.3118	-0.9765*	-0.8117*	0.9485*
C	0.4749	0.7590*	0.6946*	-0.7770*
D/F	-0.5720	0.5204	0.0772	-0.3730
Median	0.0565	0.0126	0.14	-0.0261

*Stronger linear correlations.

The models for the percent of A's ad B's were found to be acceptable (Table 12). The relationship between the percent of A's in class and the density of male-to-female interactions was statistically significant (R^2 = 0.925, *p* = .038). Therefore, the amount of male-to-female interactions has the most affect on the outcome of class grades. The B's were negatively related to the percent of B's in a class (R^2 = 0.953, *p* = .024). This supports that as male-to-female interactions increase the number of A's will increase and therefore the percent of B's will decrease. No other class performance values showed significant relationships (Appendix B).

To verify that the regression assumptions are met, a goodness of fit test was performed on the residuals. The residual plot for percent A with respect to MFI is shown in Figure 7a and the goodness of fit showed that it is a normal distribution (W = 0.847, p-value = 0.2169). The residual plot for a B with respect to MFI is shown in Figure 7b and the goodness of fit showed that it is a normal distribution (W = 0.933, p-value = 0.6111). Therefore, independence, constant variance, and normality are met and the models hold. A model for the percent of A's (Equation 5) and the percent of B's (Equation 6) in a class can be written as:

Equation 5. $Y_A = 13.88 + 1.152 * MFI$

Equation 6. $Y_B = 80.14 - 2.357 * MFI$

This follows the literature in that an increase in social interaction, assuming it is positive, will increase the academic performance of the students. The data shows that the A's will increase and, therefore, the B's will decrease, as student interactions rise. As Thomas (2000) suggests, students that have more interaction with others have the opportunity to be influenced by other individuals. If a student has a small peer group, they are reliant on each other for academic support; therefore, if one of them doesn't understand something, they may not have anywhere else to turn. However, students that have larger social networks will have more success when trying working together to understand something, as more students will be able to provide input. Lack of social networking "may result in lower levels of ... academic adjustment as well as lower academic performance and a lesser likelihood of persisting" (Thomas, 2000, p. 603).

Table 12. Step-wise regression analysis of the overall class grade with respect to gender-to-gender interactions. The regressions that showed a significant relationship are displayed.

Dependent Variable	Independent Variables	R^2	$F_{1,2}$	p
A	MFI	0.925	24.732	0.038
B	MFI	0.953	40.986	0.024

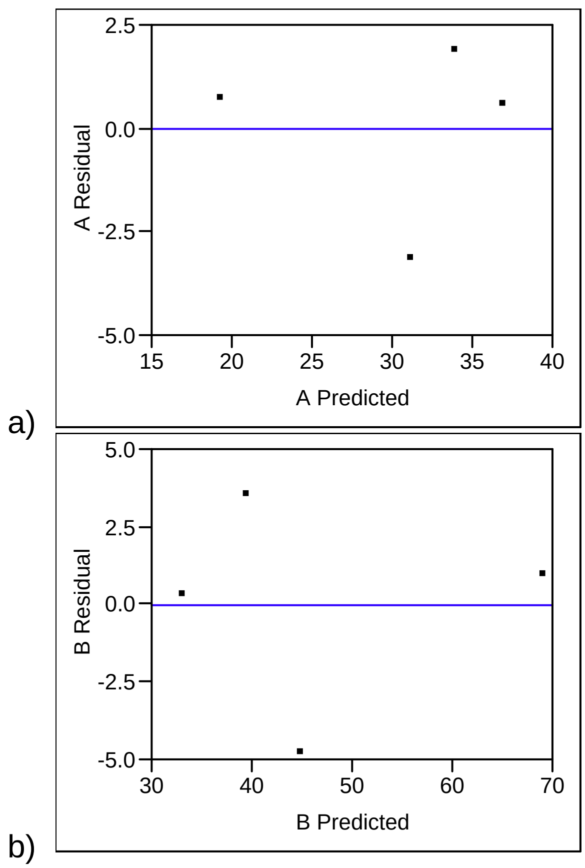

Figure 7. Residual versus predicted plots for the grades A (a) and B (b).

4.5.3 Research Question Three

Is there a relationship between the density of gender-to gender social interactions and each gender's academic performance? Do the percent of grades received by each gender change due to the type of gender-to-gender interactions? Pearson's correlation analysis was performed to see if there were any correlations between the type and density of interactions and the percent of grades based on gender. Pearson's correlation analysis was performed on the density of male-to-male (MMI), male-to-female (MFI), and the percentage of males A's, B's, C's, and D and F's and the density of female-to-male (FMI), and female-to-female (FFI) interactions on the percentage of females A's, B's, C's, and D's and F's.

The correlation of the density of female's interactions with the percent of female's grades is shown in Table 13. From this table it can be seen that there is a negative moderate correlation between the percent of females receiving a B and FMI (r = -0.6509). There is a positive moderate relationship between females receiving a C and FMI (R = 0.6716). Although, this was not predicted, it does seem to make sense as the males grades overall are somewhat lower. Therefore, if a female does interact with a poor performing male it could affect the female and bring down her grade. And there is no relationship either way for females not achieving academic success, a grade of a D or F as no females received theses grades.

The males show a strong correlation for between receiving an A and MFI (r = 0.9869) and a C (r = 0.7844) and there is a strong negative relationship between the percent of males receiving a B and MFI (r = -0.9181) (Table 14). Although this was not predicted, it does make sense given that the percent of female's grades are better overall than the males therefore, if the males that received lower grades interacted with more females their grades could increase. There is a moderate negative correlation between males receiving D's and F's and MMI (r = -0.6084), therefore, if more males interact grades will improve overall.

To see if any variables are intercorrelated and if a model can be predicted to determine the percentage of grades of each gender regression analysis was performed. Once again, there is a strong correlation between the independent factors of gender-to-

Table 13. Correlation between the female independent and dependent factors.

Grades	FMI	FFI
FA	0.5405	-0.3038
FB	-0.6509*	0.399
FC	0.6716*	-0.4186
FD/F**	0	0

*A moderate to strong relationship.
** No females received any D's or F's.

Table 14. Correlation between the independent and male dependent factors.

Grades	MMI	MFI
MA	0.3791	0.9869*
MB	-0.1661	-0.9181*
MC	0.2869	0.7844*
MD/F	-0.6084*	0.4753

*A moderate to strong relationship.

gender density; therefore, a step-wise regression analysis will be performed when computing the regression equation. Using the same settings as before, both the probability to enter and the probability to leave were set at 0.05 and the direction was mixed. The step-wise regression was run for all the factors using an alpha=0.05 significance level (probability of making a Type I error).

The only acceptable model was found between the percent of male A's and the male-to-female interaction (R^2=0.974, $F_{1,2}$ = 74.795, *p*=0.0131), the regression equation is shown in Equation 7.

Equation 7. $Y_{MA} = 11.78 + 1.363 * MFI$

To check to see if the regression assumptions are met, the residuals were checked for goodness of fit. The residual plot below shows no pattern (Figure 8), however, the fit test resulted in a small p-value (W=0.724, p = 0.0214) therefore, although the regression equation should be viewed with caution. The residuals fail to follow a normal

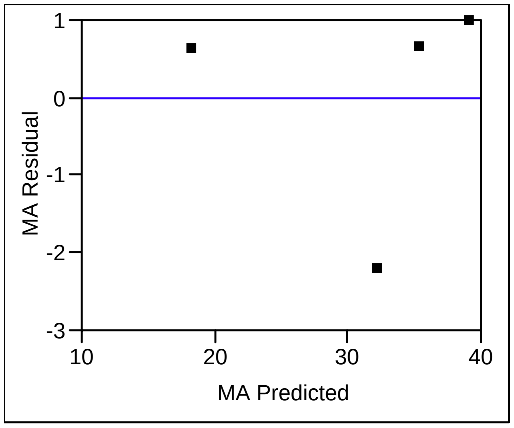

Figure 8. Residual by predicted plot of the percent of male A's. No pattern is shown.

distribution (H_0 = The data is from the Normal distribution. If p-value < 0.05 reject H_0.) A larger dataset may have shown more significant results.

No other gender grades versus gender-to-gender interactions model were found to be significant (Appendix C); however, there were many factors that have a probability within the 0.15 to 0.30 range. With a larger dataset those factors might have turned out to be significant.

The regression analysis between the letter grade of females and males with respect to all of the density values showed that none of the social interaction values are significant with respect to predicting the percentage of males or females with an A, B, C, or D or F in class as all of the probabilities are greater than alpha = 0.05, except for male A's, however, caution should be used as it does not meet the normality assumption..

From previous studies it is evident that some level of social interaction should have an influence on the letter grade. However, much of the data does not conform to any regression model. However, there were many factors that have probabilities within the 0.15 to 0.30 range. If there were a larger dataset these might have turned out to be significant. Therefore, inferences from the study and previous literature make us believe that given a larger dataset the results would be reliable and conforming to some models that would be more logical.

4.6 Summary

An analysis of the data gathered about the overall class density from the social networking questionnaire revealed no significant relationships between a class's overall social networking density and the class's distribution of grades. The analysis of each separately did not demonstrate any significant relationships; therefore, no accurate model could be formed to predict the performance of a class based on its density.

Analysis of the overall class grades with respect to the gender-to-gender density data revealed nine individually significant relationships. An analysis of a combination between gender-to-gender densities revealed that the male-to-female interactions are the most correlated with a change in grade. And analysis of the each gender's grades with each gender's interactions showed six significant correlations separately. However, no significant combinations of relationships were discovered.

Due to restriction beyond the experimenter's control, the dataset was very small. With a larger dataset there may have been more statistically significant data.

CHAPTER 5

Conclusions

5.1 Summary of Findings

The purpose of this study was to determine what factors affect freshman engineering students' grade performance, whether peer-to-peer interactions played a role, and whether gender-to-gender interactions would make a significant difference. Investigation of factors that influence academic performance is important in order to know what may improve the success rate of engineering students. By improving the success rate of students, more students will remain and graduate in engineering.

While the dataset being studied was limited, several relationships were made. The national average of females in engineering is 20 percent. In the spring of 2004, females earned approximately 20 percent of the engineering undergraduate degrees (Lerfald, 2006). The female participants from the freshman classes studied at the University of Tennessee made up 17 percent, showing consistency with the national average and reaffirming that there is not a strong representation of females within engineering. Therefore, it is important to identify solutions for women's persistently low levels of entrance and graduation from engineering.

In the classes, the overall percent of female interactions with the rest of the class was, in all but one class, higher than that of the males. The percent of interaction between females was generally higher than or equal to females' interactions with males. Whereas, the amount of male's interactions between other males or females seemed to differ in each class. This signifies the importance of women place on interaction and needing to be grouped into classes with support from other women. Although the women are able to interact with the males as well, it is apparent, and has been confirmed in literature, that most women need some level of interaction with other females. Interaction with other females allows support from people with similarities. Women and men have different socialization habits; women tend to need more "supportive interaction" (Etzkowitz, Kemelgor, Neuschatz, & Uzzi, n.d.), not just academically, but emotionally. Whereas, men tend to have the attitude of " 'Why should people need their

hands held?' " (Etzkowitz et al., n.d.). An obstacle to females in entering and persisting in engineering is that many enter with a "low degree of self-confidence" (Etzkowitz et al., n.d.). Again, most men do not put as much pressure on them self to exceed instead of just succeed. Low self-confidence compiled with an inability to interact with people who can understand or identify with them acts as a barrier to women.

Reviewing the data, simple correlation suggested that there was an influence of gender-to-gender influence that could affect the outcome of student's grades. For the class grades as whole, there was a relationship between improving the class's grades and male-to-female and female-to-female interactions. This shows that benefits accrue due to social interaction and reaffirms that involvement matters. This follows literature in that increased interaction will lead to increased academic performance. "The more students are involved, academically and socially, in shared learning experiences that link them as learners with their peers, the more likely they are to become more involved in their own learning and invest the time and energy needed to learn" (Tinto, 1997, p. 615). There was no significance in male-to-male interactions most likely because there was not a high percent of male-to-male interaction. Although the opportunity for interaction was there, many males did not take full advantage of networking with the rest of their peers.

When evaluating each genders grade with each genders interactions there were not significant correlations with the females. This is most likely due to the fact that the females represented a smaller percent of the population, and the females did not represent any of the failing population. It could also be attributed to the fact that the females were networking more, learning and helping classmates, and that is why their grades on the whole are better. The males on the other hand showed a positive correlation between an increase in their grades and more interaction; thus signifying that more interaction would be beneficial for their academic performance. Although the introvert and extrovert of each student are unknown, there is generally a higher percent of introverts in engineering. This may be a contributing factor for there not being a high percentage of social interaction, especially between the males.

5.2 Implications for Application

Implications of these findings were specific to the Freshman Engineering courses at the University of Tennessee as the study was conducted within the University's classes and specific to the EF program due to the material covered, difficulty level of the classes, and teaching methods of the program. However, since the findings confirm what has been found in the literature, other engineering programs, as well as other science and mathematics programs, may find that similarities do exist.

The "underrepresentation of women in [math, engineering, and science (MES)] is compounded by their disproportionate loss during their course of study and suggests possible inequalities within the MES culture" (Bart, 2000, p.116). According to the Women in Engineering Organization, to decrease the gender gap, many colleges, organizations, and business have created programs, workshops, and conferences to encourage and increase the number of women engineers (2005). As the lack of representation of females continues to be a significant concern, it is important to identify and determine solutions for women's persistently low levels of participation " 'to maintain [the United States] historically strong engineering workforce in the face of growing changes' " (Lerfald, 2006). Understanding the importance that gender plays in the classroom will help make educators aware that students need a welcoming and supportive environment. If there are more women in engineering, it will likely be easier to keep the numbers up because more women will feel more comfortable in the environment. As Keith Hjelmstad, dean of Academic Programs in the College of Engineering at Illinois University, stated, " 'if you look around and see other people like you, then your likelihood of feeling like you've come to the right place is higher' " (Terese, 2005). Schools can encourage more females by having more female faculty that can help support and guide women and provide the females with engineering role models. Students should also be encouraged to interact with one another. For example, students, especially females, should be encouraged to form study groups with each other.

Although the number of classes that could be analyzed for this study was rather small, the findings did show that interaction was important between all genders. It has been discussed and studied that academic success leads to higher retention and graduation

rates. As social integration promotes academic success it is more likely that student's will graduate in engineering. This is one of the reasons it is important to encourage students to integrate with other members of their class. Getting students involved through assigning group projects, allowing students to collaborate on homework assignments, encouraging students to participate in engineering societies, clubs and social events, and so forth, can do this. As engineering does tend to have a higher percentage of introverts, it seems that the traditional style of engineering classes, which stress individual work and competition for grades, may be "more compatible with natural studying tendencies of introverts," but Felder et al. (2002) determined that overtime introverts had an "increasingly positive response to group work." The EF program at UT is already implementing more collaborative teaching methods in most of their classes which has shown success as the retention rates have gone up by 15 percent, (Cowart, 2002); however, obviously there is some level of interaction between the students to be desired.

This is not to say that social interaction is enough to predict student's success or failure in engineering. There are still many factors that can contribute to individual's performance and persistence, such as, personal motivation for the course, attitude for the course, abilities, skills, learning styles, a student's mental and emotional condition, external social factors, and self-confidence, just to name a few. Academic dismissal is associated with poor grade performance where as voluntary defection or drop out is associated with a lack of congruency with the environment and social integration (Tinto, 1975). If a student has low goals, or chooses to interact with people who have negative influences, despite being socially integrated, dropout or academic dismissal still may occur.

Networking for success is not limited to interacting with ones classmates. Students that learn to interact and network are able and active in seeking guidance from other resources such as faculty members, teaching assistants, and professionals. "The quality of the college experience is [also] strongly affected by student-to-faculty interactions" (Felder, 1993). The type and frequency of student's interactions with faculty "correlates with student grade-point average, [and] degree attainment" (Felder,

1993). Therefore, if students are able and willing to interact within their environment they will have a better chance of succeeding.

For those students that do persist and graduate in engineering, learning to interact and network will offer benefits that reach far beyond that of earning a passing grade. It is to a student's advantage to start functioning this way before beginning their first job. The professional world of an engineer is revolved around teamwork and group collaboration. Industry realizes that "relationships are important for acquisition of information and … the creation of knowledge is a social process" (Borgatti & Cross, 2003, p. 440). Companies realize that in order to solve problems and design innovative products that they "want people to interact…who represent different perspectives" ("IBM," 2006).

When people seek information they may obtain solutions, ways to think about their problem differently, or affirming feedback that boosts their confidence. In companies, the communication network is a very important feature of the organization of any task-oriented group. Cross and Sproull (2004) found that "learning is affected in part by existing knowledge, but also by … one's ability to learn from another" (p. 459). "Small groups may find solutions to difficult problems faster than any of their constituting individuals, because groups profit from complementary knowledge and ideas" (Helbing, Ammoser, Kuhnert, 2006, p. 141).

While in school students need to be encouraged and permitted to learn how to network with their peers and work toward one common goal. In turn, most students will work harder, learn more, perform better in class, and graduate ready and prepared for the professional world on an engineer. In addition, as the percent of females represented in engineering is still low, it is important for females to be allowed to integrate

5.3 Recommendations for Future Research

The population included five sections of one EF course. The factors that were studied were academic performance, gender, and the density of social interactions. The EF program consists of several different courses that all freshman engineering students must take, a larger sample may come from a study involving those classes as well. Additionally, the concept may be applied to other disciplines. Following are

recommendations for future research relevant to student's social integration within their class, gender, and academic performance.

1. Due to the fact that social networks are dynamic and constantly changing, further research should include taking social networking data at different intervals throughout the semester. As interaction increases and new friendships are formed throughout the semester, if social networking data is taken before each major test or exam, and analyzed with the grade of the major assignment the effects of the network might show more of a relationship.
2. The affects of each student individually with respect to each individual's network may also provide a more valuable relationship to the role interaction has to do with performance. Additional studies could analyze each individual's grades with respect to their density of interactions. This would expand the focus of overall class grade expectations to individual grade expectations.
3. Additionally, a comparative study of the student's interaction rates with whether they remained in engineering the following year might provide more insight into the affect of interactions.
4. A comparative study with the same class the following year, comparing their interaction rate, academic performance, and retention, may also provide further insight.
5. As students progress throughout their college experience, they generally tend to form tighter, stronger knit groups within their department. Differences between the upperclassmen's interactions and performance can be compared to that of the lowerclassmen.
6. Further research could measure student's responses to how they feel about the class and how motivated they are at different intervals throughout the semester, determine who their social contacts are, and compare this to each student's academic performance. This would signify if student's attitudes influence their peers.
7. It would be advantageous to perform a more qualitative survey that included student's attitudes about their class and their instructor, as faculty integration is

said to be a predictor of class enjoyment and student persistence. Attitudes about the instructor would aid in the understanding of the role the teacher plays in academic success. In addition, a student's attitude toward the class may be associated with the student's social interactions, or lack thereof, with classmates.

8. Conducting a similar study and determining more about why students form friendships, for example their proximity to one another, living arrangements, similar characteristics, intelligence, etc., would allow an understanding of why and how students make contacts within their classes. Especially in engineering where the majority of the students are introverts, this might be helpful in learning the reasons students choose to their friends.
9. A survey to determined not only who a student's contacts are, but also the level of involvement with each of his contacts, whether it be often or minimal, or whether they discuss class information and or out of class topics might allow for more understanding of the type of social network that exists and its true affect on academic performance.

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APPENDICES

Appendix A
Graphical display of each class's social networks produced in NetDraw.

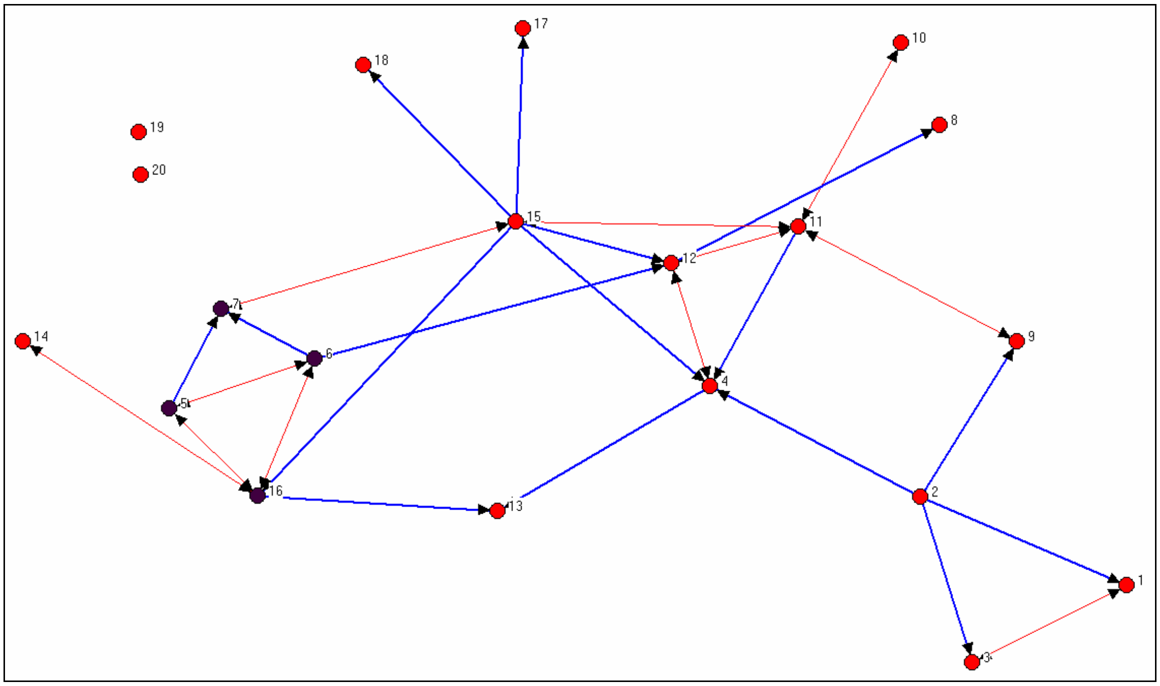

Figure 9. Social network ties between students in class 1.

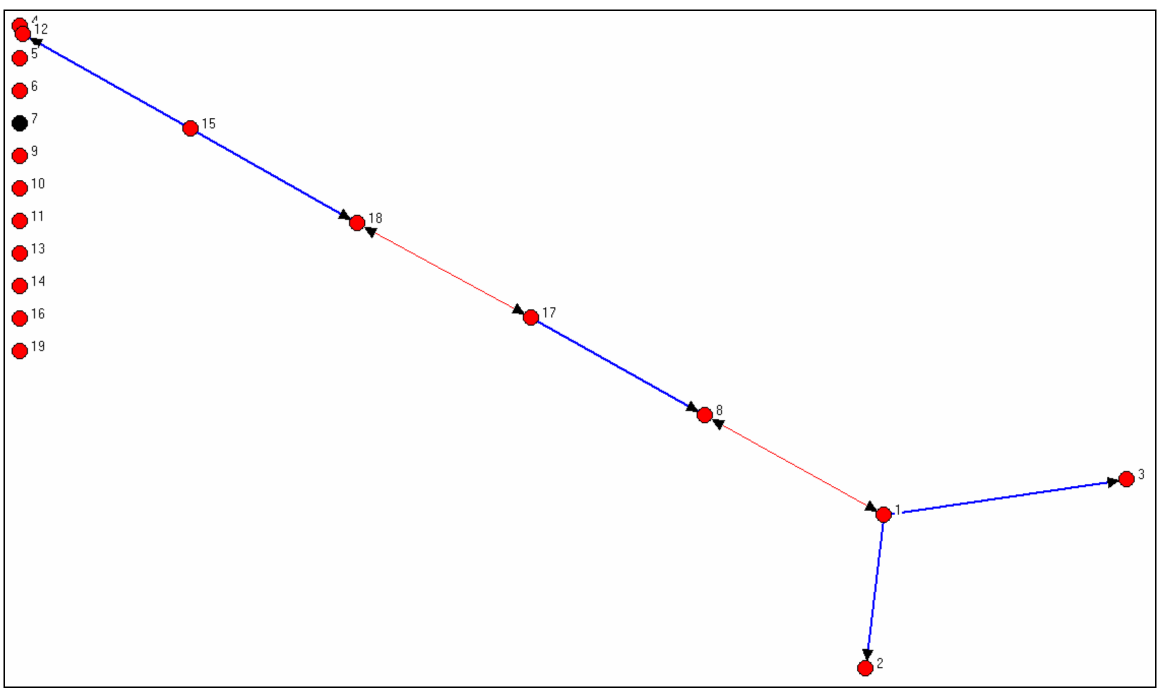

Figure 10. Social network ties between students in class 2.

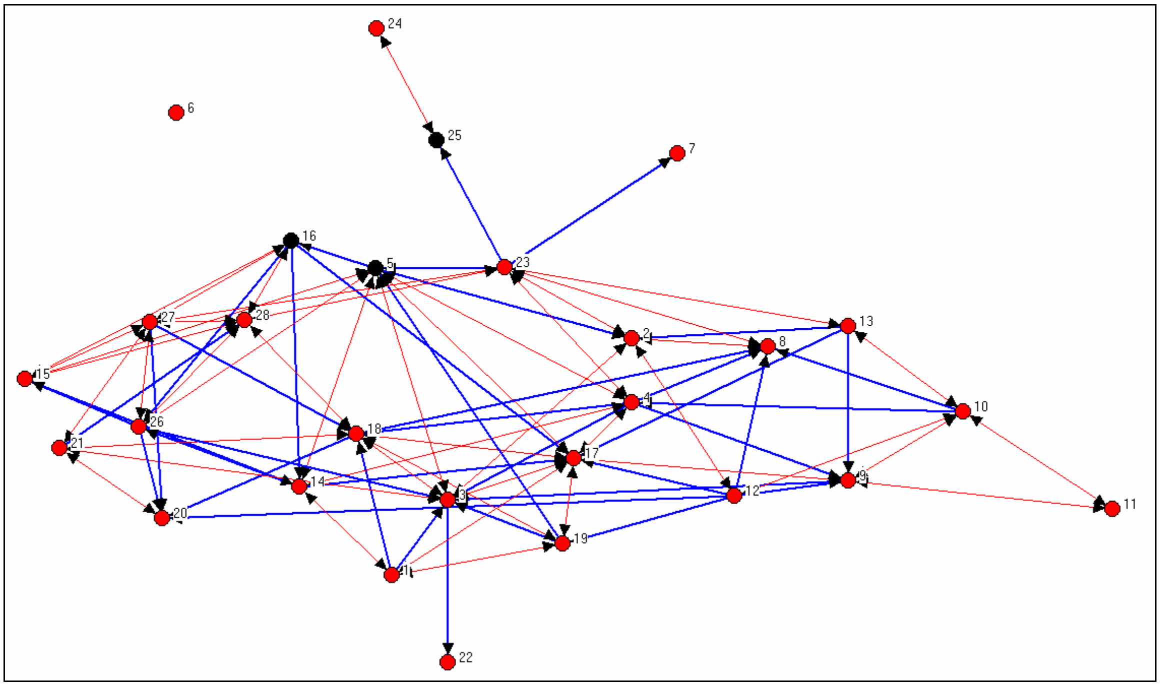

Figure 11. Social network ties between students in class 3.

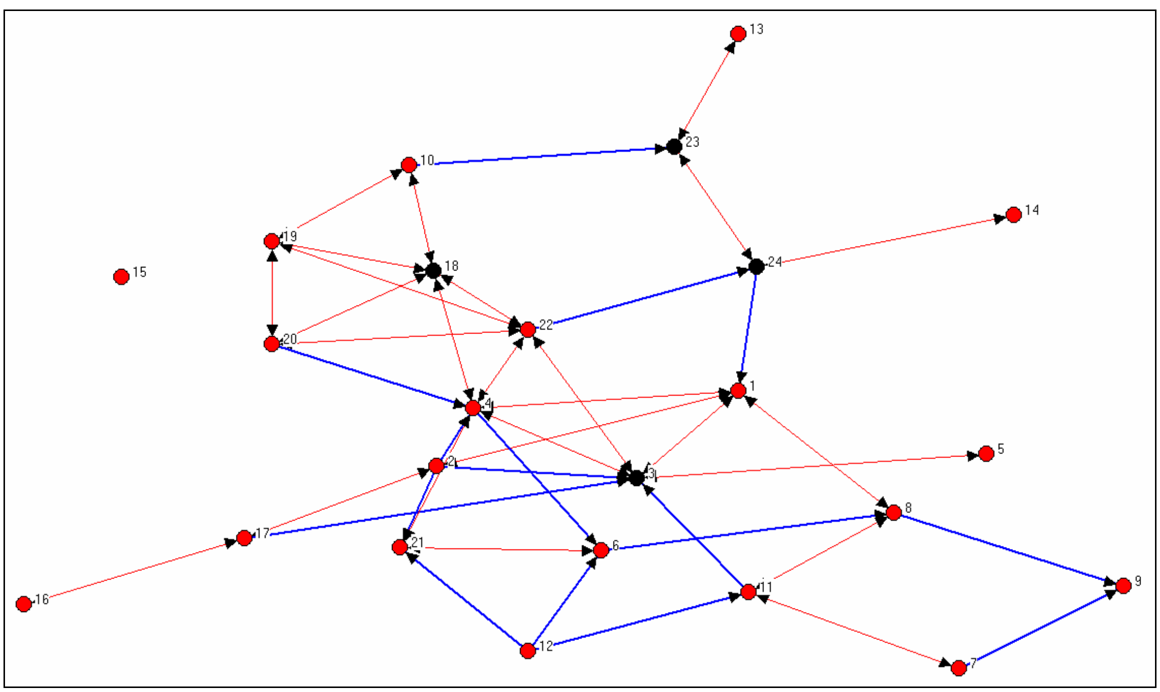

Figure 12. Social network ties of students in class 4.

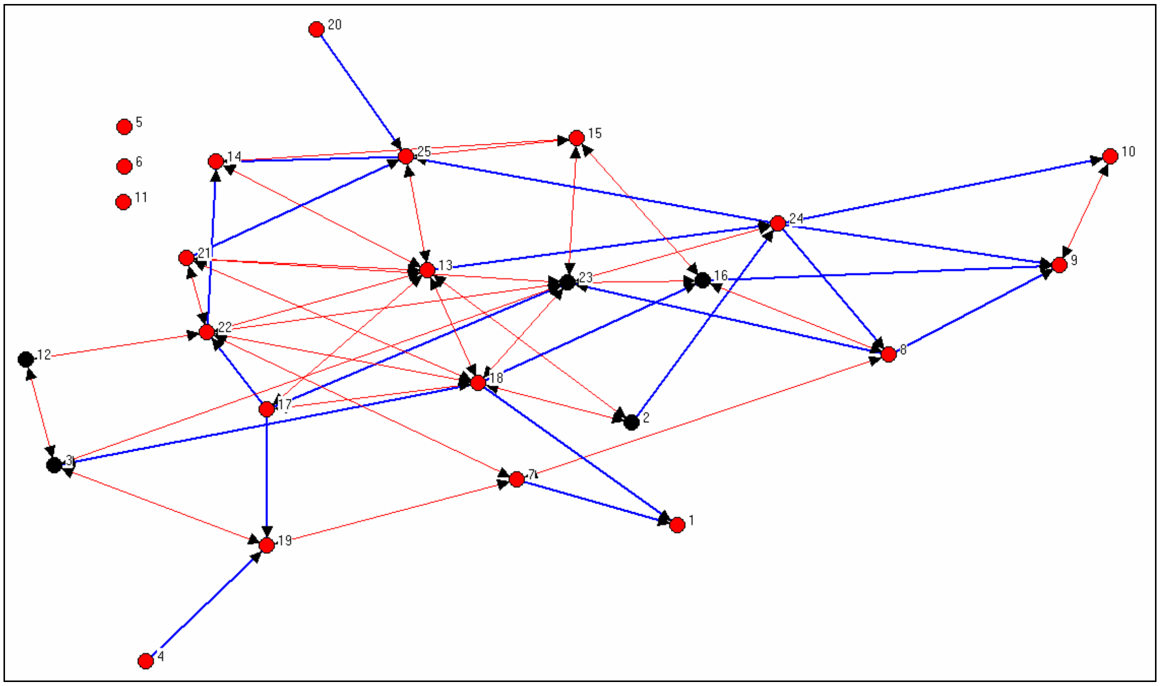

Figure 13. Social network of students in class 5.

Appendix B
Non-significant regression results of the overall class grade and the gender-to-gender density of the class.

Table 15. Regression results of the percent of C's with respect to gender-to-gender density.

Dependent Term	Independent Term	$F_{1,2}$	p
C	MMI	0.583	0.223
	MFI	2.718	0.305
	FMI	1.865	0.525
	FFI	3.047	0.241

Table 16. Regression results of the percent of B's with respect to gender-to-gender density.

Dependent Term	Independent Term	$F_{1,2}$	p
D/F	MMI	0.973	0.428
	MFI	0.743	0.480
	FMI	0.012	0.923
	FFI	0.323	0.627

Table 17. Regression results of the median with respect to gender-to-gender density.

Dependent Term	Independent Term	$F_{1,2}$	p
Median	MMI	0.006	0.944
	MFI	0.000	0.987
	FMI	0.040	0.860
	FFI	0.001	0.974

Appendix C
Non-significant regression results of the male and female class grades and the gender-to-gender density of the class.

Table 18. Regression results of the percent of female A's with respect to gender-to-gender density.

Dependent Term	Independent Term	$F_{1,2}$	p
FA	MMI	1.719	0.320
	MFI	0.079	0.805
	FMI	0.825	0.460
	FFI	0.203	0.696

Table 19. Regression results of the percent of female B's with respect to gender-to-gender density.

Dependent Term	Independent Term	$F_{1,2}$	p
FB	MMI	5.153	0.151
	MFI	0.153	0.733
	FMI	1.470	0.349
	FFI	0.379	0.601

Table 20. Regression results of the percent of female C's with respect to gender-to-gender density.

Dependent Term	Independent Term	$F_{1,2}$	p
FC	MMI	7.003	0.118
	MFI	0.173	0.718
	FMI	1.643	0.328
	FFI	0.425	0.581

**There is no table for the regression of females receiving a D or F because no females scored that low in any class.

Table 21. Regression results of the percent of male B's with respect to gender-to-gender density.

Dependent Term	Independent Term	$F_{1,2}$	p
MB	MMI	0.057	0.834
	MFI	10.736	0.082
	FMI	1.786	0.313
	FFI	6.133	0.132

Table 22. Regression results of the percent of male C's with respect to gender-to-gender density.

Dependent Term	Independent Term	$F_{1,2}$	p
MC	MMI	0.179	0.713
	MFI	3.199	0.216
	FMI	2.584	0.249
	FFI	2.950	0.228

Table 23. Regression results of the percent of male D/F's with respect to gender-to-gender density.

Dependent Term	Independent Term	$F_{1,2}$	p
MD/F	MMI	1.176	0.392
	MFI	0.584	0.525
	FMI	0.001	0.976
	FFI	0.236	0.675

VITA

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