FACTORS AFFECTING THE LEVEL OF CLASSROOM INTERACTION OF WOMEN ENGINEERING STUDENTS

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Abstract — *Today, women attend college in greater numbers than men, however, they are still underrepresented in disciplines such as physics, computer science and engineering [18]. This study addresses how undergraduate female students' learning styles, classroom environment and gender interconnection influence their degree of classroom involvement in core engineering courses.*

HISTORICAL CONTEXT

"Shall a girl receive the same education as a boy, in the same college, with the same instructors, and be awarded the same degree?" [6]. These questions stirred a heated debate in 1837, at Oberlin College, in Oberlin, Ohio. An all-male institution at the time, Oberlin shocked the nation by opening its doors to female students. Another milestone for women in higher education came with the passage of Title IX in 1972 (The Chronicle of Higher Education, 2002), which resulted in great strides for female graduate and undergraduate students in access to higher education. Although today, women attend college in greater numbers than men, they are still underrepresented in disciplines such as science, mathematics and engineering [18]. In 1995, women in the U. S. represented 32% of math and computer specialists, 27% of natural scientists, and 11% of engineers [15].

OVERALL IMPACT

While higher education is now more accessible to female students, campus climate and classroom environment in science, technology and engineering are far from welcoming. Clearly, blatant discrimination against women has declined, however, subtle forms of discouragement based on gender still exists [1]. One reason is the differential treatment of women students by faculty. Although the differential treatment by faculty is subtle, such treatment leads to devastating results for women students when they are cumulative. As a result, women's confidence in their ability is diminished, thus lowering their academic and career aspirations.

SIGNIFICANT TRENDS

Research demonstrates the attrition of women from the College of Engineering, especially during their first and second years. Although the research by Elaine Seymour was a qualitative study based on individual interviews at seven universities and should not be generalized for all universities, the trends she found may occur at other schools. Some of these findings are:

- Of those students who remain in their original engineering major of choice, 86% are men and 14% are women [25].
- Women's self-confidence and belief that they can succeed in this field seem to increase after their college sophomore year [12].
- An alarming forty-five percent of women leave the College of Engineering for reasons other than academic, where upon leaving, they had maintained an 'A' or a 'B' grade point average [25].

Such provocative research findings on the detriments to women's success has lead this researcher to focus on addressing this issue in the core engineering courses, which are taken in those first two years of engineering students' program of study.

STATEMENT OF THE PROBLEM

In general, a chilly institutional climate for women results in lower reported gains in academic success when compared to women who do not perceive a chilly institutional climate [24]. As expected, the longer women remain in such chilly environments, the more damaging the effects upon their educational gains [28]. Although women prefer classroom interaction, writing papers and having peer discussion, they are forced to adapt to the historic teaching styles of male faculty, which tend to be more introverted, lecture-based classrooms [10].

The purposes of this study are to identify the factors that may contribute to the attrition of female students in engineering and to make concrete recommendations in order to improve their enrollment and retention rates. The focus is on student-instructor interactions, because this area seems to have the strongest influence on women's learning outcomes within the classroom and is the area in which intervention can be most effective [7], [8], [11], [20], [22], [24], and [29]. Specifically, the researcher focused on how learning styles, classroom environment and gender interconnection of female students influence their level of classroom involvement.

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PARTICIPANTS, INSTRUMENTATION, ANALYSIS AND RESULTS

Participants

The volunteer sample for this study came from a population of 1,061 full-time undergraduate female students from the College of Engineering. Study participants were 146 or 13% of the total population of women undergraduate engineering majors, ranging in age from 17-27 and represented different cultural and ethic backgrounds.

Instrumentation & Analysis

A Demographic Information Sheet was used to obtain relevant background information. Based on Jung's (1971) theory of psychological types, the Myers-Briggs Type Indicator (MBTI) Form M was used as a measure of learning styles. The SETA-Experimental Form B in [23] was used to assess classroom environment. The SETA was designed to operationalize the taxonomy of environmental types and to work in combination with the MBTI instrument to provide a means for researchers to study personality functioning within an interactional paradigm.

The Gender Interconnection Scale (GIS) was used to measure gender interconnection [26]. The Classroom Involvement Survey (CIS) was designed to assess the level of college students' participation in classroom environments. The CIS focused on student behaviors pertaining to involvement, which included more than students' verbal participation. Stepwise-multiple regression analysis was implemented via SPSS 11.

Results & Discussion

It was hypothesized that collectively, learning styles, gender interconnection and classroom environment would influence the level of women's classroom involvement. Only three dimensions were significant variables in explaining variance in the level of classroom involvement. The SETA-Thinking/Feeling, SETA-Extraversion/Introversion, and Gender Interconnection Scale-Total Male dimensions explained about 45% of the variance as indicated by the R^2 value of .448 (F = 38.40; $p < .001$) (see Table I).

The results indicate that higher SETA-T/F values are associated with higher perceived classroom involvement values (partial r =. 392). In other words, the feeling classroom environments were associated with higher degrees of classroom involvement from female students compared to the thinking classroom environments. This finding makes sense since it is easy to imagine that the feeling oriented classrooms, especially the extraverted ones, are more open to student participation (Barrett, 1989). Instructors who create such an environment want students to feel comfortable in sharing their ideas, opinions, comments and questions so they design techniques to draw in such student involvement. Students tend to feel good about being involved in these classes because they are not ridiculed or humiliated when they are incorrect. Instead, their instructors and classmates appreciate and respect their contributions. Also, such classes are not the traditional stereotypical engineering classes where the instructor lectures and the students rush to take steady, detailed notes. Such environments leave little or no time for students' questions and instructors' feedback. First-Year Seminars are examples of courses, which were included in the core engineering course requirements, which tend to be smaller in size and more open to student involvement [19].

The regression results indicate that as SETA–E/I values increased, indicating introversion, classroom involvement values decreased. For SETA-E/I, the relationship with classroom involvement was negative (partial r = -.163). Not surprisingly, the extraverted classrooms were found to approach significance (at the p = .051 level) in relation to classroom involvement. In other words, the introverted classrooms had lower levels of classroom involvement when compared to the extraverted classrooms. This finding is consistent with the findings in [2]. There were not many extraverted engineering classrooms. In this study, participants rated the core engineering classrooms as mainly introverted (70%).

The Myers Briggs Type Indicator is an assessment instrument of the theory of learning styles or personality preferences, which derived from Jungian type constructs. This theory allows us to expect personality differences in people and assists us in better communicating with people and their differences in a productive manner. This indicator is broken into four major preferences, Introversion & Extraversion; Intuition & Sensing; Thinking & Feeling and Judging & Perceiving [17].

Of the 146 female participants in this study, 88 were extraverts (60.3%) while 58 (39.7%) were introverts. This finding agrees with the percentage of women who are extraverts (63%) and introverts (37%) in the population [13]. It is surprising that the MBTI E/I dimension was not significant (p = .236). According to [13] extraverts tend to talk as they think which may lead to higher classroom involvement indices. The extraverted students would be more likely to be involved in both the introverted and extraverted classrooms. However, results from this study do not coincide with the findings in [13].

INTJ individuals are characterized as: independent; innovators; reorganizers; they enjoy new tasks which challenge their strengths; and they enjoy technical interests and are strong in mathematics. Engineering classrooms seem to be primarily INTJ environments where the fast-paced nature of the discipline does not encourage student involvement [17]. Involvement refers to brief, concise answers to questions and students are penalized for anything beyond. Since women are a minority in engineering classrooms, regardless of their extraversion, their status as minorities in the classroom may contribute to their low levels of classroom involvement.

This finding is similar with the findings in [14], which indicated that female students are more likely to be extraverts than introverts. According to [21], introverted students tend to be more successful in engineering than extraverted students. This finding leads to the provocative assumption that classroom involvement may not be necessary for success in the engineering discipline. Results from this study did not support nor reject the findings in [21]. It is possible that introverted students may have an easier time coping in an introverted classroom environment since it matches their learning style preference. However, introverted students may also be more at risk in such an environment since they are less likely than extraverted students to seek assistance inside or outside of class when needed.

Lastly, women who interconnected with males tended to have higher levels of classroom involvement when compared to women who interconnected with other females. One explanation of this result could be that such women see themselves as different from other women and more similar to men. In this case, these women are likely to identify with certain stereotypical male characteristics such as assertion in the classroom.

Male students tend to be more assertive and care less about how they are perceived than female students [27]. Such qualities are valuable in a field that is so competitive. Therefore, female students who are assertive and self-reliant may be more respected by their male peers and instructors, explaining why they remain in their engineering majors. These women, being more assertive than females who identified or interconnected with women, may make more eye contact with instructors, volunteer to answer or ask questions rather than passively wait to be called upon, and may be less afraid of what others think of them.

Societal gender roles teach women to be feminine. According to [27], feminine women are seen as less competent. This finding implies that women who want to be taken seriously for their abilities may adopt characteristics typically exhibited by males or connect to the gender identity labeled as male with the objective of being successful. If this phenomenon is allowed to continue, the engineering field and culture will lose its diversity by including only those who think and behave in a male-oriented fashion. Do women need to adopt male characteristics in order to succeed in engineering or does the engineering culture need to accommodate to women's strengths? This is a very interesting and provocative question that still remains extremely controversial.

CONCLUSION

The "leaky pipeline" needs immediate repair because we lose women before they ever contemplate engineering as a major. We lose the majority of them during their first year in their engineering disciplines and this attrition results in a diminutive group who complete their Bachelor of Science degrees in engineering who may then pursue graduate programs in engineering [5].

This study has added to the body of research that has investigated female students' minority status in engineering. This study was unique because it combined the use of learning styles, gender interconnection and classroom environment in its search to understand female students' level of self-reported classroom involvement.

Even though engineering classrooms tended to be introverted-thinking environments in this study, extraverted-feeling environments had more positive benefits for female students. The EF combination of classroom environments tends to have higher levels of female student classroom involvement. Understanding that students learn more when they are actively involved in the classroom leads to the clear objective of creating extraverted-feeling classroom environments in all disciplines [4], [9].

Another major finding of this study indicated that female students who possessed higher levels of connection and interest in male issues and concerns tend to have higher classroom involvement indices than women who possessed lower levels of connection in these areas. Although more research in this area is necessary to make more concrete conclusions, it may be worth discussing whether it would benefit female engineering students in the short term, to understand the advantages of adapting to such areas.

In assessing students' participation, instructors could evaluate active participation in discussion; contribution of relevant resources to the class; preparedness to class; acceptance of course requirements and constructive feedback and making contributions to the class [9]. When grading classroom participation, instructors need to be sure they give every student a fair opportunity to participate [4]. For the shy and quiet students, being prepared is very important. Assigning "guided journals" where students write their responses before class and share their comments in class is a way of helping these introverted students to be more comfortable in participating in class [3]. Other techniques instructors may use to increase the level of student classroom participation include allowing email entries to be part of class participation; coaching the quiet students to be more active participants in class; allowing at least one minute of silence after posing questions for students to prepare their responses; and allowing students to submit comment cards of their written responses of class questions [4], [16].

Based on this study's findings, it is the responsibility of higher education administrators to assist the faculty in understanding how they can design their classroom environments to be more feeling and extraverted in order to increase student involvement and overall learning. Such change in classroom environments may result in greater recruitment, enrollment, retention and graduation rates of not only women engineering students, but also racial minority and white male engineering students as well.

Reference [1] was on target when she concluded that intervention alone is not the final answer to increasing the number of women in engineering. The fact that science functions as a masculine field creates an internal frostiness that does not invite women into this circle. Its culture values independence, emotional toughness, objectivity and rational thought, which are associated with the masculine identity. Understanding the connection of science to masculinity may be the key to comprehending why there are so few women in engineering. By sending the message to women that they need to choose between careers in engineering or be true to their identity as women, society is not encouraging them to pursue engineering as a career. The culture of science was designed to fit the needs of men however; it can be redesigned to include the needs of women. This practice would very likely increase the number of women in engineering.

The goal should not be to change women's values and ways of thinking to fit that of men. Instead the goal should be to strive to challenge the culture within engineering to fit the needs of women as well as men [1], [5]. Our goal should be to diversify and excel by elevating to the next level, not to assimilate and keep the same level of quality. On a positive note, such change is not impossible to accomplish although it is not going to arrive without challenges. If we do not get started soon, it definitely will take a couple generations before significant changes in the current gender gap within engineering are visible [1]. The benefits of these recommendations for men, women, and society are quite clear. What does not make sense is why these recommendations are not yet implemented.

SUMMARY

Research in this area is critical to the field because it will bring society one step closer to understanding why women do not pursue nontraditional fields such as science and engineering at the level that men do. Research implies the chilly classroom climate is especially a problem for female students in engineering. This research project focused on the classroom climate for female engineering students in the hopes to identify strategies to recruit, enroll and retain more women in this field. In addition, this researcher hopes the data from this study will explain women's experiences in engineering and assist in strategizing methods in which to create a warmer more supportive classroom environment of female engineering students.

Practical implications of the present project include a) giving educators a clearer understanding of ways to design methods to counter the harmful effects of the present chilly classroom climate phenomenon in higher education; and b) improving educators' understanding of female students' learning styles, preferences in teaching styles and styles of communication. Most importantly, the number of women in engineering may increase due to the changes made; it may help to tear down some societal gender stereotypes; more female students may consider and have confidence that they could succeed in nontraditional fields at an earlier age; and finally, such a study could give a clear rationale for the existence of Women in Engineering Programs and women's support centers on college campuses.

The potential value of this study may include a) an explanation of how the classroom environment influences women's involvement in higher education and future career involvement, therefore increasing their contributions to society; b) the adoption of a fair and equitable teaching and learning environment for female students within the College of Engineering, thus diminishing the discrepancy in ratio of men to women in engineering; and c) the improvement of faculty teaching methods, teaching women to be more aware of their learning styles and steering administrators' policy decisions by demonstrating the importance of classroom environments to student learning.

TABLE I
REDUCED REGRESSION MODEL

Independent Variables	SETA TF	GIS Total Male	SETA EI	Constant
b	.909	2.876	-.322	55.94
SE b	.179	1.052	.164	3.988
ß	.485	.171	-.188	
Part *r*	.316	.171	-.122	
Partial *r*	.392	.224	-.163	
R^2 Change %	40.0%	3.3%	.3%	
t	5.071	2.735	-1.964	10.316
p	.000	.007	.051	.000

Reduced Regression Model Results for the Classroom Involvement Scale (CIS) Regressed on the Myers-Briggs Type Indicator, the Salter Environmental Type Assessment, and the Gender interconnection Scale , where $F = 38.40$, $df = 3, 142$, $p = <.001$, Multiple $R^2 = .669$, $R^2 = .448$, and Adj. $R^2 = .436$.

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