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Article 1

Counselors: Partners in the Recruitment/Retention of Female Mechanical Engineering Students

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Abstract

The overall number of females entering engineering programs remains relatively low. This is particularly true when discussing the percentage of female mechanical engineering students currently enrolled in university programs. If this percentage of female mechanical engineering graduates is to increase, school, college, and career counselors must assess existing differences between male and female students and systematically target female characteristics related to program recruitment and retention while partnering to change the engineering environment. This study compared male and female mechanical engineering students' self-reported levels of depression, anxiety, professor and peer influence, perceptions regarding the applicability of engineering projects for each gender, perceptions of the correlation between engineering projects and current skill levels, and need for social connectedness/empathy. Stratified random selection was used to select comparative male and female groups from within two Texas universities' mechanical engineering programs. Significance was found in the

areas of depression, anxiety, professor and peer influence, and social connectedness. Correlations between anxiety, depression, and professor and peer influence were noted. Implications for assisting female engineering students in school, college, and career counseling settings as well as overcoming gender inequity in recruitment and retention are discussed.

Greater efforts are needed to retain and recruit females into mechanical engineering programs (Potter, 2008; Tsui, 2009). According to the Engineering Workforce Commission (2009), only 19.2% of engineering majors and 12-13% of mechanical, electrical, and computer engineering majors are female (Lim, 2009). Despite this under-representation, it has been suggested that female-focused engineering program recruitment efforts are lacking (Tsui, 2009). School, career, and college counselors as partners with university faculty are in optimal positions to change the cultural environment within engineering programs such that the needs of female students are understood and met. Once specific gender based issues are identified, systematic approaches involving K-12 school counselors, college counseling centers, career counselors, engineering students, and engineering professors can be developed to aid women in mechanical engineering programs.

Relevant Trends

A central task in formulating methods to improve female recruitment and retention in mechanical engineering programs is distinguishing personal characteristics that impede women's interest and success and determining how environmental changes can be made to improve programs. Once an understanding of gender differences is evident, specific recruitment efforts and program improvements can be devised and implemented. Following is a discussion of trends relevant to understanding these gender based issues.

Research has attempted to reveal the manner in which females relate to others. For example, Hudd et al. (2000), as well as Hicks and Miller (2006), found that female undergraduate students experienced greater levels of irritability, stress, and depression than their male counterparts. Further, feelings of belonging and self-efficacy have been mentioned as keys to success for females in engineering programs (Lim, 2009). Unfortunately, many in the engineering field view the aforementioned issues as unacceptable feminine qualities and refuse to address them much less change the environment so females experience a sense of belonging (Bastalich, Franzway, Gill, Mills & Sharp, 2007). The perception that engineering is a masculine field (Phipps, 2002), some men's fear of dominant females (Palermo, 2004), and antidiscrimination policies may lead some men to practice subtle bullying tactics and cause lack of acceptance and discrimination for females in the engineering field (Wadhwa, 2006). These researchers contend female success has less to do with feminine qualities and more to do with discrimination, treatment, and connectedness of women to professors and peers in the program.

Sexual discrimination has been mentioned as an obstacle faced by female engineers (Franzway, Sharp, Mills, & Gill, 2009; Lehr, 2006). For example, Alansari (2006) found that sexual discrimination and lack of job opportunity correlated with

female depression levels. To further illustrate the prevalence of the issue, the National Academy of Sciences (2009) issued a report indicating rampant bias against females employed or entering the fields of engineering and science. Male students and engineering professionals may perceive female peers as threats to future jobs and often react in a hostile manner (Schafer, 2006). As a result, recent literature reviews suggest the importance of changing the engineering workplace culture to one that is more gender friendly (Bastalich et al., 2007; Mills, Bastalich, Franzway, Gill, & Sharp, 2006). This task is extremely daunting given the limited knowledge available regarding the specific needs of female students.

Much remains unknown when discussing correlations between gender, mechanical engineering programs, and stressors such as depression and anxiety, as well as influencers such as social connectedness, professor and peer influence, and gender based perceptions regarding engineering projects and skills. For example, social connectedness has been suggested in the literature as a missing element within engineering programs yet a dearth of research exists on the importance it may play on female recruitment and retention (Bastalich et al., 2007; Koehler, 2008; Lim, 2009). Knowledge of the aforementioned issues may enlighten school, college, and career counselors such that related and creative recruitment/retention strategies emerge. As a result, additional research and strategies are needed if recruitment efforts are to focus on the crucial aspects needed for recruitment and retention of female students in mechanical engineering programs.

Purpose of Study

The purpose of this study is, therefore, to determine if gender differences are evident regarding depression and anxiety levels, professor and peer influence, perceptions regarding the applicability of commonly assigned academic engineering projects for both genders, perceptions of the correlation between engineering projects and current skill levels, and need for social connectedness among mechanical engineering students. Findings will be used to create strategies that serve to facilitate gender balancing as well as to foster improvements in engineering programs. Further, this study offers insight into systemic changes that need to be made so female mechanical engineering students experience a positive environment and an equal playing field in mechanical engineering programs.

Method

Participants

Thirty male and 30 female students self-reporting enrollment as sophomore, junior, or senior level mechanical engineering students from within two Texas universities were randomly selected via stratified random selection for participation in the study. Each student currently enrolled in a course unique to the mechanical engineering program and indicating the aforementioned degree as their declared major was grouped into separate male and female groups. Twenty males and 20 females were selected via stratified random selection from the first institution (a large university comprised of over 30,000 students) and 10 of each gender were selected from a smaller university comprised of less than 8,000 students.

Stratified random sampling was used to select 30 females and 30 males into two comparable groups. A total of 60 participants comprised 19 Anglo males, 22 Anglo females, 10 Mexican-American males, 7 Mexican-American females, 1 African American male, and 1 Asian female. Of this group, 21 of the females and 23 of the males indicated a classification of senior, 7 of the females and 7 of the males reported their class rank as junior. The remaining two females were classified as sophomores. Participants' ages ranged from 19-27 for males and 18-24 for females. The median age for both male and female participants was 22. The mean self-reported GPA (to include only courses listed on the mechanical engineering degree plan) for males and females was 3.28 and 3.20 respectively. All 60 selected participants agreed to take part in the study.

Instruments

A total of six instruments were administered in a single session to participants in March of 2009. Information on each assessment follows.

The *Beck Depression Inventory II (BDI-II)* was used to measure student self-reported depression levels. This instrument contains 21 items developed to assess patients' severity, depth, and intensity of depression. Questions address mood, pessimism, sense of failure, self-dissatisfaction, guilt, punishment, suicidal thoughts, crying, irritability, social withdrawal, energy level, and libido. Scores from zero to nine indicate minimal depressive symptoms, scores from 10 to 16 represent mild depression, scores from 17 to 29 indicate moderate depression, and scores ranging from 30 to 63 represent severe depression.

The *BDI-II* has been shown to be valid and reliable. When comparing the instrument to clinicians' ratings of depression, results overlap for over 90% of cases. Further, construct validity is evident when comparing the instrument to similar constructs such as anxiety, stress, sleep patterns, and suicidal behaviors. Test/re-test reliability and average reliability coefficients for mixed depression are .90 and .86 respectively. Internal consistency reliabilities are .93 for college aged students (Beck, Steer, & Brown, 1996).

The *State Trait Anxiety Inventory (STAI) Form Y-S* Anxiety Scale was used to measure current anxiety levels among mechanical engineering students. Spielberger (1983) developed the instrument in order to provide objective measures of state and trait anxiety. The S-Anxiety Scale has been described as measuring a palpable reaction or current process as well as changes based on current perception of threat or danger. As a result, S-Anxiety may change over time as levels of stress increase or decrease. Each of the 20 items on the *STAI Form Y-S* Anxiety Scale measures the intensity of anxiety ranging from 1 (low anxiety) to 4 (high anxiety). As a result, the higher the score, the more intense a person's current anxiety level. Spielberger reports alpha coefficients of .91 for college aged males and .93 for similarly aged females. Working adults between the ages of 19-69 reported alpha coefficients between .90 and .94 for both males and females.

The remaining 4 instruments were researcher constructed and normed during the fall of 2008 using 15 male and 15 female engineering students at a small Texas university (under 8,000 students enrolled). Students in the norming group were administered each of the instruments twice over a 7 day period. Test/re-test reliability coefficients were calculated for each instrument and will be described in the following description of each instrument.

A researcher-constructed Professor and Peer Influence Questionnaire (PIQ) was designed to measure mechanical engineering students' perceptions of treatment by professors and peers in the mechanical engineering program. Twelve items asked participants to self-report perceptions of treatment by professors, treatment by peers, and professor/peer expectations for school success. Four items including: "My professors in the mechanical engineering program treat me fairly," "My professors treat me as well as anyone else in the mechanical engineering program," "My mechanical engineering professors treat all students equally regardless of gender," and "My mechanical engineering professors are helpful," were asked to determine perceptions of treatment by professors. An additional four questions asked about treatment by peers and included: "My peers in the mechanical engineering program treat me fairly," "My peers treat me as well as anyone else in the mechanical engineering program," "My peers in the mechanical engineering program treat all students equally regardless of gender," and "My peers in the mechanical engineering program are helpful." The final four items asked such things as, "My professors expect me to succeed in this mechanical engineering program," "My peers expect me to succeed in this mechanical engineering program," and, "Professor and peer expectations for success in this mechanical engineering program are the same for males and females." A likert scale of "definitely agree" (scored zero points), "agree" (scored one point), "disagree" (scored two points), and "definitely disagree" (scored 3 points) was utilized. Points assigned for each item were summed creating a total score ranging between zero (no differences in perception of treatment) and 36 (perceptions indicating extreme differences in treatment). Test/re-test coefficients ranged from .78 for males to .81 for females.

The Social Connectedness Questionnaire (SCQ) was designed to measure students' self-perceived need for relationships (connectedness) as well as desire for unconditional positive regard and/or empathy from others. For example, items such as "I feel more comfortable when I have support from other students," "I do better in classes when the professor cares about the students," "I do better in classes when I have support from my peers," and "Supportive classmates help students overcome insecurities about classroom performance," were rated on a Likert scale ranging from 0 (never), 1 (sometimes), 2 (often), to 3 (always). Points assigned to each of the 11 items were summed creating a total score with a possible range from 0 (no need for social connectedness) to 33 (high desire for social connectedness). Test/re-test coefficients ranged from .88 for males and .82 for females.

Two items were used to assess student perceptions regarding the applicability of engineering projects (assigned by engineering faculty and programs; PPGQ) for both genders. Engineering projects is defined as academic activities commonly assigned in engineering programs. Students rated the following questions on a Likert scale from 1 (strongly disagree), 2 (disagree), 3 (agree), to 4 (strongly agree): "Engineering projects are relevant to both male and female students" and "I believe male and female students both benefit from participation in projects." Item scores were summed creating a total gender perception score ranging from 4 (gender disparity strongly evident) to 8 (gender disparity non-existent). Test/re-test reliability correlations for these questions were .91 for males and .88 for females.

Student perceptions of the correlation between engineering projects (as defined above) and current skill levels (CBPSQ) were assessed using 14 items rated on a Likert

scale from 1 (no help at all), 2 (some help), 3 (moderate help), 4 (much help), to 5 (a great deal of help). Skills consisted of paradigms such as team work; problem identification, formulation of problems; problem set up; solving problems; applying engineering principles; writing technical reports; critical thinking; designing experiments; conducting experiments; making oral presentations; interpreting data; using engineering tools; and applying engineering ethics. For example, the instrument stated, "Engineering projects helped me learn to write technical reports" and students rated the item from 1 to 5 as mentioned above. The same wording was used for each question but a different skill was mentioned for each of the 14 items. Scores for each item were summed creating a total scale score. Test/re-test correlation coefficients ranged from .88 for males and .84 for females.

Finally, participants were asked to self-report overall GPA. This GPA included only courses listed on the mechanical engineering degree plan. This self-reported measure was used as a covariate in the research design.

Research Design

An ex-post facto causal comparative design was utilized with subjects randomly selected via stratified random selection. This led to two groups, one per gender. Dependent variables consisted of scores on each of the six measures (BDI, STAI, PIQ, SCQ, PPGQ, and CBPSQ). Self-reported engineering grade point averages were used as covariates to equalize initial differences in achievement between groups. Gender served as the independent variable in the study.

The relationship between gender and the six dependent variables was tested using multivariate analysis of covariance and preplanned univariate analysis of covariance as follow-up comparisons. Means were compared to ascertain significant differences between genders using an alpha level of .05.

Test Procedures

A separate group testing session was scheduled on each campus the first two weeks of March, 2009. Selected participants from each campus met at a designated time and were administered a total of six instruments (BDI, STAI, PIQ, SCQ, PPGQ, and CBPSQ). Additionally, participants self-reported grade point average in engineering courses, age, ethnicity, class rank, and gender.

Assessments were completed anonymously. Each participant was given a large envelope containing a disclosure statement, consent form, instructions, and instruments. After completing assessments, participants sealed envelopes and placed them in a box containing all envelopes.

Results

This study examined gender differences of current mechanical engineering students with regard to depression, anxiety, professor and peer influence, need for social connectedness, perception of gender regarding the applicability of engineering projects, and perception of the correlation between engineering projects and current skill levels. To determine significance, a multivariate analysis of covariance (MANCOVA) was conducted using grade point average in mechanical engineering courses as a covariate,

group placement (gender) as the factor variable, and scores on the six instruments as dependent variables. The MANCOVA revealed a significant interaction of group (as measured by an alpha level of .05 for all statistics) on the combined dependent variables (p=.0001). The covariate (grade point average in engineering courses) did not indicate a significant difference (p<.396) nor did Box's test of Equality of Covariance Matrices (p<.096).

Univariate statistics (ANCOVAs) were run as a follow-up to determine which of the six dependent variables were significantly related to group. Significance was found between males and females in the areas of depression (F=34.98, p<.001), anxiety (F=13.44, p<.001), professor and peer influence (F=25.12, p<.001) and social connectedness (F=39.14, p<.001). Significant differences were not found with regard to project perception based on gender (F=.02, p<.90) and perception of project influence on skills (F=2.22, p<.14).

Finally, correlations were run between professor and peer influence, depression, and anxiety. Correlation coefficients illustrated a strong positive relationship between professor and peer influence (based on PIQ scores) and depression levels (r=.96; based on BDI scores), professor and peer influence (based on PIQ scores), and anxiety levels (r=.94; based on STAI scores). As professor and peer influence levels increased, so did anxiety and depression levels.

Table 1 illustrates comparison means and standard deviations for each dependent variable.

Table 1

Comparison Means and Standard Deviations for Males and Females on Dependent Variables

Scale	Gender	N	Mean	Standard deviation	Significance (p)
BDI-II	Males	30	2.33	3.46	
BDI-II	Females	30	8.03	4.08	*.001
STAI	Males	30	27.07	9.43	
STAI	Females	30	38.87	8.27	*.001
PIQ	Males	30	15.90	7.32	
PIQ	Females	30	23.93	4.76	*.001
SCQ	Males	30	15.97	9.75	
SCQ	Females	30	28.43	4.83	*.001
PPGQ	Males	30	6.17	2.44	
PPGQ	Females	30	6.23	1.92	.900
CBPSQ	Males	30	53.53	9.33	
CBPSQ	Females	30	49.70	10.09	.142

* p < .008 (based on Bonferroni correction)

Discussion

The object of this study was to determine if gender differences were evident among mechanical engineering students in the areas of depression, anxiety, professor and peer influence, social connectedness, student perceptions of gender regarding the applicability of engineering projects, and student perceptions of the relationship between engineering projects and current skill levels. Conclusions of this study indicate several gender differences among mechanical engineering students. This study infers that females in mechanical engineering programs are more depressed and anxious than their male counterparts, desire more social connectedness, and perceive they are treated less favorably by peers and professors in mechanical engineering programs. Further, correlations between perceptions of professor and peer influence, specifically equity in treatment and expectations for success in the mechanical engineering program based on gender, indicate a relationship between anxiety, depression and the aforementioned perception of inequitable treatment.

The aforementioned correlations are interesting and greatly add to the literature, (specifically that regarding needs of female mechanical engineering students), yet outcomes leave researchers with more questions than answers. This study indicates the presence of greater levels of female depression, anxiety, need for connectedness and less favorable perceptions of equitable treatment based on gender for female students in mechanical engineering programs. Correlations between anxiety, depression and perceptions of professor and peer treatment are thought provoking, yet a causal relationship between the variables cannot be made. Nonetheless, high correlation coefficients indicating a strong relationship between these factors makes one wonder if perceptions of inequity based on gender contribute to anxiety and depression levels among female mechanical engineering students. Further, one wonders if this perception of an unequal playing field contributes to a need for social connectedness. Do perceptions of discriminatory treatment by professors and peers lead to feelings of low connectedness, anxiety, and depression? Do perceptions of treatment by professors and peers leave females feeling alone and isolated? How important is the environment in the engineering program to women's mental health and success? According to Beck et al. (1996), loneliness and isolation are factors considered when measuring depression. Therefore, it may be little wonder females in this study displayed more depression than their male counterparts.

Implications

The evidence of high levels of depression and anxiety indicate a need for systemic involvement and environmental change. K-12 counselors, college counselors, career counselors, engineering program students, and engineering program professors can work collaboratively to improve engineering environments as well as female recruitment and retention.

At the K-12 level, school counselors play an important role in preparing female students for a college mechanical engineering program. The image of engineering can be masculine and may require a change of image (Tietjen, 2004). Like the girls they advise, many school counselors may not have a clear picture of mechanical engineering careers or the value of an engineering education for women. According to many in the field,

adults and children have an unclear definition of the nature of mechanical engineering and harbor the common misperception that engineers are males who sit alone at a desk all day solving math and/or computer problems (The Creative Engineer, 2008). Dispelling these myths means teaching the creativity involved in mechanical engineering and discarding gender bias. For example, most girls and school counselors may not understand the teamwork and collaboration involved in the mechanical engineering field or the way in which it makes a real difference in people's lives. We suggest teaching K-12 girls the practical aspects involved in mechanical engineering. For example, mechanical engineers develop safer car seats for infants, create water filtration systems for third world countries, and design high-tech running shoes. In short, K-12 counselors have the power to attract more females into engineering programs and combat initial stereotypes and biases based on gender. Greater numbers means more opportunities for female bonding and social connectedness, fewer feelings of isolation, and hopefully, more favorable peer treatment and expectations, and lower levels of depression, stress, and anxiety. Further, gender bias can be eliminated by teaching boys gender neutrality when discussing engineering as a career choice.

College counselors can assist young women as they uncover personal successes, strengths, perseverance, and motivation. Despite all obstacles, females often outperform males in engineering programs (Lewis, Harris, & Cox, 2000). College counselors can be sources of strength as girls focus on inner strengths and successes instead of inequitable and often discriminatory treatment. Focusing on issues such as intuition, relationship skills, and past successes in overcoming these obstacles can help girls recognize the outstanding personal strengths they possess that will help them not only compete but outperform many others despite inequities.

Strengths can further be enhanced in engineering programs through career counseling. Career counseling professionals can reduce anxiety by transforming women's perspectives from that of looking only at the end product to that of focusing on steps to get there (Misra & McKean, 2000). Large goals can be broken down into small steps and sub-steps to be accomplished weekly, monthly, and yearly. Further, college career counselors can work with males to ensure they understand the strengths of working collaboratively with females in the engineering profession, thus reducing fear of dominant women and therefore, subtle discrimination (Schafer, 2006).

One very useful resource that offers a strengths-based resource is the Society of Women Engineers (SWE). College counselors can suggest implementation of a student chapter at the university. The Society of Women Engineers (SWE), founded in 1950, is a not-for-profit educational and service organization. "SWE is the driving force that establishes engineering as a highly desirable career aspiration for women. SWE empowers women to succeed and advance in those aspirations and be recognized for their life-changing contributions and achievements as engineers and leaders" (Society of Women Engineers, 2012, p. 1-2).

Next, enhanced peer support and social connectedness could be enhanced through Web sites such as Facebook or Myspace. Female mechanical engineering students should establish connections with other girls enrolled in similar programs and universities. These girls can offer ongoing support and encouragement for one another. As such, the students themselves become a part of the systemic program.

Finally, mechanical engineering professors should develop strong student-faculty relationships. This contributes to adequate social connectedness, academic success, and well-being regardless of a student's gender. These sentiments corroborate the findings of Pascarella and Terenzini (1991), who found that a student's interaction with faculty significantly influences his or her learning and intellectual development. Due to the importance of professors' teaching styles and skills on students' academic performance (Seldon, n.d.), efforts should be made to enhance the quality of teaching in the mechanical engineering classroom. Faculty may enhance this resource by assigning more collaborative class work, reinforcing gender neutrality, and emphasizing the contribution that engineering work could have to society.

Limitations

Causal comparative and correlational studies do not indicate cause and effect. This study intends only to illustrate gender differences and relationships between gender and dependent variables. Much can be learned by studying existing differences and correlations despite the inability to form cause/effect relationships.

Qualitative studies might determine perspectives of female mechanical engineering students related to depression, anxiety, professor and peer influence, and social connectedness. Studies might also indicate if males experience levels of these emotions yet withhold expressions. Replications of this quantitative study can determine the applicability of generalizations to other settings. Finally, experimental studies might determine the efficacy of interventions aimed at reducing depression and anxiety for both genders and improving environments while increasing social connectedness among female mechanical engineering students.

Conclusion

Despite the under-representation of girls in mechanical engineering programs, few programs are addressing the issue (Tsui, 2009). This study aimed to uncover gender differences among mechanical engineering students that might lead to environmental changes as well as better recruitment and retention efforts for university programs. The significance found between genders with regard to depression, anxiety, professor and peer influence, and desire for social connectedness encourages discussion while correlations between anxiety, depression, and professor and peer influence offers new insight. School, college, and career counselors can assist female mechanical engineering students focus on strengths despite inequitable treatment, instill opportunities for connectedness among female students, and suggest improved interactions and instruction by engineering faculty. Since gender issues are influenced systemically, involvement of several stakeholders (K-12 counselors, college counselors, career counselors, and university professors) offers promise in addressing facets such as depression, anxiety, professor and peer influence, and lack of connectedness.

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Note: This paper is part of the annual VISTAS project sponsored by the American Counseling Association. Find more information on the project at: http://counselingoutfitters.com/vistas/VISTAS_Home.htm