AC 2007-2571: A STUDY ON SOCIAL NETWORKING AMONG ENGINEERING FRESHMEN

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Analysis of Information Networks of Freshman Engineering Students

Abstract

The effect of social interactions on individual and collective performance is receiving increased attention. The general assumption is that an individual's success is, to a large extent, dependent on social ties and attainment of social capital. This paper presents the results of a study performed to determine if social interaction within freshman classes in the College of Engineering (COE) at The University of Tennessee, Knoxville (UTK) 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 UTK freshman classes taught by the Engineering Fundamentals (EF) Division were surveyed to determine their interaction 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. This data was analyzed in terms of demographics and sharing of information. Social network analysis of the interactions within the class was used to identify density and structure of networks. A description of the analysis, results, conclusions, and recommendations are provided as a basis for recognizing the potential impact of social networking in forming teams and in conducting classroom discussions. These results could also be used to determine better ways to present materials and provide information to improve academic performance. 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.

Introduction

Amongst graduating high school students, the number of students interested in engineering is declining; and, of the students who enter engineering, only fifty percent graduate in engineering.[8] The Science, Math, and Engineering (SME) majors have "the highest defection rates among undergraduates [and] the lowest recruitment rates."[14] 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."[14] In education columnist Jay Matthew's[16] article, "Five Weird Ways To Graduate College," 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 drop out of college entirely.

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."[13] One of the single major predictors of persistence within engineering is academic achievement.[8] Academic achievement is associated with several 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. Some researchers have recognized that social integration is also an important factor to academic success.[10, 19-21]

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."[10] Students are willing to share information within their network, issues out of the class and issues in the class. Unfortunately, "the classroom has not played a more central role in current theories of student persistence."[21]

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.[19] However, as satisfaction with college and academic success have been shown to be attributable to 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.

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 final grades received from the classes studied.

Background

The academic success and retention of engineering and other science and mathematics students has become a major concern. In 1993 the SME majors suffered a relative student loss rate of 40 percent between their freshman and senior years.[18] In 1995 a national movement was underway to recruit and retain more college students into the SME majors. 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.[18] Therefore, engineering student retention has become a central issue as "the demand for qualified engineers threatens to outpace the number of graduating engineers."[7]

"Due to the demanding curriculum, retention and graduation rates for engineering students have traditionally been lower than those of other academic disciplines."[3] Additionally, engineering has traditionally been a male dominated major. While women make up 50 percent of college undergraduates, women only make up 20 percent of engineering.[22]

The goal of the freshman engineering program at UTK is increasing student's academic success and increasing the engineering retention and graduation rates. The program 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"[4] increases.

This research addresses the issue of what class factors contribute to academic success in freshman engineering college classes. The problem addressed is determining 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.

General Approach

This research involved using a questionnaire to determine the Spring 2006 freshman engineering class's social information networking data; and from this, determining correlations of social integration and the overall class's success. The research questions 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?

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. Numerous studies have discussed that involvement matters in student's persistence.[1, 10, 14, 19-21] High levels of involvement have been associated with learning gain which leads to better academic performance, increased persistence, and more class enjoyment and self-confidence. Low levels of involvement generally result in lower levels of achievement.[14]

In *An Engineering Student Survival Guide*, Felder[6] 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.

"College students learning cooperatively perceive greater social support (both academically and personally) from peers and instructors than do students working competitively."[11] Jurkowski, Antrim, and Robins[12] 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. Students who have more social contacts within a course are at an advantage because "students learn best when interacting with others."[12]

Many researchers agree on the importance of social integration in college as it can be correlated with commitment to the institution and persistence. Thomas[19] 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."

Social Network Analysis

Social Network Analysis (SNA) has been used since the 1930s in the social and behavioral sciences. 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."[4] Social networks can be generally defined as a group of inter-connected individuals.

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. "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"[17] the network is. 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." [17]

SNA uses two kinds of tools to represent the network compactly and systematically and to determine information about patterns and ties among social networks: graphs and matrices. The graphical displays consist of nodes, each of which represents individual actors, connected by lines or arrows, representing relational ties between the objects. An example of such a graph is shown in Figure 1. The network represents the social friendship connections of a fictional set of students in a class.

The graphical representation in Figure 1 displays binary data. A tie, or a connecting line with arrows, represents a yes or no type relationship. Figure 1 represents a directed graph because not all ties between two nodes are reciprocated. The direction of the arrow indicates who is directing a tie at whom. A double-headed arrow (red) represents a reciprocated tie between two nodes.

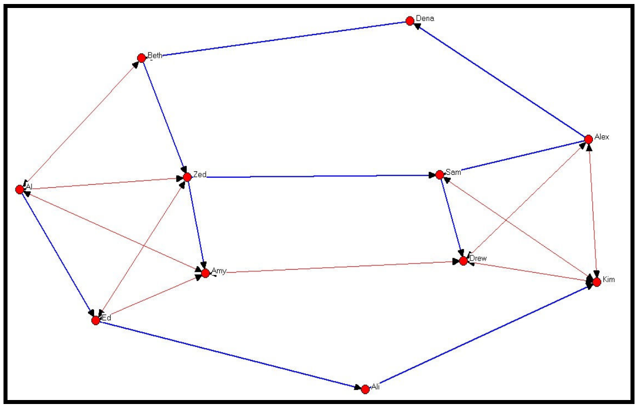

Figure 1. Fictional directed network displaying class friendships using NetDraw.

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."[2] 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 $\mathtt{N} = \{1, 2, \ldots, n\}$, and $\mathtt{X}$ denotes the particular relation between the actors. Therefore, "$\mathtt{X}$ is a set of ordered pairs recording the presence or absence of relational ties between pairs of actors."[2] 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.[2]

As the association matrix is square, the rows, *i*, and the columns, *j*, both represent the set of actors in the network being studied, as shown in Table 1. An association, such as friendship between two actors is most easily represented as binary data where ones and zeros represent the presence or absence of ties. 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*.

Table 1 represents the same directed matrix as in Figure 1. Table 1 shows that each entry in the $X_{i,j}$ cell is not necessarily the same as the entry in the $X_{j,i}$ cell.

Table 1. Matrix of the fictional directed network displaying class friendships.

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

Methodology

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; and then
c) Correlating the data.

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

Data for the class's social network density came from a questionnaire administered to students to discover a class's information sharing network. Academic performance was measured by looking at the final class grade performance collected from the professor. Academic success includes an A, B, or C and academic failure will include a D or F. The data was then statistically analyzed by correlation analysis and multiple regression analysis to determine the relationships, if any.

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.

To limit variability, the population for this study consisted of students enrolled in five sections of the same computer Freshman Engineering College course under the direction of the same professor at The University of Tennessee, Knoxville in the Spring of 2006. Therefore, the teaching style, content, and assessments were the same between classes. All classes met weekly 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 studied. Each class chosen had similar class sizes of approximately thirty students. The Office of Research Internal Review Board (IRB) regulated the amount and type of data collected from the participants and the methodology used. Due to IRB regulations, a student's participation in the survey was completely voluntary; also, due to the nature of most college classes, there was no guarantee that the entire class would attend the day the survey was distributed.

Although the classes surveyed were held in Spring 2006, the course is a co/pre-requisite for other engineering courses. Therefore, although the students may have been at UTK for a semester or more, this is the students' first semester actually in the engineering program. The survey was distributed three-quarters through the semester, allowing students the time needed to integrate within the class. A representative went to each class during the regularly scheduled class time and administered a survey to the students who chose to participate in the study; all non-participating students stepped out while the participants completed the survey. Considering only the classmates who were participating in the survey, each participant wrote down all classmates in the room with whom they would have a conversation with weekly and share information concerning the course. It was stressed that this interaction required a conversation between the two individuals and went beyond saying "hello". This interaction could take place either inside or outside of the class period.

The data obtained from each class's social networking questionnaire was used to create a graphical representation of each network and to determine the social interaction densities within each network. This was performed using the SNA software packages, NetDraw version 4.14 that maps the flow and UCINET version 6.0 that measures the flow of relationships within a network.

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, $n(n-1)$. 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).

Equation 1. $$Density = l / (n(n-1))$$

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.[9] 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 was 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 (MMI) interactions, male-to-female interactions (MFI), female-to-male interactions (FMI), and female-to-female interactions (FFI). 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.

Table 2. Block density matrix of fictional data set representing the proportion of gender-to-gender interactions. Performed in UCINET version 6.0.

Gender	Males	Females
Males	0.333	0.333
Females	0.267	0.1

JMP version 6.0 was used to perform correlation analysis and linear regression. Pearson's Product Moment Correlation analysis was used to focus on the correlations between the class social interaction densities and academic performance. Pearson's correlation, *r*, measures the direction and strength of the linear relationship between two variables. The closer *r* is to ±1 the stronger the positive or negative relationship between the two variables.

Step-wise multiple regression analysis was used to analyze the separate effects of two or more independent variables (gender-to-gender social interactions) on a dependent variable (GPA). Step-wise regression rests on the assumptions of normality, linearity, independence, and constant variance in order for the results to be trustworthy. Using this procedure, an equation is produced based on one dependent variable and n independent variables as shown in Equation 2.

Equation 2. $Y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \in$

Where Y represents the dependent or response variable, and β_1 to β_n are the *n* independent or regression coefficients. Models were tested for significance by comparing the coefficient of determination, R^2, and the F ratio and its p-value. On a scale of 0 to 1, a larger value of R^2 indicates the model is successful in explaining variability. An F ratio much greater than 1 and a small p-value, less than 0.05, indicate that the model is most likely significant.

Results

As discussed earlier, the participants in this study were students in five different sections of a freshman Engineering course. Of the five engineering courses, there were 161 students. Of the 161 students, 116 students (72%) chose to volunteer in the study. 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. Of the 116 students who 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% of the population. The percentage of male and female participants in each class is provided in Table 3.

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

Figures 2 - 6 display circular graphical representations produced in NetDraw of each class's social network. 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.

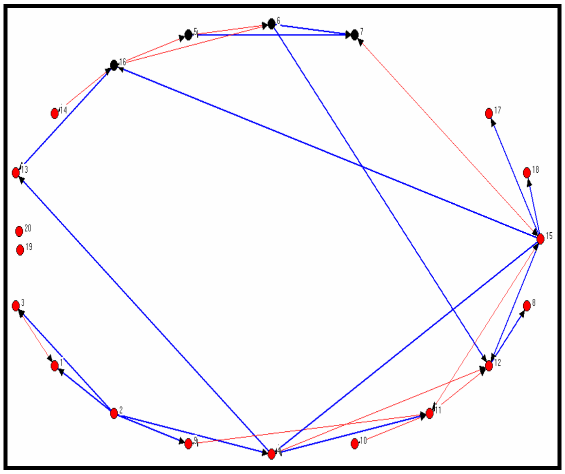

Figure 2. Circular display of class 1's social network.

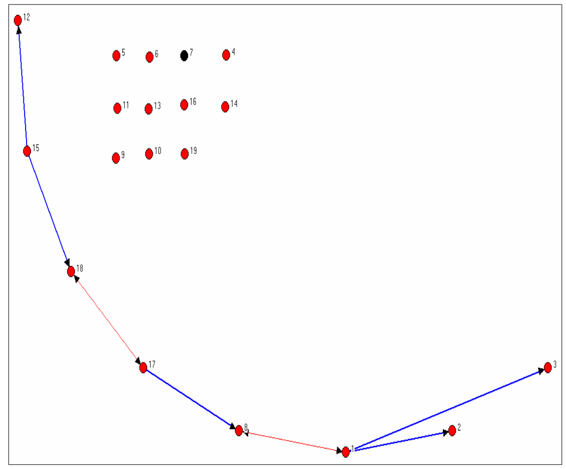

Figure 3. Circular display of class 2's social network.

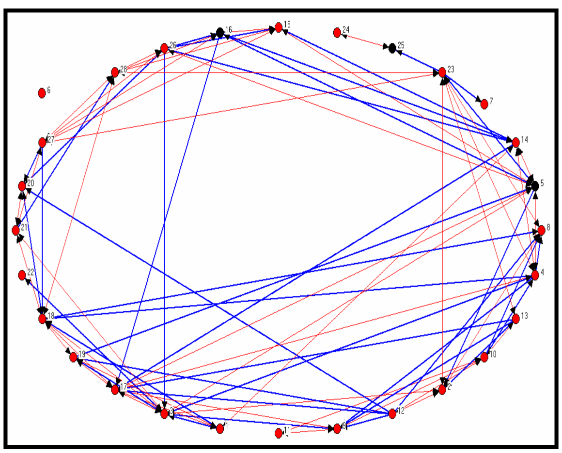

Figure 4. Class 3's social network.

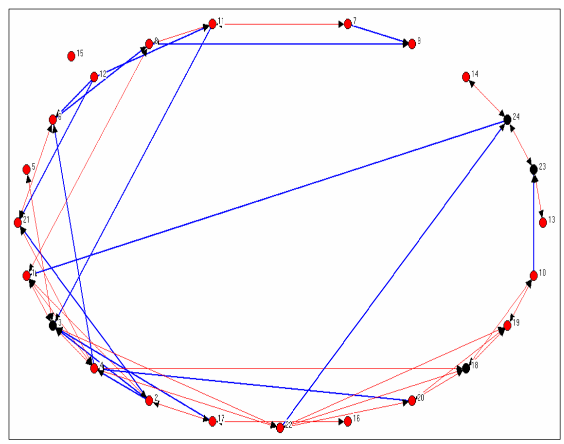

Figure 5. Class 4's social network.

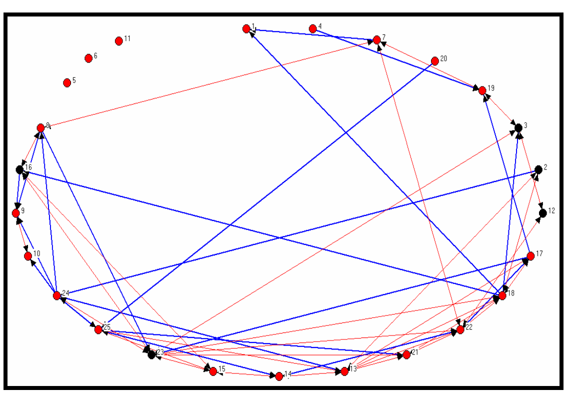

Figure 6. Class 5's social network.

The social network questionnaire data was mathematically 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 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 original class 2's social networking results were removed from the study because students often used it as a transient class – attending that class when they missed their registered section.

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. *N/A as class only had 1 female.

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

The academic performance data is displayed in Table 6 and only includes those students who participated in the social networking questionnaire. 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.

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

Pearson's correlation analysis was performed (Table 8), and no strong correlations were found. A simple regression was run for the factors using 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).

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

The correlation matrix in Table 10 shows the correlation between the overall class percentages of A's, B's, C's, D's and F's, and median in the class and the gender-to-gender social interaction densities within the class.

Table 10. Pearson's correlation data, *r*, on the percent of each grade and the median grade and the interaction between the students. *Stong linear correlations.

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

The models for the percent of A's and B's were found to be acceptable (Table 11). 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. The residual plot for B with respect to MFI is shown in Figure 7b. Independence, constant variance, and normality were met and the models hold. A model for the percent of A's (Equation 3) and the percent of B's (Equation 4) in a class can be written as:

Equation 3. $Y_A = 13.88 + 1.152 * MFI$ **Equation 4.** $Y_B = 80.14 - 2.357 * MFI$

As Thomas[19] suggests, students who 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 does not understand something, they may not have anywhere else to turn. However, students who have larger social networks will have more success understanding a topic when working together, 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."[19]

Table 11. 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

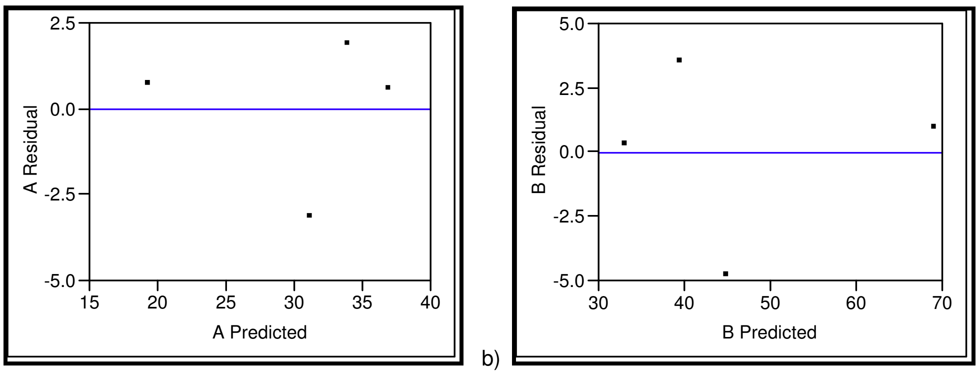

Figure 7. Residual versus predicted plots for the grades A (a) and B (b).

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 12. 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 relationship between females receiving a C and FMI (R = 0.6716). The males show a correlation between receiving an A and MFI (r = 0.9869) and a C (r = 0.7844); there is a negative relationship between the percent of males receiving a B and MFI (r = -0.9181) (Table 13).

Table 12. 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 13. Correlation between the male independent and 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.

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. The step-wise regression was run for all the factors using an alpha=0.05 significance level. 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 5.

Equation 5. $Y_{MA} = 11.78 + 1.363 * MFI$

Summary

While the dataset being studied was small, several relationships were found. The national average of females in engineering is 20%. In the spring of 2004, females earned approximately 20% of the engineering undergraduate degrees.[15] The female participants from the freshman classes studied at UTK made up 17%, showing consistency with the national average and reaffirming that there is not a strong representation of females within engineering.

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 males' interactions between other males or females seemed to differ in each class. This signifies the importance of interaction for women and needing to be grouped in classes with support from other women. Although the women 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 academic support as well as social and emotional support.

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.

Reviewing the data, simple correlation suggested that there was an influence of gender-to-gender interaction that could affect the outcome of students' grades. For the class grades as a 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. Increasing social density will provide students with additional educational and support resources. "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."[21] There was no significance in male-to-male interactions.

When evaluating each gender's grades with each gender's interactions there were not significant correlations with the females. The males, however, showed a positive correlation between an increase in their grades and more interaction; thus signifying that more interaction, increasing the density of the social network, would be beneficial for their academic performance as well.

It has been discussed and studied that academic success leads to higher retention and graduation rates. As social integration can promote academic success it stands to reason that an increase in integration will also lead to more students graduating in engineering. Therefore, 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 promote involvement. The EF program at UTK is already implementing more collaborative teaching methods in most of their classes. This has shown success as the retention rates have gone up by 15 percent.[3]

This study does not purport that social interaction is enough to predict a student's success or failure in engineering. There are many factors that contribute to an individual's performance and persistence. These include personal motivation for the course, interest in the course, abilities, skills, learning styles, external social factors, and self-confidence, just to name a few. Instead, the results indicate that students who learn to interact and network within their classes and environment have more resources at their disposal; therefore, they are more able to seek assistance from classmates, and perhaps guidance from other resources such as faculty members, teaching assistants, and other professionals. It also indicates that if students interact positively with their environment, they will have a better chance of succeeding.

Future Research

1. Additional studies will analyze individual's performance with respect to individual connectivity.
2. Social networks are dynamic and constantly changing, further research will include collecting social networking data at different intervals throughout the semester and correlating it with performance on major assignments throughout the semester.
3. Additionally, more information can be gathered over time by tracking the students throughout their time in college.
4. More insight might be gained from performing a more qualitative survey that included students' attitudes about their class and their instructor and the level of involvement with their contacts.

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