AC 2010-708: ADJUSTING GENDER-BASED RECRUITING STRATEGIES TO FIT THE APPALACHIAN PEER-MENTOR MODEL

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Introduction

The well-known document often referred to as "The Rising Storm"[1] suggested for the first time that even though the U.S. remains the undisputed leader in many research and development areas, the country is not getting young people into the pipeline to engineering and technology-based careers, nor is the country doing a good job keeping existing students in the pipeline. Less well known, ironically, is another important National Academy of Sciences document titled, "Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering"[2]. This report says in its Executive Summary,

> *Women scientists and engineers face barriers to success in every field of science and engineering, a record that deprives the country of an important source of talent. Without a transformation of academic institutions to tackle such barriers, the future vitality of the U.S research base and economy is in jeopardy." [In particular, while] women have the ability and drive to succeed in science and engineering, women who are interested in science and engineering careers are lost at every transition.*[2]

As part of a National Science Foundation* funded project, West Virginia University seeks to attract Appalachian-region high school students to science, technology, engineering and math (STEM) careers, with particular emphasis on recruiting females and underrepresented minorities in an effort to begin to offset regional STEM numbers that are typically half that of neighboring states. The objective of this study was to better understand how to effectively recruit and retain qualified girls from Appalachian high schools into STEM educational paths. The lessons learned from this study will guide future recruitment and retention practices to enhance the probability that Appalachian women will ultimately enter STEM-related careers as scientists or engineers.

National Gender Differences on Achievement

In the U.S., evidence unequivocally points to the fact that fewer girls than boys show high science achievement, have positive attitudes and values toward science, and later choose science-related careers. Males and females may be differently affected by risk factors during school age and beyond.[13, 14, 15, 16, 17, 18] For example, motivation profile analyses show that females from grade six to junior college are more self-determined, but less externally-regulated and motivated

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toward science-related activities than boys.[18] With respect to achievement in courses and more particularly on advanced placement exams, females are more likely to excel over male peers in language arts, and males are more likely to excel in science.[13, 19, 20, 21] Progress in addressing this problem is evident since striking gender inequities in education[20] and the under-representation of women in science were illuminated decades ago.[23] Nevertheless, marked areas of science education inequity remain.[24, 25] Females have closed the gap on math and made significant progress on science components in national and international assessments such as National Assessment of Educational Progress (NAEP), Third International Mathematics and Science Study (TIMSS), and Programme for International Student Assessment (PISA) and in taking challenging science courses in high school, but still earn fewer advanced placement credits for college.[13, 20, 26] Even though more females enter college with higher educational aspirations than males, fewer degree recipients in computer science, engineering, and some physical sciences are women.[20, 26, 27]

Career Development in Appalachia

By almost any measure, the difficulties in attracting high school students to STEM careers are enhanced in Appalachia, and especially in West Virginia. Tang and Russ suggest the reason that the literature on career development for the people of Appalachia is sparse, is the "people of Appalachian culture have become an invisible minority because they do not appear outwardly different from mainstream Americans."[28] The authors of this paper found that for gender differences, the literature is sparser still.

Declining population and particularly out-migration of college graduates with in-migration of non-high-school graduates characterizes this region.[2] In fact, McDowell County in southern West Virginia has the lowest in-migration of the 400-plus counties making up all of Appalachia.[3] Over 20 percent of US residents have college degrees, but only about 14 percent of residents in Appalachia have college degrees, with West Virginia as the lowest state on this measure.[4] In the most rural Appalachian areas (subtracting out the large metropolitan areas), the college graduation rate averages only 7.75 percent, with Lincoln and McDowell counties in West Virginia at the very lowest end of that scale at 4.72 percent and 4.59 percent, respectively.[5] Among all 13 states comprising Appalachia, northern Appalachia, which includes West Virginia, has the highest mortality rate at 10.24 persons per 100 residents compared to the U.S. rate of 8.8, and the lowest fertility rate among women 15-44 years of age, at 55.42 births per 100 residents compared to the US rate of 66.70.[7] Residents in the region of Appalachia have lower median family incomes than the rest of the U.S. and in the very poorest areas, the disparity has actually accelerated.[8]

Not surprisingly, the Appalachian region has high unemployment with West Virginia's McDowell County second highest in the late 1990s at 22.74 percent for men and 20.84 for women.[9] One major industry in Appalachia, coal mining, employed 229,494 workers in 1980, but dropped to 99,801 jobs by 1996. The manufacturing sector in Appalachia lost 202,173 jobs in the same period.[10] The poorest regions in Appalachia compete with more affluent states and even Appalachian metropolitan areas in attracting the jobs of the future.

As University faculty and people who live in Appalachia, we have known anecdotally for years that most young people in our region, and particularly first generation college girls, are reticent to move away for college, for a new job, or even to go to an engineering summer camp. We call this the "invisible fence" theory, as if there is an invisible barrier to leaving their home. Some have said "Morgantown is too big of a city for my parents to visit." Students, more girls than boys, have actually asked if after college, they can go back and work in their tiny hometown, and even live near their parents. Among those that leave their rural communities and graduate from college, some will give up a promising job out of state in order to come back to their small hometown to work for half of their former salary.

There seems to be some support for the anecdotal "invisible fence" theory, such that it might prevent qualified students from pursuing a STEM field. Tang and Russ[28] suggest in the following abbreviated list certain factors that characterize rural Appalachian families as they apply to career selection:

- mistrust of outsiders;
- seek help first from family or local community members;
- career pursuits focusing on individual goals may not be acceptable because they surpass or conflict with family career stations;
- mothers that tend to spoil their sons, probably in an effort to keep them within the family [or region];
- extremely strong church and community ties;
- patriarchal socialization with gender-specific career choices;
- preference for the concrete in career choices including site visits rather than reading about or hearing about career options
- preference for oral rather than written information (see Tang and Russ[#] for an extensive literature review)

Tang and Russ report that "parents are distrustful of career education programs that prepare their children for opportunities not available in their home area, and that could require them to leave the family. Many [parents] feel they are in contention with the schools over the future of their children."[29] Judging by the extensive evidence presented by Tang and Russ, there may be some real basis for the "invisible fence" theory, even if the “fence” is more metaphorical than real. If Appalachian parents do not want their children to move away from home for work or for college, and if the children have no role models to suggest anything different, might there be a model for moderating that stress? How do these students learn about STEM and engineering careers?

Adapting the "social stress" model

The Rhodes and Jason "social stress" model says that the "likelihood of an individual engaging in drug abuse [or un-adaptive behavior] is a function of the stress level and extent to which it is offset by stress modifiers such as social networks, social competence, and [social] resources” [30]. It was originally applied in psychosocial research in the 1980s [30,31] and its application to bicycle safety, alcohol abuse among rural adolescents, smoking and substance abuse, among other areas, has been described thoroughly elsewhere [32]. The model fits especially well in describing the sets of ecological and psychosocial stressors encountered by Appalachian youth trying to find a way to survive and adapt under difficult circumstances, and offsetting these stresses with "moderators, " ways to eliminate or at least reduce the stressors in order to make more adaptive decisions.

In impoverished and under-resourced Appalachian communities, the stressors are unique and include, as the literature review here suggests, poverty, out-migration, unemployment, lower college completion rates, lower family incomes, higher dependency rates, major industries in flux, isolation by geography, absence of role models, a penchant for gender-specific career choices, and others. The authors propose that these stressors can be reduced by exposing Appalachian females to age and culture-matched peers through a variety of planned activities as shown in Figure 1. If their preferred channels of information reception and interests toward STEM fields can be measured effectively, then recruitment and retention efforts can be shaped accordingly.

Appalachian Regional Stressors	Moderator Category [30,31]	Project Interventions
High unemployment	Social Networks	Peer influence, i.e., tutoring, recruiter, adviser, roommate
		Web course
Low college completion rates		Summer camp
		Virtual communities
Out-migration of college graduates	Social Competencies	Peer influence, i.e., tutoring, recruiter, adviser, roommate
		TIME Kits
Low family income		Calculus readiness
		Summer camp
Industries in flux	Social Resources	Peer influence, i.e., tutoring, recruiter, adviser, roommate
		Freshman program
Affinity for home and community		Summer camp
		Undergrad. Engineers
Geographic isolation		

Figure 1: Adaptation of the Social Stress Model to Appalachia STEM Students at West Virginia University *(revised: 2009)*[33]

A central part of WVU's "Engineers of Tomorrow" (EoT) project is comprehensive mentorship (peer influence) defined loosely as planned relationships among high school students and engineering undergraduate or graduate students for the purpose of sharing information about college life, college courses, career choices, and engineering as a profession. Mentorship channels are interpersonal at the summer camp, for example, but also include virtual communities such as Facebook; special help for engineering students in freshman calculus and physics courses; and special on-line "bridge courses" to foster interest among high school students in engineering and STEM careers generally before they get to college. Planned peer mentoring opportunities are also arranged when engineering undergraduates go out to their former high school with a design exercise, and details on exploring STEM careers. In this update of the original 2009 model,[33] *virtual communities* and *undergraduate engineers* who lead engineering design exercises in their former high schools were added to increase the interaction between peers within an engineering major with prospective students. Both of these peer "interventions" serve to reduce social stresses on Appalachian youth because each represents a channel of age and culture-matched peer-mentoring. Peer mentors in this context would be young, paid, culturally-matched, age-matched, West Virginians (or regional) undergraduate or graduate engineering students who have overcome some of the stressors and barriers themselves; who have the same regional accents; who share the same hunting stories and football rivalries, and who may be someday employed in the same large industries back home.

Research Objectives

In evaluating how recruiting and retention programs may be adjusted to better reflect the interests and preferences of Appalachian girls toward STEM careers, and engineering in particular, the following research questions were posed:

1. Do Appalachian girls report confidence in their abilities to do demanding college level work and manage their time effectively?
2. Do Appalachian girls who are potential STEM majors indicate a preference for guidance/assistance from peers of the same gender when they and their family visit a college?
3. Do Appalachian girls who are potential STEM majors indicate a preference for guidance/assistance from peers of the same gender if they experience academic difficulty and seek assistance once at college?
4. Is having an engineer in the family a key influence on career path for Appalachian girls?
5. What kinds of demonstrations at local high schools would appeal to Appalachian females to broaden their understanding of what engineers do?

Research Methods

Summer camp is a key part of an NSF project to increase STEM enrollment. It is an intense, peer-supervised, one week, residential, academic and socializing activity designed to give rural, Appalachian high school students of both genders an early college simulation with an engineering focus. Each year, an IRB approved survey was used to gauge the interests, preferences and level of understanding of students immediately following their summer camp activities. Beginning in 2008, survey data was collected and the results were analyzed by racial affiliation and gender.

For the purpose of this study, a peer mentor has been operantly defined [33] as an advanced high school, undergraduate or graduate student who is *age-appropriate* (16 – 24 years old), *culture-appropriate* (Appalachian-born or raised); *major-appropriate* (engineering or one of the nine NSF-approved STEM majors at West Virginia University *and skill-appropriate* (peers who have mastered specific academic subject(s) themselves). These mentors taught or assisted in instruction or activities during the summer camp, and were resident advisors in the dorms and during evening recreation activities. They were paid volunteers selected to aid in providing information about admissions, testing, tutoring, career paths, college life, and STEM topics. Using these paid volunteers facilitated an attempt to discover how to make effective use of Appalachian peer mentors in high school demonstrations and "first college contact" situations and to use Appalachian peer mentors in tutoring, counseling and advising situations if suggested by the data.

In 2008 and 2009, a voluntary IRB approved survey was administered to student participants at an engineering summer camp (n=107). In addition to demographic information, survey items discussed below include what types of engineering, if any, might appeal to female participants, whether boys or girls report confidence in their abilities to do difficult math, manage their time, and excel on SAT/ ACT tests. Inquires about types of high school demonstrations that would appeal to the girls were also included.

Research Results

Participants were, on average, 15 years old and entering grade 10 in the fall; 36% were female and 64% were male; 65% were White/Caucasian and 33% were African American. While the percentage of female students who attended the camp was higher than that of female students enrolled in engineering undergraduate programs nationally, it was lower than the representation of female students in high school. Indeed, the number reflects active recruitment of female (and minority) high school participants in summer camp.

Figure 2 presents participants' evaluation of whether boys or girls are better at time management, non-engineering course work, difficult math, and math or verbal components of the SAT. Female participants rated themselves better than boys in all areas, with the largest difference in time management and the smallest difference in SAT verbal. Repeated measures ANOVA indicated a significant "between subjects" main effect of gender [$F(1, 103) = 23.11$, $p < 0.05$, partial $\eta^2 = 0.18$] and a significant "within subjects" main effect of question after Greenhouse-Geisser correction for a violation of sphericity [$F(3.09, 318.23) = 2.90$, $p < 0.05$, partial $\eta^2 = 0.03$]. There was no significant interaction between question type and gender.

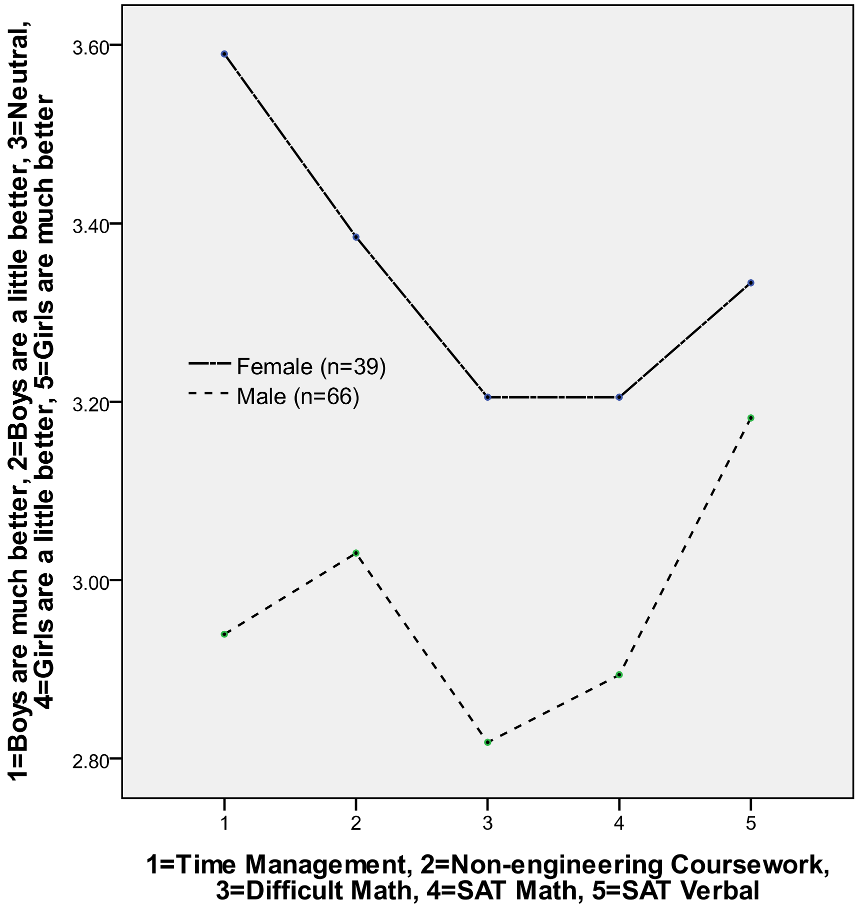

Figure 2: Participants' Evaluation of Whether Boys or Girls "are better at …"

Figures 3 and 4 present participant's preferences regarding who to talk to when they visit campus and who to receive help from if they encounter difficulty in college classes, respectively. Both males and females preferred talking with other students over graduates or professors when visiting campus and were relatively split between peers and professors when needing help with coursework. Responses were highly contingent on gender in both cases [$\chi^2(5) = 65.87$, $p < 0.05$ and $\chi^2(3) = 39.08$, $p < 0.05$, respectively]. Odds ratios indicated that females were 61.3 times more likely than males to prefer talking with a female when they visit campus and 17.4 times more likely to prefer help with challenging coursework from females.

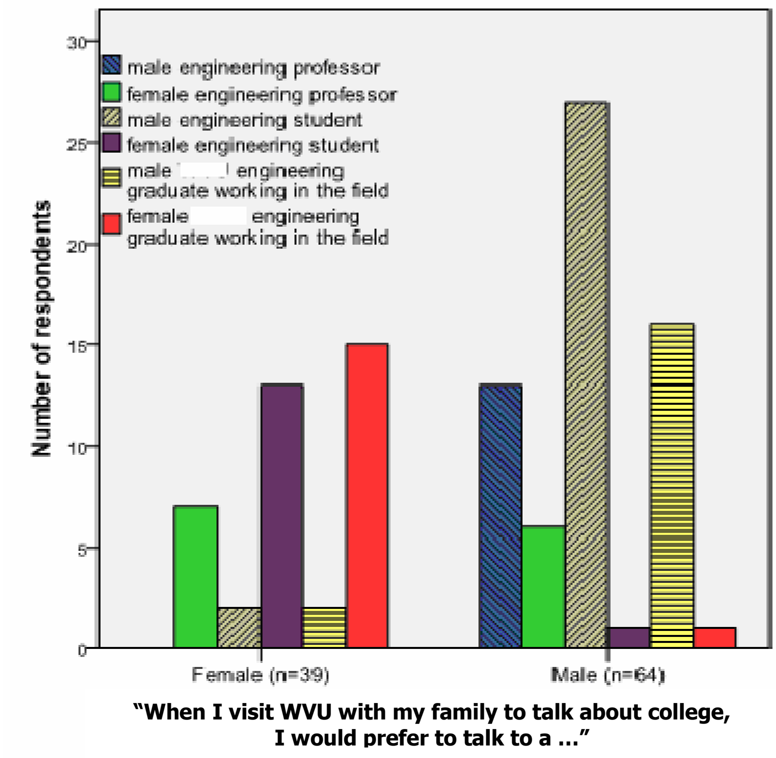

Figure 3: Participant's Preferences During Campus Visits

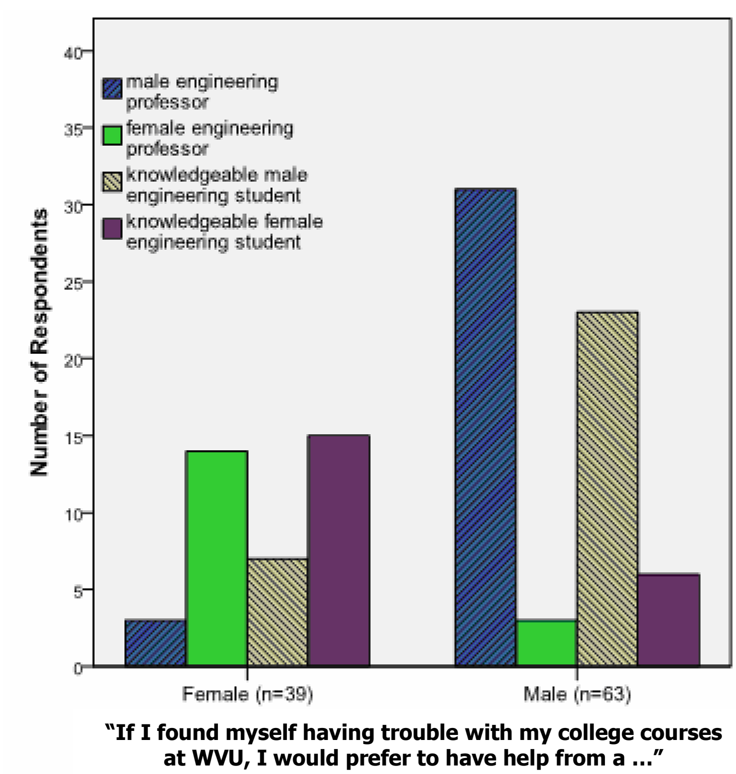

Figure 4: Participant's Preferences for Retention Efforts

Girls and boys had similar incidence of an engineer in their family (45% vs. 53% respectively), but those engineers were overwhelmingly male (38 out of 45), as shown in Figure 5. Girls (n=17) rated the influence of an engineer in the family on their educational/career decision making slightly higher (mean rank = 26.97) than did boys (n = 33, mean rank = 24.74), but a Mann-Whitney U test indicated that this difference was not statistically significant, [$U = 255.5$, $p = 0.57$, $r = 0.08$].

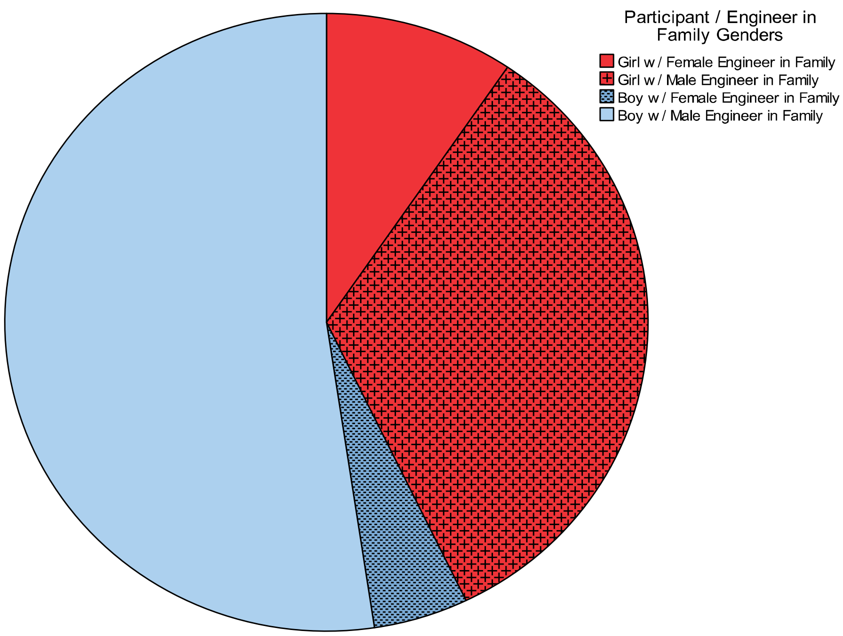

Figure 5: Correspondence Between Gender of Participant and Gender of an Engineer in the Family (for those who had one or more relatives who were engineers, n=45)

Figure 6 shows the significant difference found between males and females regarding their preferences for who should give presentations in their high schools [$\chi^2(5) = 21.56$, $p < 0.07$].

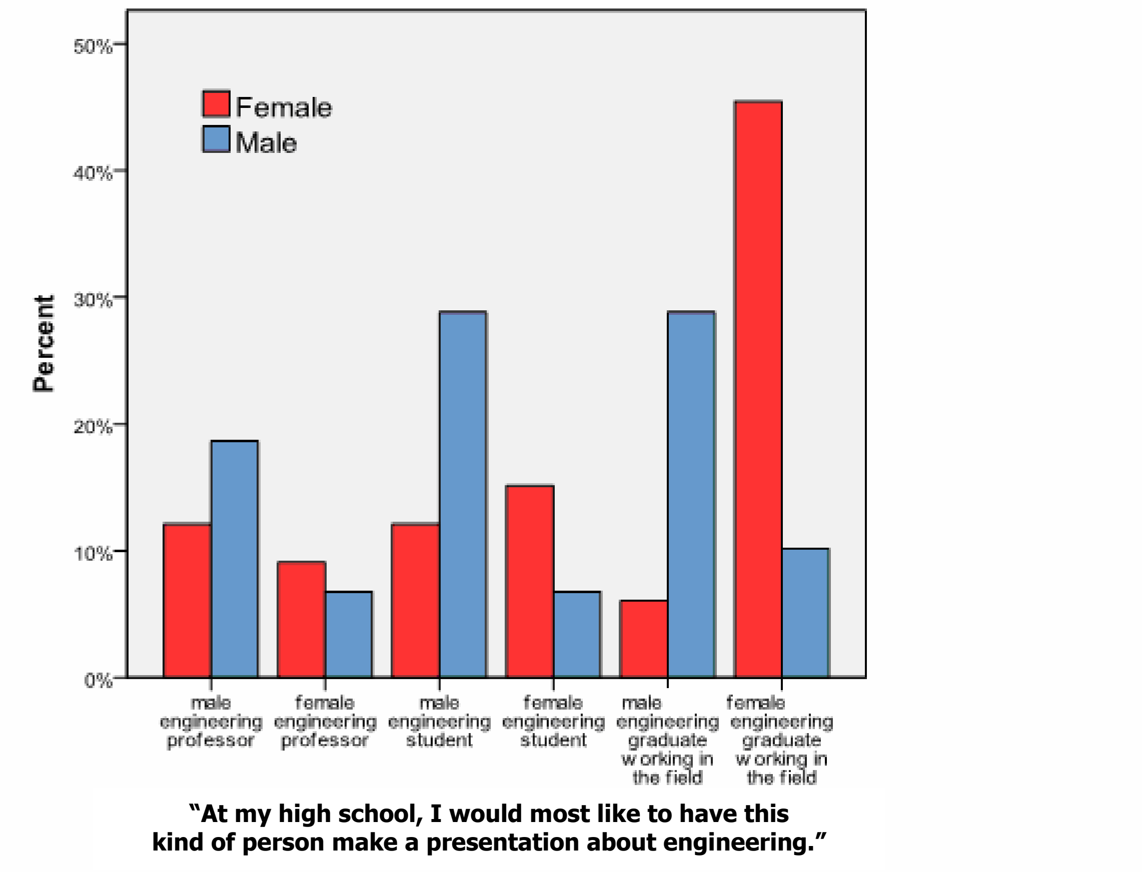

Figure 6: Preferences for High School Presentations, (n=45)

Student preferences appear to be split by gender. Females clearly want to hear about engineering and related career choices from other females, and especially from those who are currently working in the field, while male high school students prefer to hear presentations from male professors, students, and engineers.

Figure 7 shows, however, students of both genders agree on the type of presentation they would like to see in their high school. There was no significant difference between males and females regarding their preference for what types of activities in their high schools would most interest them in engineering at WVU [$\chi^2(1) = 2.47$, $p = 0.12$] All students prefer realistic, hands-on projects in which they can actively participate over a lecture about engineering and its related careers.

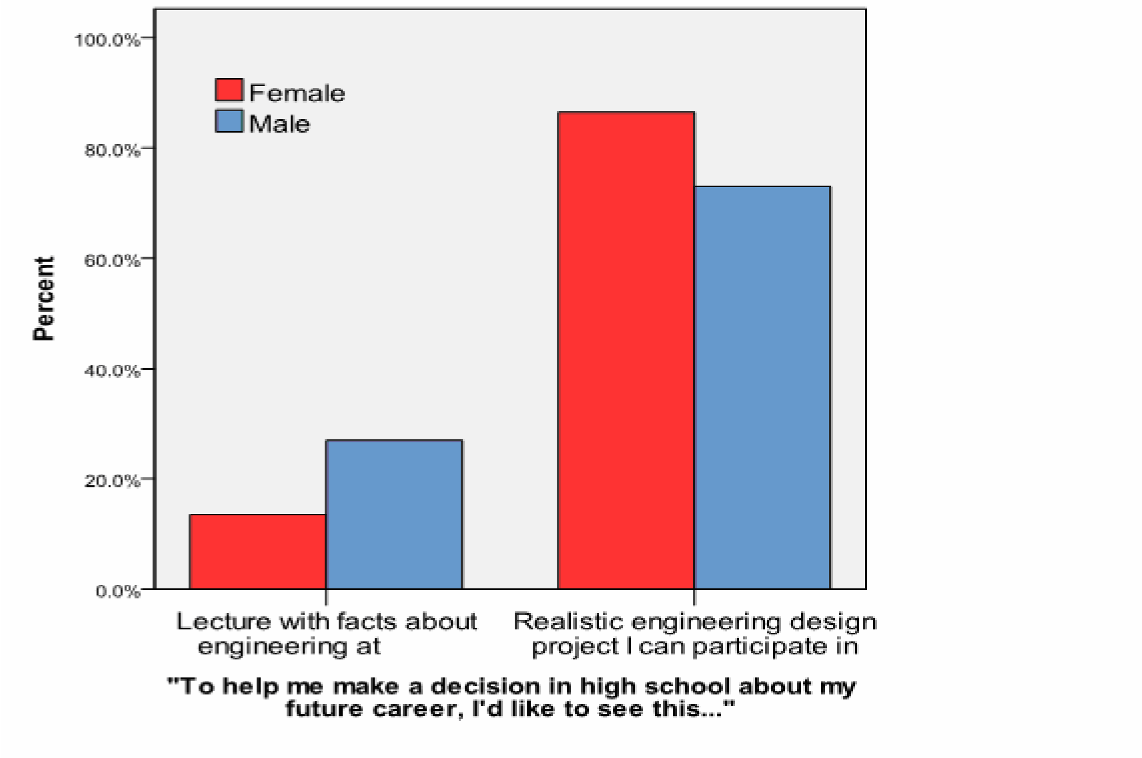

Figure 7: Preferences for Type of High School Presentation

Summary and Conclusions with Discussion

From two years of survey data collected through an NSF-supported summer camp, the following salient points are concluded. First, Appalachian girls are far more confident than boys in their academic abilities, such as difficult math, SAT prep and time management. This confidence may positively affect their persistence in STEM fields, once they decide to pursue a STEM career. The link between confidence in ones abilities in these areas and persistence in pursuing a STEM field needs to be investigated further. If confidence in ones ability is positively correlated with STEM persistence, then, perhaps, recruiting is the major hurtle to producing more female STEM graduates.

Second, during campus visits, female prospective students prefer to talk with female students, faculty, and engineering professionals while male students prefer to talk with males. This result is really not a surprise. Previous research indicates that students relate most effectively to similar peers. While not surprising, the result is significant for college recruiters who want to recruit females into STEM fields. In planning campus visitation events, care should be given to who is presenting the STEM major and career information to prospective students.

Third, when students have academic difficulty, again female students prefer to get help from female students and faculty while male students prefer to get help from male students and faculty. These results are important to consider when staffing tutoring programs and learning centers. There is concern that while the percentage of female faculty has increased in some of the STEM fields, there are very low percentages of female faculty members in most engineering colleges. While female faculty provide excellent role models for students, these results suggest that the deficit can be offset, somewhat, by supplying a higher percentage of female student tutors, advisors, and learning center staff in the various "help centers" available on most college campuses. Administrators who want to increase retention of females in STEM fields will want to recruit upper level female STEM students to work as tutors and mentors for freshmen and sophomores.

Fourth, having an engineer in the family is not especially important to career selection among Appalachian high school girls, especially since most of their related engineers are male. What is unclear in this investigation is whether or not Appalachian high school girls, or any high school girls, would be influenced by having female engineers in their family. Since there is such a low percentage of female engineers, in general, and an even lower percentage of female engineers in Appalachian families, this effect cannot yet be measured. Perhaps, if programs to recruit and retain more females into STEM fields, and especially in to engineering, are successful, this problem can be investigated at some future date.

Fifth, while all students prefer to have engineering career information delivered through a realistic engineering design project at the high school, having those activities be led by a working female engineering graduate or female engineering student may positively influence more female students to consider pursuing engineering. Simply stated, all students want to see "engineering in action" from someone with whom they can relate, which is, in theory, someone who shares several characteristics with themselves. Hence, to encourage female students to consider engineering careers, it makes sense to have female engineering students or young graduates visit high schools to lead hands-on "engineering in action" activities for all students. This result may be relevant and important to all colleges with outreach programs designed to increase females to enroll in STEM fields.

Finally, the data and results presented indicate, indirectly, the students' preference and need for information, mentoring, and support from current engineering students and professionals with similar backgrounds. These results are especially true for female students and important for anyone who wished to recruit or retain females in STEM fields. While the research focused on gender differences in communication preferences, the student sample was from Appalachian students who participated in an engineering summer camp, so these results are also relevant to and significant for anyone trying to recruit Appalachian females into STEM programs and to retain them once enrolled. In keeping with the peer-mentor model, Appalachian universities should provide gender and age-matched recruiters, preferably with an Appalachian heritage. Schools trying to recruit and retain Appalachian females must invest in providing Appalachian or regional female role models to go to high schools to lead interesting and realistic, hands-on, engineering activities to groups of students, and to encourage and mentor students to continue to pursue math and science in preparation for potentially rewarding STEM careers. On-site programs at universities designed to give students a "taste" of engineering, such as the popular summer camps run by many universities, must employ female student and faculty role models to teach content and to interact with students as much as possible. Including interaction with female engineers working outside of academia is an important element in both recruiting avenues. Then, as the carefully recruited students move into university programs, again, female students and professionals are needed to continue to encourage and to help these students as they begin their collegiate academic preparation for a STEM career. Though there is currently a recognized shortage of female engineering faculty, perhaps the effects of this shortage can be offset by providing gender, age and culture-matched peer mentors, recruiters, academic advising assistants and tutors. If these efforts are successful, perhaps in time, the shortage of female engineers and female engineering faculty can and will be eliminated.

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