Women and Minorities in Engineering:

A Review of the Literature

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The National Science Board (NSB) released the *Science and Engineering Indicators 2008* report which synthesized major findings in these areas. In 2005, women earned more than half of bachelor's degrees in psychology (78%), agricultural sciences (51%), biological sciences (62%), chemistry (52%), and social sciences (54%). On the other hand, men earned the majority of bachelor's degrees awarded in engineering (80%), computer sciences (78%), and physics (79%). Undergraduate engineering enrollment declined through most of the 1980s and 1990s, rose from 2000 through 2003, and declined slightly in recent years. The declines in undergraduate engineering enrollment in recent years were evident for both men and women. These findings suggest that despite men having more success in earning a bachelor's degree in engineering than women, still a fewer number of men enroll in engineering fields compared to the sciences (see Table 1). However, more men than women continue pursuing engineering graduate degrees (see Table 2).

Table 1. Science and Engineering Bachelor's Degrees Earned by Sex and Field in 2005

	Both Sexes	Male	Female
Science and Engineering	466,003	230,806	235,197
Sciences	399,870	177,870	222,000
Engineering	66,133	52,936	13,197

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov.

Table 2. Science and Engineering Graduate Enrollment by Sex and Field in 2005

	Both Sexes	Male	Female
Science and Engineering	583,226	295,547	287,679
Sciences	462,753	201,952	260,801
Engineering	120,473	93,595	26,878

Source: National Science Foundation, Division of Science Resources Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov.

The data shown in Tables 1 and 2 provide a snapshot of the status of men and women in the engineering field. Men outnumber women in earning bachelor's degrees and pursuing graduate degrees in engineering. Eighty percent of those who earned bachelor's degrees were men; 20% were women. Approximately 78% of graduate students in engineering were men and 22% were women.

Not only are women outnumbered in the academic engineering field but also in the labor force. In 2003, 11% of employed engineers were women (National Science Foundation, 2006). For that same year, women engineers made up approximately 1% of the total workforce. It should be noted that of the 11% of women engineers, 65% were White, 18% were Asian, 6% were Black, 8% were Hispanic, and 0.5% were American Indian/Alaska Native (NSF, 2006). Table 3 shows us the number of men and women employed in science and engineering fields and in all occupations.

Table 3. Employed Scientists and Engineers by Occupation in 2003

	Both Sexes	Male	Female
All Occupations	18,019,400	10,437,200	7,582,200
Science and Engineering Occupations	4,927,500	3,597,100	1,330,500
Scientists	3,372,700	2,214,500	1,158,200
Engineers	1,554,800	1,382,500	172,300

Source: National Science Foundation, Division of Science Resources Statistics, Scientist and Engineers Statistical Data System (SESTAT).

In 2006, The U.S. Bureau of Labor Statistics (BLS) reported that engineers held about 1.5 million jobs. The estimates of women engineers employed in the various engineering disciplines pale in comparison to the number of women in life, physical, and social science occupations. The percentage of women in engineering fields ranged from 6 to 23%. In contrast, the percentage of women in life, physical, and social sciences ranged from 22 to 68%. Table 4 presents the percentages of women in different occupations.

Table 4. Percentage of Women Employed by Detailed Occupation

Occupation	Percent Women
Engineering Occupations	
Aerospace engineers	13.1
Chemical engineers	17.1
Civil engineers	11.9
Computer hardware engineers	16.2
Electrical and electronics engineers	7.7
Industrial engineers, including health and safety	22.6
Mechanical engineers	5.8

Life, Physical, and Social Science Occupations	
Biological scientists	46.6
Medical scientists	45.4
Chemists and material scientists	34.1
Environmental scientists and geoscientists	22.0
Psychologists	67.7

Source: Current Population Survey, U.S. Department of Labor, U.S. Bureau of Labor Statistics.

These figures bring up the fundamental question of why women do or do not major in engineering. This review investigates the various factors identified by researchers to explain women's underrepresentation in the engineering field. It provides an overview of current findings on the lack of women in engineering presented throughout the literature and will provide some potential solutions to many of these problems.

International Comparisons

Is the lack of women in engineering just an American phenomenon? Charles and Bradley (2002) argue this is a mute question as cultures are too different to make comparisons. However, in recognizing culture and attempting to control for it Van Langen and Dekkers (2005) found in a comparative study between the U.S., United Kingdom, Sweden and the Netherlands that accessibility of the pipeline, social traditions, broadness of curriculum and labor market characteristics are the major reasons for differences, as a few countries actually have respectable numbers of women in engineering. For example, EUROSTAT (2004) suggested that Turkey (34.8%), Bulgaria (35.5%), and Portugal (35.3%) possess the highest proportions of female students in engineering in Europe (Kusku, Osbilgin, & Ozkale, 2007). Generally speaking, however, this is not the norm. Hersh (2000) posited that women engineers are still in a minority in all countries. Bradley (2000) argues when comparing higher education majors across countries, women are still majoring in traditionally female fields, and men are majoring in traditionally masculine fields. Historically, the image of engineering has been "heavy", "dirty", and "involving machinery" such that both men and women see it as a masculine profession

(Ismail, 2003). In Asian countries like India and Malaysia, engineering is a male-dominated profession. In India, Gupta and Sharma (2003) reported that most people believe mechanical engineering “is not suited for girls” (p. 605). This belief could soon change, however, because recently a growing trend of “feminization” of pure science fields has occurred due to women associating prestige to science degrees, as it is believed social prestige could improve marriage prospects (Gupta, 2007).

The underrepresentation of women in engineering has also become a key preoccupying factor in Europe, in particular with regard to the fact that up to half the potential talent for the European engineering workforce is missing. The number of women involved in engineering in Europe and elsewhere in the world is increasing very slowly (Beraud, 2003; Isaacs, 2001). A project funded by the European Commission (2006) aimed to provide understanding as to why women are not attracted to engineering studies and careers. The project found that gender stereotyping and discrimination may play a role in driving women away from engineering studies, whereas interest in math and sciences, good job prospects, salary and social standing led women to choose engineering studies.

Regardless of the reasons for women being outnumbered by men in engineering fields, it appears that this phenomenon is not unique to the United States. Other countries around the world are also concerned with the underrepresentation of women in engineering. Though cultures may differ, there may be common reasons why women do not pursue engineering degrees and careers.

Pre-college Factors

Smyth and McArdle (2004) found the vast majority of graduation disparities can be explained by pre-college academic preparation. Students who were encouraged by teachers and counselors to try engineering in high school were advised to take courses that would help them prepare for engineering (Erickson, 1981). For most engineering students, completion of an engineering degree was linked to their high school experiences (Gardner & Broadus, 1990), SAT math scores, high school GPAs and having taken courses in science and mathematics (Seymour, 1992; U.S. Department of Education, 2000). Gardner and Broadus (1990) reported that mathematics was the basic culprit undermining engineering students' academic progress.

Singer and Stake (1986) hypothesized that women with math-related career goals would have higher scholastic ability, better math backgrounds, and higher self-assessments of math ability than men with similar career goals. They found that math-relatedness of career goal was significantly related to high school participation in math. This finding was consistent with the increase of female students in such math-related fields as engineering during the early 80s. However, their results suggested that although women may have positive attitudes toward mathematics, they lacked confidence in their abilities to perform mathematics (Eccles, Adler, & Meece, 1984; Singer & Stake, 1986). Because of this, women were less likely than men to select a math-related career goal such as engineering.

Ventura (1992) found girls interest in math, chemistry and physics slowly diminishes the further they progress from middle school to college. Testing to see if this notion still held true, Van Leuvan (2004) found in a survey of females in grades 7-12 that their interest in STEM fields declined each year as they progressed, further corroborating Ventura's findings. Dryler (1999) believed students' choices of major differ significantly between schools and classrooms. His study also found that both sexes choice of major correlates with peers of the same sex, but does not correlate with peers of the opposite sex. The study also revealed the "frog pond effect". That is, high achieving students in the "hard" sciences will more likely enter fields in the social/behavioral sciences and humanities, whereas lower achievers in "hard" science subjects will likely enter the "hard" sciences in college.

Another major predictor of success in engineering was students' success with calculus. Aside from chemistry and physics, a one-year calculus sequence is a prerequisite for many engineering courses (Frehill, 1997). Bonsangue and Drew (1995) described calculus as the "gateway course". They found that women who demonstrate good performance and persistence in calculus will likely succeed in engineering. Moreno and Muller's (1999) research corroborated these findings as well. Moreno and Muller, however attributed engineering success more to college classroom experiences than pre-college preparation. Most would argue it is still logical to believe that students who are exposed to calculus in high school will be better prepared for engineering courses in college.

In the case of minority students, even though the math achievement and course-taking of minority students has been increasing, relatively few African American, Hispanic, and Native American students graduate from high school with the skills and knowledge they need to continue in quantitative disciplines (Campbell, Jolly, Hoey, & Perlman, 2002). White students were almost twice as likely to take Precalculus and/or Calculus as Hispanic students and almost four times more likely to do so than African American students (Campbell, Hombo, and Mazzeo, 2000). This may somehow explain why Hispanics, African Americans, and American Indians/Alaskan Native comprise 5%, 3.4%, and less than 1% of the entire engineering workforce, respectively (NSF, 2003).

Confidence, Persistence, Personality and Perceptions

A number of theories relevant to women's career behavior have been studied with respect to their persistence in engineering. To name a few, these theories include Bandura's (1986) self-efficacy theory, Vroom' s (2000) expectancy-value theory, and Holland's (1985) interest congruence theory. However, many researchers have attempted to arrive at a framework that encompasses variables that originated from seemingly diverse theories of career development. Schaefers, Epperson, and Nauta (1997) studied five theoretically relevant blocks of variables (ability, math and science self-efficacy, expectancy-valence, support-barriers, and interest congruence) to predict both men and women's persistence in engineering. They found that ability strongly predicted persistence. In addition, math and science self-efficacy, support and barriers to pursuing an engineering career, and interest congruence significantly added to the prediction of persistence beyond contributions of ability alone. These findings confirm the importance of ability, confidence in one's ability, external support, and interest in the persistence of students in the engineering field.

As mentioned previously, math and science abilities are essential in preparing students for engineering courses in college. But as research (Nauta, Epperson, & Waggoner, 1999; Scahefers et al., 1997) has pointed out, ability does not fully explain the gender difference in representation in engineering fields. Some researchers believed that students' beliefs about the nature of abilities and the meaning of difficulties also influenced their pursuit of engineering degrees. Heyman, Martyna, and Bhatia (2002) examined achievement related self-beliefs of engineering students based on Dweck's (1999) implicit theories about the nature of abilities. Implicit theories and assumptions people make about the malleability of personal attributes help explain how people interpret and respond to academic difficulties they encounter. Dweck (1999) posited that an individual with an entity (fixed mindset) view of intelligence would think that a person's intelligence cannot be changed. On the other hand, a person with an incremental (malleable or growth mindset) view would think that intelligence is something that can be changed or developed. These two views are especially relevant when students face difficulties. Entitists associate difficulty with lack of abilities and fail to persist in a task they find difficult. Incrementalists see difficulty as a challenge that signals a need to put more effort or to change one's strategy to accomplish a task. Heyman and colleagues found that although no gender differences were seen concerning general beliefs about intelligence (they endorsed entity views about half of the time), there were 72% of females and 46% of males enrolled in engineering programs who held entity theories with regard to aptitude for engineering. It appears that more women subscribe to the theory that their aptitude for engineering is fixed such that when difficulties come their way, they would likely succumb to the belief that they cannot do the task at hand. In the face of perceived incompetence, female engineering students with entity beliefs may not persist in the engineering field.

Heyman et al.'s findings are consistent with Dweck's (1999) argument that girls and women, particularly those of high ability, may be more likely than boys and men to develop entity views of ability and to avoid difficulties. A reason given for this was that high achieving girls were especially likely to receive praise when they were young and this can send the message that ability can be easily measured on the basis of performance outcomes (Dweck, 1999). This may also explain why female engineering students who face difficulty switch majors. When they do not receive high grades in engineering, they seem to opt for programs in which they might be more successful (Heyman et al., 2002). In addition, Dweck (2007) emphasized that when people think of ability as a gift, it is easier to identify groups who have it and groups who do not. In the case of students in the engineering fields, female students who see their abilities as gifts rather than learned abilities are likely to accept the notion that "men have it and women don't."

Aside from implicit theories, self-efficacy is one factor often investigated in success in engineering studies. Self-efficacy beliefs, a major construct of social cognitive theory (Bandura, 1986, 1997), are thoughts or ideas people hold about their abilities to perform those tasks necessary to achieve a desired outcome (Bandura, 1986). "Judgments of self-efficacy also determine how much effort people will expend and how long they will persist in the face of obstacles" (Bandura, 1982, p. 123). In their study of self-efficacy among first-year engineering students, Hutchison, Follman, Sumpter, and Bodner (2006) discovered gender trends in student responses to factors that affect confidence in success. The researchers identified nine categories of prominent factors: understanding or learning of the material, drive or motivation toward success, teaming issues, computing abilities, availability of help and ability to access it, issues regarding assignments, student problem-solving abilities, enjoyment, interest, and satisfaction associated with the course and its material, and grades earned in the course. Of these factors, students ranked drive and motivation, understanding of material, and computing abilities as most influential. In addition, the results of this study indicated that mastery experience was the single most influential source of self-efficacy because students were more efficacious when they are able to understand the material. This finding was common to both men and women. Needless to say, students believe they can make it through engineering courses when they feel they understand the materials. Their past performances in their classes help them think positively about their capabilities and give them confidence to carry on in engineering programs. If they do well on assignments, tests, and projects, students think they have a better chance at passing the course. Performance in these tasks is related to their abilities to use problem-solving techniques effectively. Another interesting finding in this study was that women, compared to men, were more influenced by vicarious experiences. Zeldin and Pajares (2000) had similar findings as they found vicarious experiences and verbal persuasions were the most critical sources of women's self-efficacy. Particularly, the researchers found women tend to better observe and learn more from other people's experiences and take into consideration what is communicated to them.

Mau (2003) found that academic proficiency and math self-efficacy were the two most predictive variables in science and engineering career persistence. This finding supports the social cognitive career theory (SCCT; Lent, Brown, & Hackett, 1994) because contextual, experiential, and learning factors were mediated by the self-efficacy beliefs that predicted career goal outcomes (Lent, Brown, & Hackett, 2000). Hackett and Betz (1981) proposed a model suggesting that women limited their career options in part as a result of their lack of strong self-efficacy beliefs in relation to career related behaviors. Although several factors affect people's choice and pursuit of a career, "perceived self-efficacy is posited as a pivotal factor in career choice and development" (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001, p.187). Knowledge and skill are not the best predictors of success because "the beliefs that individuals hold about their abilities and about the outcome of their efforts powerfully influence the ways in which they will behave" (Pajares, 1996, p. 543). Possessing the skills to succeed in certain domains may not necessarily translate to individuals having confidence in their abilities to actually be successful in those domains. For example, girls in high school mathematics and science earn better grades in these courses than boys do (Rhoads, 2004), yet girls report feeling less confident in these areas than do boys (Yee & Eccles, 1988). Sagebiel and Dahmen (2006) pointed out U.S. research has shown that one of the most powerful influences on women and engineering is a lack of self-confidence in their intellectual abilities which may be brought about by female students' perceptions of minority status and their feelings of isolation.

Aside from self-efficacy, other constructs such as personality and perceptions may also predict career choice and development. Harris (1994) suggested that men and women in universities have different key personality traits which may make them prefer to pursue different types of careers. Personality differences among disciplines were found. For example, engineers were generally high on cognitive structure and endurance, whereas students from majors such as nursing were nurturing. Past studies on students' personality characteristics found that science and engineering students were tough-minded, conscientious (Kline & Lapham, 1992) and precise compared to social science and arts students who were considered sociable and sensitive to experiences of the senses (Harris, 1993). Taking the construct of interest congruence, the degree of fit between individuals' personalities and the demands of occupations or environment (Holland, 1985), research has shown that women who persist in engineering majors were likely to be women who have personalities that are congruent with engineering fields (Schaefers et al., 1997). However, Heyman et al. (2002) found that among engineering majors, women were less likely than men to report that engineering was a good match for their interests. This bodes the question are these personalities developed or are men and women hard-wired to have sex-typed preferences?

In his book *The Essential Difference*, Baron-Cohen (2003) provided evidence to suggest that the male brain is a systemizer. Systemizing is "the drive to understand a system and to build one" (p. 61). Consequently, boys are more interested in mechanical and constructional systems. He claims that the adult equivalents of children's play with mechanical and constructional toys are physics and engineering. On the other hand, he presents the female brain as an empathizer. Empathizing is "spontaneously and naturally tuning into the other person's thoughts and feelings" (p. 21). Thus, a good empathizer by this definition would be someone who can sense and read the emotional atmosphere between people, what the causes of emotional changes might be, and what the other person may be feeling or thinking. Baron-Cohen argues that the female brain is hard-wired for natural and effortless empathizing. This leads to the case he makes that women are better communicators in all aspects of language (e.g., reading comprehension, verbal memory) than men. On the other hand, there are researchers who are careful to point out that aside from biologically-oriented “nature” explanations, there are socio-cultural “nurture” explanations. Spelke (2005) suggested looking beyond abilities to explain preferences of men and women in careers. Furthermore, she argued that since disparities in gender representation in the science and engineering fields have been eliminated or reversed through the years, there may be socialization pressures that work into the preferences of men and women.

Gender Socialization and Expectations

Using identity theory as the framework for study, Lee (2002) examined science and technology involvement by means of social relationships and experiences of high school students. Identity theory asserts that individuals’ behaviors are products of their mental constructs of how they fit into the activities of various situations (Lee, 2002). The study found “girls are more responsive to the programs’ educational interventions, whereas boys are driven more by an ‘internal compass’ that reflects past Science, Math, and Engineering (SME) identities and behaviors” (p. 349).

Many people assume men are better suited for engineering fields than women because they are “built” for engineering. The sex differences found in students’ fields of concentration, that is, men received more degrees in engineering, whereas women received more degrees in biology and medicine may perpetuate this assumption. However, Eccles (1987) suggested that women are less likely than men to aspire careers with heavy mathematics components because women are less likely than men to view mathematics and related fields as useful. Women may avoid fields like engineering that are particularly demanding in terms of educational commitment and length of work hours (Betz, 1994).

Seymour and Hewitt (1997) found perceptions of competition and difficulty cause many female students to assess their own math ability and competence. Often times, this results in math anxiety for students and they discontinue interest in engineering. Unfortunately, this notion coupled with the perception of math being a male dominated subject sometimes causes instructors to have lower expectations for women. This results in less encouragement for females, thus ultimately hindering women from participating in engineering. In a related note, Leslie, McClure and Oaxaca (1998) found early socialization experiences related to notions of self efficacy, peer influence, and goal commitment often account for the majority of engineering participation disparities among race and gender. Another product of early socialization experiences is gender-typing occupations. Kenkel and Gage (1983) posited that, in American society, there is a pronounced gender-typing of occupations beginning early in life (Hewitt, 1975; Papalia & Tennent, 1975; Siegel, 1973), and in high school and college (Albrecht, 1976; Brito & Jusenius, 1978; Dunne, 1980; Frye & Dietz, 1973). Gender-typing of occupations have led people to classify which jobs are feminine, which are masculine, and which may appropriately be filled by either men or women (Kenkel & Gage, 1983). Consequently, social structural barriers are formed from gender-role socialization. Gender-role socialization is likely to lead to gender differences in the kinds of work individuals would like to do as an adult: there is evidence that males are somewhat more interested than females in activities and jobs relating to manipulating physical objects, while females are more interested in activities and jobs related to people and social interactions (Eccles, 2005). Tietjen (2004) believed the U.S. maintains a stereotypical image of engineers and until that image changes colleges and universities can continue to expect low female and minority enrollments.

In a recent study by Starobin and Laanan (2008), female students reflected on their experiences and expressed a lack of social and academic support to pursue STEM fields. The female students tended to believe in the stereotype that men are good in math and women are stronger in humanities (Seymour & Hewitt, 1997) and that engineering was not one of those options given to them as females. Frehill's (1997) study on education and occupational sex segregation found that women were not deterred from entering engineering due to family orientation values despite females' anticipation of roles as family caregivers. However, she presented the need to determine the extent to which students choose fields of study based upon issues of gender-appropriate behavior.

Climate in Engineering Settings

Men and women's preconceived notions of male- or female-types of occupations do not foster a sense of belonging for men in traditionally female occupations or for women in traditionally male occupations. Yoder and Schleicher (1996) found in a study of student perceptions and gender-skewed fields that students typically aligned men with traditional male roles and women with traditional female roles. As a result, women in traditionally male-dominated career fields and college majors, such as engineering, feel unwelcome, ignored, and treated differently (Morris & Daniel, 2008). Serex & Townsend (1999) found students generally perceived engineering as less "warm" than typical female-dominated fields such as education and nursing. This kind of atmosphere was labeled the "chilly climate" by Hall and Sandler (1982), who contended that this chilly climate pushed women away from traditionally male-dominated careers. If women are in an environment in which they perceive differential treatment, but their male classmates do not, it may serve to increase the gender divide between men and women (Heyman et al., 2002). Murphy, Steele, and Gross (2007) proposed that poor numerical representation in the STEM setting may already cause even highly confident, high ability women to avoid or leave these fields. Being outnumbered in the engineering field brought about in women identity threat experiences and a lesser desire to participate in engineering settings (Lackland & De Lisi, 2001; Murphy et al., 2007).

Employment in Engineering

Graham & Smith (2005) discovered that college-educated women are half as likely as men to be employed in science and engineering (S&E) and, if employed, earned 20% less than their male counterparts. This is not far from the NSB (2008) finding that there is about a 25% salary differential between the median salaries of female and male scientists and engineers. The NSF identified women's tendency to have a fewer number of years of experience as a contributing factor to the salary differential. Although it is believed that engineers generally have higher salaries than social scientists, newer employees earn less than those experienced engineers. Aside from experience, other factors such as age and engineering discipline (e.g., chemical, mechanical, etc.) contribute to the differences in salaries. Comparing salaries of scientists and engineers based on race/ethnicity, blacks, Hispanics, and other ethnic groups with S&E degrees had full-time salaries that were 18.8% less than those of non-Hispanic whites and Asians/Pacific Islanders with S&E bachelor's degrees.

Salary differential is not the only issue of women employed in the engineering field. Women engineers are also concerned about sexual harassment, indifference, and discrimination in working in an all-male environment (McRae, Devine, & Lakey, 1991). Once experienced, any of these may lead to women leaving the profession. Valian (1998) suggested that women may find it easy to leave high-prestige or high-paying male areas of work for marriage or lower status of employment that offer less stress.

U.S. surveys show that male and female engineers face very different problems in their careers: 34% of women consider balancing work and family, presence of a glass ceiling, the old-boy network, and outright discrimination as their biggest obstacles, whereas only 2% of male engineers report family issues to be their main career obstacle (Boiarsky et al., 1993; Carter & Kirkup, 1990). The percentage of women facing problems may paint a bleak picture to young women aspiring engineering careers. Engineering students who already are threatened by women's poor numerical representation may increasingly lose the desire to participate in the engineering setting given that women engineers in the workforce face such problems. Moreover, given that few women progress in the engineering field, women's perceptions of engineering as a male-domain and as an inappropriate career for women may be reinforced (Hersh, 2000). Therefore, it is imperative that these issues in employment of women engineers be addressed in order to attract women to pursue engineering careers.

Race-Specific Research

Several pieces of literature have cited the importance of community/community membership in the likelihood and success of students majoring in engineering. African Americans, Native Americans, and Latinos possess strong cultural values of group and community membership that may be at odds with the perceived levels of individualism and competition associated with the sciences (NSF, 1996, as cited in Chang, 2002). Brown (2002) found a similar finding in a study that interviewed Hispanic students in engineering. She found seven themes that lead to students majoring in engineering, three of which relative to community: family support, small class sizes, and small communities, are key. McShannon and

Derlia (2000) suggested even learning styles are communal as minority engineering students learn better with other students. In light of this evidence, it is important that researchers identify the physical locations from which students originate. Understanding the extent of diversity in areas surrounding a college or university could be instrumental in predicting the applications from minority students.

Actions Taken to Increase Diversity

Numerous measures are being taken to promote women and minorities in engineering, with programs beginning as early as elementary school and continuing throughout the college undergraduate curriculum. Some programs designed to capture students' interests in elementary and secondary school include Glendale Community College's Mathematics, Engineering, Science, and Achievement (MESA) program (Mendoza, 1991) and Tennessee Technological University's Precollege Initiative for Minorities in Engineering (PRIME) (Marable, 2000). These programs introduce and expose young students to engineering via seminars, tours, academic courses, and tutorial periods. The PRIME program also incorporates role models and mentors as undergraduate engineering students share their insights. Marable believed this is a major key to the PRIME program's success. A similar program can be found at Worcester Polytechnic Institute (WPI). The Reinventing Engineering and Creating New Horizons (REACH) program is intended to assist female students in gaining self-confidence with regard to engineering, as well as educate their parents about engineering (Nicoletti, 2002).

College-level programs intended to recruit and retain minorities in engineering include Purdue University-West Lafayette's Women in Technology program. This program is also intended to provide mentorship and social support for students (Wasburn and Miller, 2005). Lam, Doverspike, and Mawasha (1997) discussed a program at the University of Akron that emphasizes learning communities and excellence, as opposed to remediation. The program provides several transition activities, counseling, a study center, and financial incentives. Students are held accountable via learning contracts. The Massachusetts Institute of Technology (MIT) has Women's Technology Program (WTP) to spark high school girls' interest in studying engineering. The WTP is a four week summer program where female high school students explore engineering through hands-on classes, labs, and team-based projects in the summer after 11th grade (WTP, 2008).

A major question with any program is "does it work?" Good, Halpin, and Halpin (2002) conducted a program evaluation of minority programs on black engineering students to test its effectiveness. Results indicated that these programs do help retain students. However, it is important to note that most of these programs' effectiveness occurs during the freshman year, as results tend to diminish and taper over time.

There are engineering initiatives already in place to open up opportunities for women and minorities in engineering. Although there may be a greater number of women in engineering today, the literature strongly suggests that women are experiencing more interpersonal struggles in engineering careers. Vogt (2003) saw this as an indication that there is "something particular about the engineering pipeline that may subtly inhibit women" (p. 221). She argued that access or enrollment in engineering majors may not directly translate into retention of women in engineering if there is subtle discrimination toward them. Adams (1994) believed that campus climate could be very influential in the retention of women in engineering. One way he thinks a welcoming environment can be fostered is if there is more involvement from engineering faculty. Examples of faculty involvement include mentoring, allowing students to actively participate in research, and being empathetic toward minority students' needs and concerns and addressing those issues to key individuals on behalf of minority students. Therefore, actions should be taken to provide not only access to the engineering field but also to provide an environment that makes women feel a sense of belonging.

Educational and Counseling Implications

High academic intensity and quality of high school curriculum is a strong predictor of college completion (see review in Campbell et al., 2002). Specifically in the engineering field, taking advance math and science courses in high school may lead to progress in engineering majors. High school curricula may be modified for students who aspire to major in engineering. With particular interest in women, Hodgkinson and Hamills (2005) mentioned one strategy being adopted by some schools is to teach science, technology, and mathematics in single-sex classes. The rationale for this is that it provides a welcome opportunity for girls in coed schools to gain confidence in areas that have traditionally been male domains.

Greater efforts could be made to increase awareness among students of the intellectual and professional aspects of engineering to counter associations with manual work, dirty conditions, or physical exertion (Hodgkinson & Hamills, 2005). Moreover, closer attention should be given to the ways in which family formation issues play a role in women's engineering career outcomes (Frehill, 2007). Engineering is also perceived to demand long hours of work. It is then also important to stress that engineering can provide an opportunity for self-fulfillment and it involves teamwork and social contact (Hodgkinson & Hamills, 2005). In addition, flexible work hours may be possible.

With the growing ethnically diverse student population, differences in culture may contribute to perceptions of the engineering field. Perceptions may be changed together with the changes that arise in society. Trenor, Waight, Zerda, and Sha (in press) proposed that successful engineering recruitment and retention programs should emphasize the important roles parents and models play in the selection and persistence of women. For women and minorities, having a positive role model and strong support group may weaken the social structural barriers that exist. Consequently, they may perceive engineering as a career for women.

Based on the literature, it is clear that there is much to desire for women in engineering. Much effort has been put forth in terms of recruiting women in the field. However, as earlier discussed, the issue of underrepresentation of women and minorities in the engineering field involves a complex interplay of social, cultural, and personal factors. Although recruiting may not seem as difficult as it was forty years ago as evidenced by the increase in number of women enrolling in engineering, the more pressing concern is the retention of women in engineering fields.

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