AC 2009-1733: GENDER DIFFERENCES IN EXPRESSED AND MEASURED INTERESTS IN ENGINEERING-RELATED FIELDS OVER A 30-YEAR SPAN

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Gender differences in expressed interests in engineering-related fields over a 30-year span

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This study examines gender differences and historical trends of high school student interest in engineering based on ACT data on expressed interest compared with that of students' and ability. Changes have been observed in the interest in engineering fields over time most likely because of societal influences. These influences are especially seen in computer related fields causing speculation that both males and females were influenced by the dot com era but that only male interest was piqued due to the rise of computer games in the late 1990's. Another interesting observation is the number of students stating they are interested in engineering careers but who minimally or poorly prepared based on their ACT math scores. This raises the question of whether these students understand what engineering is, and whether they have been informed of the demands of the major. These students are likely to face retention issues in engineering fields and are often candidates for math remediation. By better understanding the societal influences as well as gender and ability disparities we will have a better understanding of what needs to be done in order to reverse the current trends of gender disparity and lack of interest in engineering fields.

For almost a century, researchers have observed gender differences in the expressed and measured interests of adolescents and young adults. These differences exist across career and academic interest domains and may partly explain gender disparities in several occupational fields including engineering. In national samples, boys and young men have consistently reported higher interests in engineering relative to their female counterparts. Moreover, recent statistics published by the Commission on Professionals in Science and Technology (CPST; http://www.CPST.org[1]) show declines in the percent of first-year female undergraduate engineering majors from a recorded high of approximately 20% in 1996 to approximately 15% in 2003. Further, womens' enrollment in engineering graduate programs is lower than all other NSF identified science and engineering-related graduate programs (National Science Foundation, 2005[2]). Not surprisingly, there exists a large gender disparity in engineering employment. According to the U.S. Department of Labor[3], less than 15% of all employed engineers are women. This representation plummets in certain engineering specialties (e.g., electrical and mechanical) such that less than 10% are women.

In contrast, women make up almost half of the labor market in life and physical sciences, and over 25% of the labor market in computer and math-related occupations. The fact that engineering continues to lag behind these other technical fields is particularly surprising given the considerable effort and resources allocated to reverse these gender

disparities. Similar efforts in the sciences appear to have paid off. For example, the National Science Board[4] reported increases of almost 15% in the number of women receiving their bachelor's degrees in biology and physical science between the years 1983 and 2002. During that same period, engineering realized only a 7% increase in the number of women receiving degrees.

There have been a number of theories to explain the gender disparity in engineering, from different life choices and priorities to discrimination. Recent theories proffered by vocational psychologists emphasize the central role that career and academic interests play in the career-decision making of young men and women – and evidence in support of this role is mounting (Farmer, Wardrop, Anderson, & Risinger; 1995[5]; Lent, et al., 2005[6]; Schaefers, Epperson, & Nauta, 1997[7]). Thus it may be important to consider expressed interests when examining gender differences in career aspirations or attainment.

Career interests and choice

Career and academic interests are pivotal constructs in career decision-making and have repeatedly been shown to influence individuals' selection of college majors and careers (Lent, Brown, & Larkin, 1986[8]; Nauta & Epperson, 2003[9]). Although no one commonly accepted definition exists, most authors agree that interests can be defined as likes for, dislikes for, or indifference to objects, occupations, persons, tasks, or activities. Today, most interest inventories (also referred to as measured interests) assess interests for school subjects, occupational titles, work-related activities, and vocational activities. Students with science and engineering-related measured interests choose related majors at a higher frequency, and are more persistent in those majors. A recent meta-analysis suggests that interests begin to stabilize in early adolescence (Low, Yoon, Roberts & Rounds, 2005[10]) indicating potential for early career intervention. It also appears that STEM-related self-efficacy beliefs are important co-determinants of college major choice and performance. Self-efficacy beliefs are developed through a number of psychological mechanisms – the most influential being personal performance accomplishments. Together, these psychological constructs account for substantial variance in career and academic choice, implementation, persistence, and a satisfaction.

The purpose of this paper is to provide quantitative evidence on the timeline and assessment of historical trends of career and major interest development to provide a timely intervention that will reverse the current trend towards a decreased discrepancy between genders in STEM majors and careers. This paper highlights recent historical trends in those interests, and to uses this data in order to explicate the relations between interests and academic achievement. By investigating the historical trends in gender differences in interests as well as illuminating trends on interest and skills we are able to better understand who is choosing an engineering major, and potentially answer why they are doing so. We do so in an effort to further understand how and when these gender disparities develop, to track these gender disparities over time, and to propose possible solutions that may assuage the current gender disparity.

Participants and Methods

The present research was conducted using archival ACT, Inc. data from the last 30 years (1974-2006). The total number of examinees included in these samples exceeded 38 million with gradually increasing sample sizes from 1974 (N= 744,050) to 2006 (N=2,037,479) due to the increased number of students aspiring to college and the increased use of the ACT exam for that purpose. Demographic information also varies by year. Girls outnumbered boys during early study years (e.g., 1974; 53% vs. 47% respectively) and even more predominantly in later study years (e.g., 2006; 56% vs. 44% respectively). Not surprisingly, increased racial/ethnic diversity was observed across study years. For example, in 1974, over 70% of sample participants were Caucasian (6% African American, 2.5% American Indian, and 2.5% Hispanic/Latino). In contrast, in 2006, Caucasians made up only 63% of examinees (11% African American, 1% American Indian, and 8% Hispanic/Latino, and 3% Asian American). Statistical data analyses is conducted using SPSS software, whereby both high school students' interests and historical trends were analyzed in reference to specific career aspirations and college majors. Every student taking the ACT during those years was included in the current study. (estimate current number). Demographic information includes gender, ethnicity, religious background, socio-economic status and geographic location were all part of the available data source. ACT scores, as well as expressed interests and general demographic information were compiled. Expressed interest in academic major and future career were assessed on the ACT registration profile using two items (e.g., which college major [program of study] do you plan to enter and what career aspiration do you have). Students were presented with over 300 choices that included 25 engineering and 3 computer science majors. Students were also asked how certain they were of their college major and career choice. Only students who indicated they were fairly or very certain of their choice were included in subsequent analyses; thus ensuring that students with measured interest were the focus of the study

Results

Comprehensive reviews of all the results of this study are beyond the scope of this preliminary paper. As such, we will focus on results from the historical analysis with an emphasis on gender differences and on preliminary results from our analysis of the relationships among achievement, and occupational and educational interests.

Results from our analysis of historical data suggest that gender differences in engineering-related interests have existed since the early 1970s and persist to this day. However, gender differences seem to be more pronounced in some areas of engineering and less pronounced in others. Figure 1 shows the expressed interests of male and female students in several engineering college majors and highlights the importance of historical analyses of interests. For example, pronounced gender differences can be observed in majors such as mechanical and electrical engineering (see Figure 1). In general, it appears as though expressed interest in engineering majors has steadily declined for both women and men from peaks observed in the early to mid 1980s. Interestingly, computer engineering experienced a second peak in 1999/2000, which could reflect the rising

popularity of computer video games. Of significant interest is the differences between the peak in the early 1980's and that of 2000 is that in the 1980s both men and women expressed a significant rise in interest, with the women nearly reaching the same level of interest as the men. The peak of 2000, however, was predominantly noticeable among males. This observation exemplifies the potential of societal influences on engineering major interests.

In Figure 1, focus is placed on the top four most populated majors. The interests in computer and information sciences (top right panel) show the speculated impact of sociocultural events such as the introduction of the personal computer in the early 1980s. Within a 6 year period, expressed interest in computer and information sciences increased nearly fourfold with equally precipitous drops in subsequent years. The interest levels of women rose proportionally even higher than those of men, thus bringing female interest in these fields much closer to male interest for the only time in this 30 year period. A similar spike can be observed in the mid to late 1990s (dot com, Y2K, consumer demand for internet-enabled services) but only for male students. The observation of trends in electrical and mechanical engineering suggests that while male interest in electrical engineering is on the decline, male interest in mechanical engineering has risen progressively since 1974. Female interest in both of these fields has more or less tracked male interest.

Figure 2 shows preliminary results from an analysis of engineering college major of students by past achievement (ACT math scores). The last year (2006) of the available data was analyzed in order to understand the current level of disparity between interest and measured ability. These data clearly highlight the large number of students who are expressing interests in engineering-related college majors and careers but who may lack sufficient mathematics preparation to succeed in these pursuits. The students in the lowest group (ACT scores under 20) are unlikely to be admitted to these programs at most universities. The students in the marginally prepared group (ACT from 20-26) are often admitted but placed in pre-calculus or similar remedial programs. Interestingly, differences were observed in this incongruence by engineering subspecialties. For example, the largest number of "interested but marginally prepared" students expressed interest in computer-related majors and mechanical engineering. Large numbers of these students were also observed in the General Engineering category. In contrast, more students with adequate to excellent mathematics preparation can be seen in aerospace, biological and chemical engineering areas. This discrepancy illuminates the potential differences in retention in different engineering fields. This also is indicative of students' lack of understanding of what engineering majors actually mean and what will be expected of them. Earlier advising/career information might allow students to better prepare themselves for these disciplines. It is equally possible that this advising would discourage them from pursuing the major altogether.

Figures 3 and 4 show students' career interest data vs ACT scores (academic achievement) but presented separately for female (Fig.3) and male (Fig.4) students. These results demonstrate that the inconsistency between ability and interest in engineering fields is often greater in males than in females.

Discussion and Conclusion

Results from the present study clearly demonstrate the sustained presence of gender differences in expressed engineering interests and extend our understanding of these differences through a historical perspective and an analysis by engineering subspecialty. Further, our results highlight the possibility that sociocultural events can have immediate and relatively profound influences on the expressed interests of American youth. This data may also give hope that programs designed to advertise the impact of engineering in society may lead to an increase of student interest in these fields. It also shows that the response to society events does vary by gender, so it is important to be sure that these messages appeal to both men and women students.

Our preliminary analysis of the relationships between expressed interest and math achievement highlight the importance of early and aggressive career and educational guidance beginning as early as middle or high school age. Clearly, students with math achievement scores of less than 20 will struggle in most pre-professional engineering training programs yet there appear to be large numbers of these students who express interest in these fields. High school counselors might use data such as those shown in Figure 2 in an effort to help students identify more realistic career options or to target students for math remediation in high school. These data may also be used by policy makers, educators, colleges, and employers to understand the engineering pipeline and to use this knowledge to better prepare students for careers in STEM fields.

Given the identification of "interested but marginally prepared" students, we intend to follow up with additional analyses that will enable us to identify "prepared but not interested" students and students who are mathematically prepared, have measured interests congruent with engineering-related fields (note: measured interests not described in this study but available to the investigators), but who express interests in non-engineering fields. This last category of students might represent a viable recruitment pool for engineering programs. It is plausible that students in this category have not been exposed to engineering-related experiences or career information.

Taken together, these observations argue for continued efforts designed to encourage young women to enter engineering and related careers through early intervention (most likely from teachers and guidance counselors, although parents and the general public may also be a viable resource). Based on existing research, such efforts should focus not only on identifying and promoting math, science, and engineering interests in young women, but also on the past math and science achievement of these students. Strong past achievement is likely to be associated with strong positive self-efficacy beliefs, which, according to the literature, are potent determinants of behavioral initiation and persistence. (Lent, Lopez, Brown & Gore, 1996 [11]).

Efforts to increase the number of women in science and engineering fields might be further strengthened by population studies describing the interests and achievement of current secondary education students. For example, how many U.S. high school seniors currently express interests in engineering and have the mathematics achievement to be

successful in a rigorous undergraduate engineering curriculum? Such data would be quite valuable. With this in mind, educators and policy makers could target interventions designed to enhance awareness of engineering careers to students with strong academic capabilities and who have expressed measured interests congruent with engineering, but who are not explicitly aspiring to engineering-related careers. Alternatively, academic enrichment programs might be targeted to students with measured and expressed interests, but who lag behind in their academic preparation. These as well as other related issues will be analyzed and discussed in future publications.

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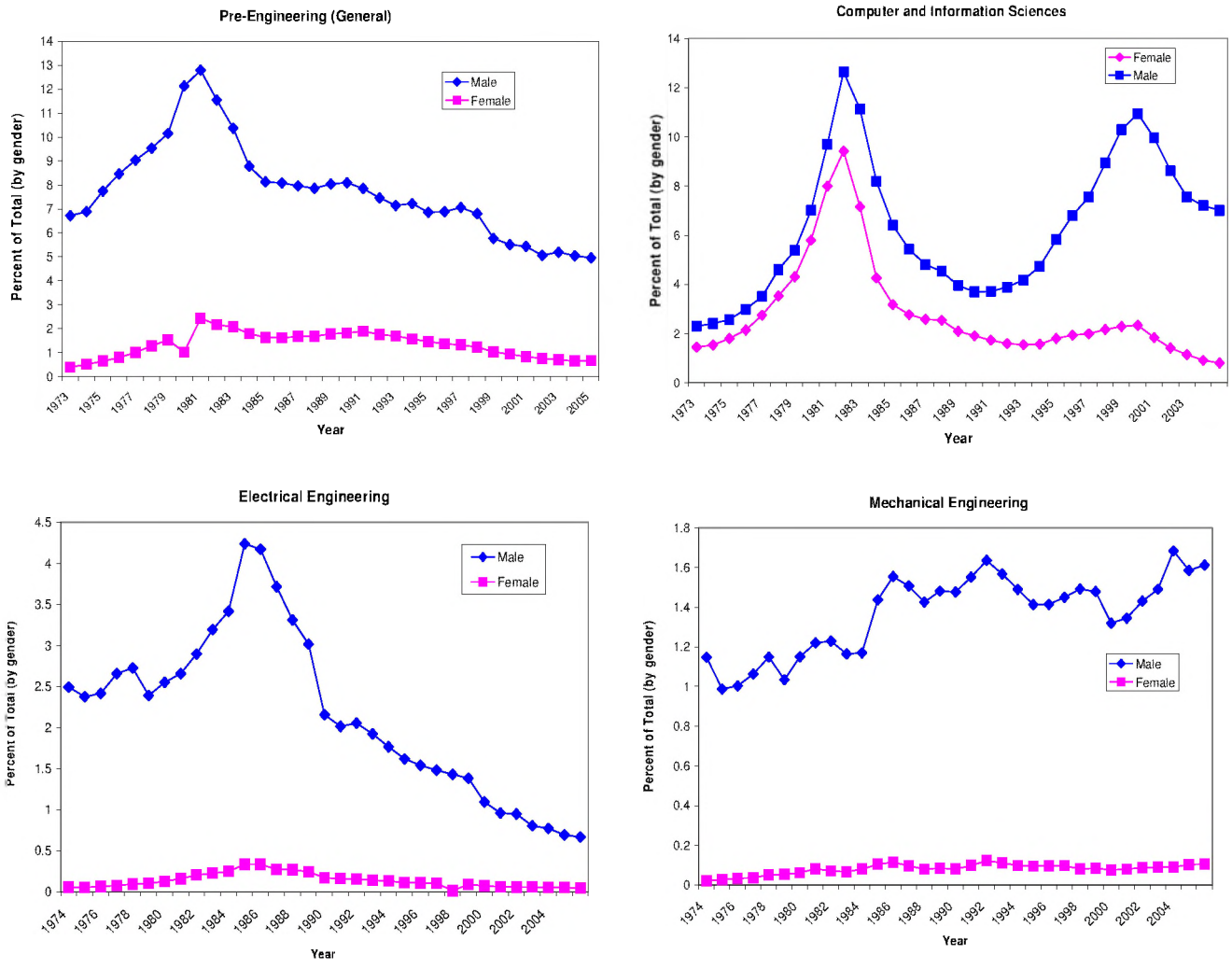

Figure 1
Expressed interest in college major by gender for the four most popular engineering disciplines: Pre-Engineering (general engineering, covers all degrees in many programs), Computer and Information Sciences, Electrical Engineering, and Mechanical Engineering

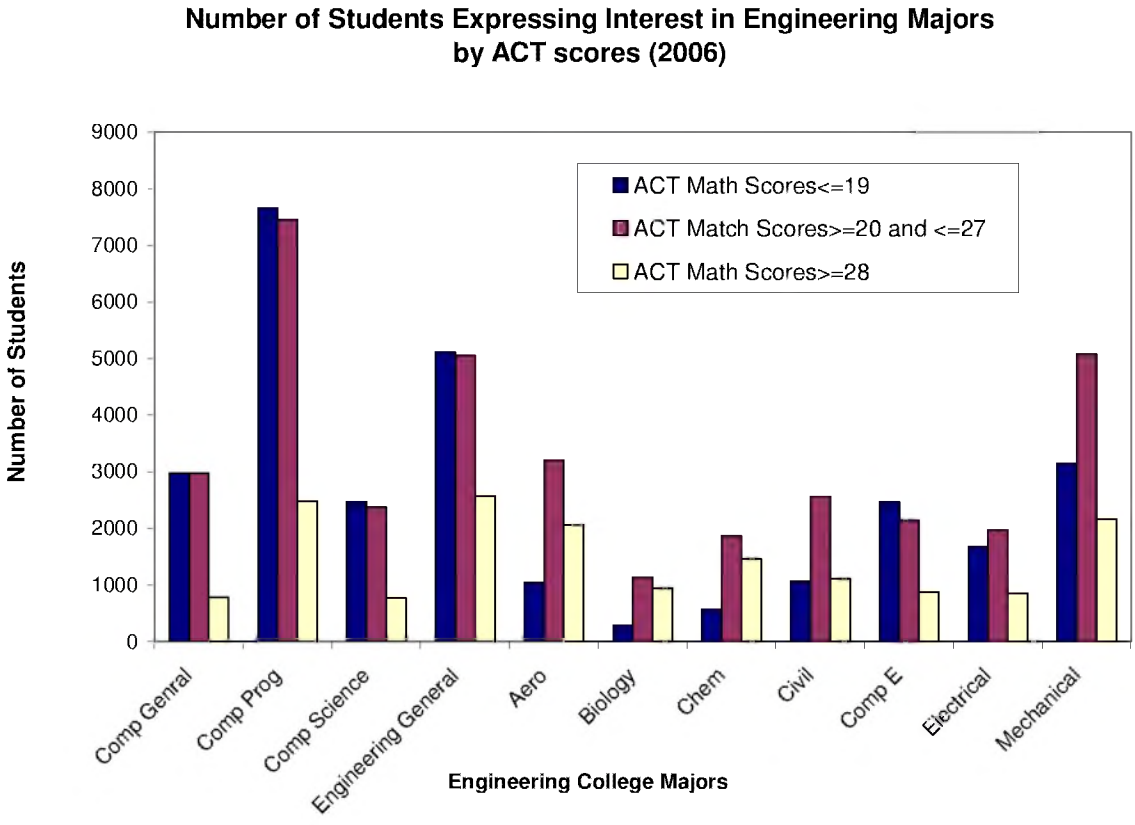

Figure 2
Students' (both male and female) expressed interest in engineering major by academic achievement

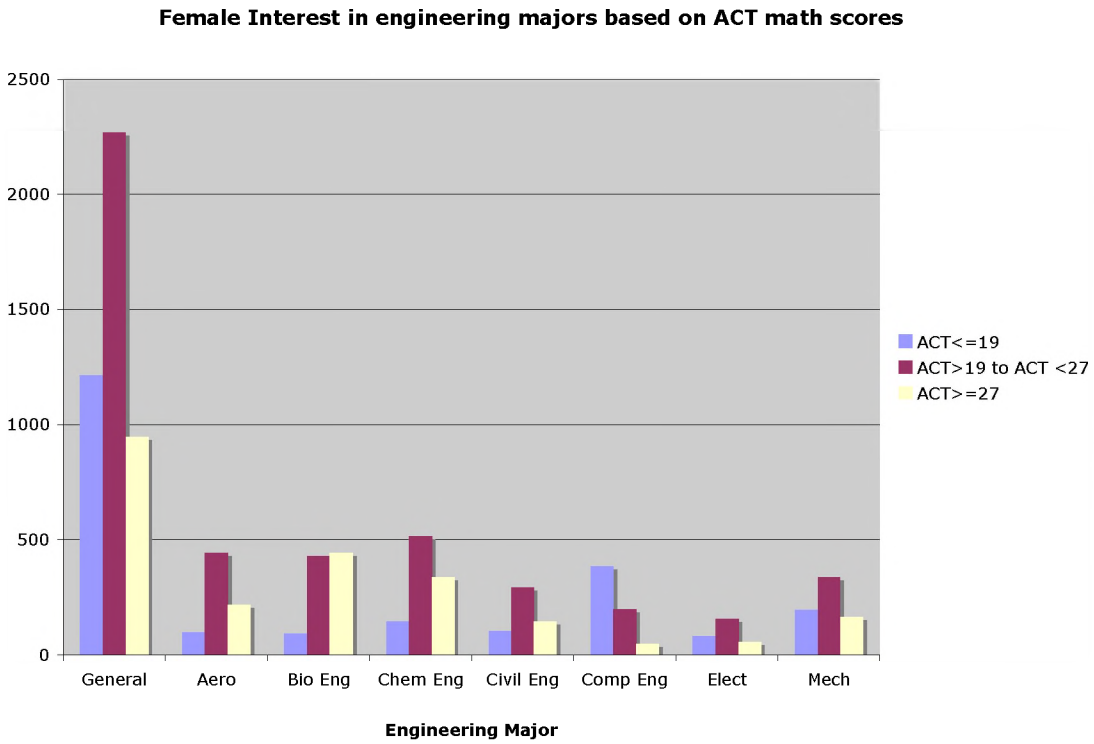

Figure 3
Female expressed interest in engineering major by academic achievement

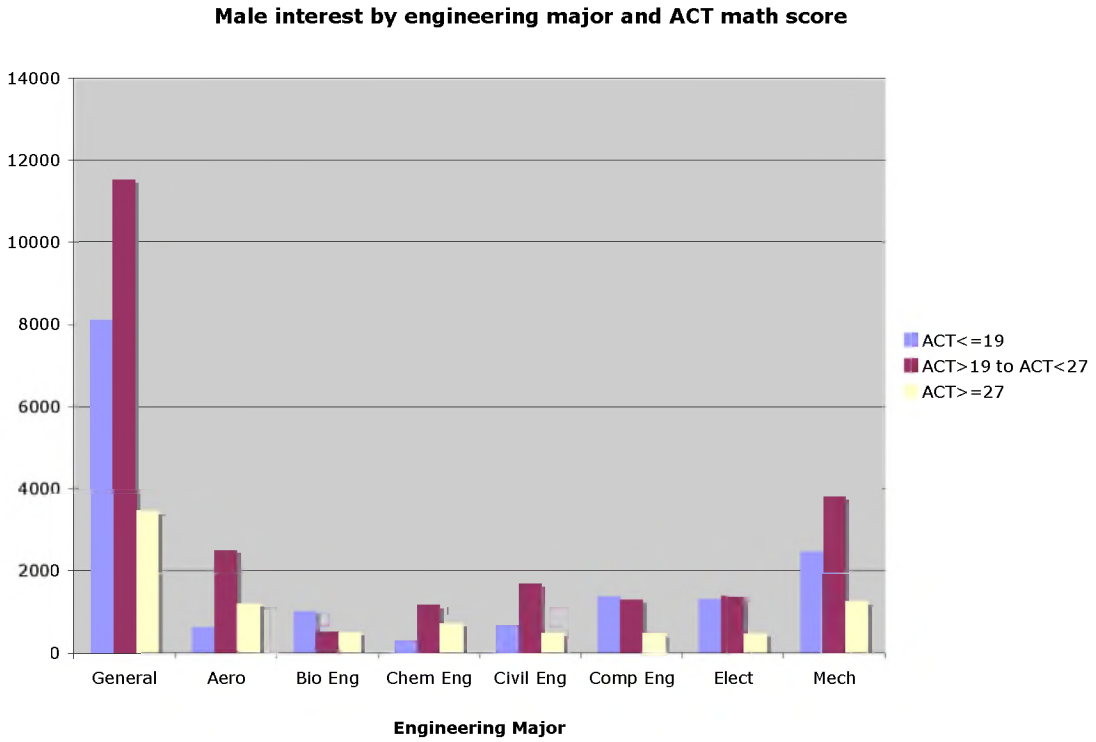

Figure 4
Male expressed interest in engineering major by academic achievement