Theory and Practice in Recruiting Women for STEM Careers

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Abstract - The National Science Foundation funded project "Proven Practices for Recruiting Women to STEM careers" is now in its second year. This work is part of a larger project funded by the Advanced Technological Education Program of the National Science Foundation, DUE #0501971. This paper provides the interim results of the project's review of existing literature on practices currently in use to recruit women into STEM careers, and on the career development and gender theories on which these practices are based. A description of each practice is presented along with research-based evidence on its effectiveness. Concluding remarks summarize the major findings of this review.

Introduction

When beginning any research project, it is a standard and "proven" practice to start with a review of existing literature. Accordingly, we began reviewing the literature on career theory for our project "Proven Practices for Recruiting Girls and Women into STEM Careers in ATE-Funded Programs." This project, as well as the overall Advanced Technological Education (ATE) program, is funded by the National Science Foundation (NSF DUE 0501971). The ATE program has several goals: to improve technological education; to recruit more people, especially women and minorities, into science, technology, engineering and mathematics (STEM) careers; and to increase the number and productivity of skilled technicians in advanced technology fields (Patton, 2005). We quickly discovered, of course, that the literature on career choice and development, particularly on adolescents, is drawn from a variety of fields and is, to say the least, voluminous. But we also noticed that many of the articles are concerned with proving, disproving, refining or extending aspects of several major theories. Additionally, the review was necessary to become conversant with the concepts developed by career choice and development theorists but left undefined in most research (see Brown & Brooks, 1996; Super, Savickas, & Super, 1996; Super, 1990). Because of the prominence and influence of John L. Holland's theory of person-environment interaction, Donald E. Super's life-span, life-space theory, and Lent, Brown and Hackett's social cognitive career theory (SCCT), we chose to review these three theories in detail.

Several researchers point out that the study of career choice began with trait and factor approaches (Super, 1990; Brown & Brooks, 1996). John L. Holland's theory of matching each individual to a job on the basis of shared personality and job traits is considered an important example of this type of theory. In particular, his concepts of person-environment interaction and fit are still in use. Donald E. Super began his own career using a trait and factor approach, but later changed to a developmental approach. Super also changed the focus of vocational studies from occupation to career (Savickas, 1994), and recognized that career decisions are made over and over again, not just at one point in time (Super, 1990). Social Cognitive Career Theory

(SCCT) represents a third line of theory development. SCCT adapts Albert Bandura's social learning theory of personality development to career development and choice (Lent, Brown & Hackett, 1994), and incorporates much of the work of early vocational psychologists who, according to Super (1990), focused on aptitudes and interests. According to its originators, SCCT is intended to serve as a framework to bring together diverse threads of career theory (Lent et al., 1994). Researchers using SCCT emphasize the concepts of interests, goals, outcome expectations and self-efficacy. Bandura's concept of self-efficacy in particular has received much attention via SCCT and other approaches.

Additionally, a number of interventions focusing on the recruitment of women into STEM careers incorporate one or another type of gender theory. Goodwin (2006) divides the major gender theories into three categories—deficit theory, dominance theory, and difference theory. Deficit theories assume that women lack capacities with which men are endowed. For example, Sanders notes that much of the research on gender and computer technology "has focused on female deficits: their lower experience levels, less positive attitudes, and failure to persist and perform well in educational programs, as compared with males" (Sanders, 2005, p. 23). Dominance theories focus on relations of power between the genders and especially on how men exert power over women (Goodwin, 2006). Smith (2000) recounts the experience of a woman who, in the 1970's, received "a full mathematics scholarship to college [which was withdrawn] when the funding committee realized she was a woman" (p. 11). Dominance theories easily explain this event. Difference theories constitute the third and most influential category of theories. According to this approach, men and women constitute two separate groups, each of which is psychologically different from the other. Thus, men and women have different and unique natures (Goodwin, 2006). This approach grew out of Carol Gilligan's 1982 book *In a Different Voice: Psychological Theory and Women's Development*. According to Goodwin (2006), Gilligan "contrasted a form of male orientation to moral development concerned with forms of justice based on rights and rules, separation and independence, with a 'feminine' orientation based on caring, attachment and dependence" (p. viii). This is the source of many statements in the literature associating men with the public sphere and women with the private sphere; women as caring and cooperative, men as aggressive and competitive; women as concerned with relationships and people, and men with abstract ideas. Goodwin sees these contrasts as just another type of trait and factor theory yielding yet more stereotypes of both men and women. Hyde and Linn (2006) identify an additional category--similarity theories. These hold that males and females are very similar on most but not all psychological variables. According to Hyde and Linn (2006), the differences reported in the literature are a statistical artifact caused by interpreting study results in terms of tests of significance rather than in terms of the effect size of various factors. Goodwin (2006) refers to herself as a social constructionist, and it's quite clear in her writing that she considers the psychological processes of boys and girls to be the same.

Adherence to one or another career theory and/or gender theory underlies most currently existing practices for recruiting women into STEM careers. The rest of this paper will review some of these practices, beginning with traditional practices centering on career goals, interests, and aptitude that are considered tried and true, at least for men, followed by a discussion of practices focused on removing economic barriers, practices that attempt to appeal to feminine values, and efforts to raise women's confidence in their abilities to pursue STEM careers. Numerous studies

have been done to test the effectiveness of most of these practices, although some practices have received more attention than others. For example, the importance of self-efficacy has been researched extensively, while literature on the effectiveness of equity training sessions for teachers and school staff members is more limited.

Traditional Recruitment Practices
Career and Career Goals
Traditional career theory assumes that everyone aspires to a career, has career goals and can formulate a plan to attain those goals. Bateson (1989) sums it up as pursuit of a quest in which one resists attractions along the way and "obstacles are overcome because the goal is visible on the horizon, onward and upward. The end is already apparent in the beginning" (p. 6). Many people, and especially women, have other commitments. Super pioneered the ideas that people participate in a number of different roles during their lifetime, and that the individual may consider some roles to be relatively more important than others. He called this "role salience". Some work places, such as IBM (2005), recognize multiplicity of roles by providing women with childcare, flexible schedules and family leave. As for role salience, research suggests that many women (Brown, 2002; Fassinger, Scantlebury & Richmond, 2004; Cook, 1994), and some ethnic and racial groups as well, such as Hispanics (Menchaca, 1996 on Hispanics), do not consider the work role their most important life role. Similarly, much research has been done showing that self-efficacy is an important consideration for women in career development and choice (Betz & Voyten, 1997; Phillips, Barrow & Chandrasekhar, 2002; Argyropoulou & Sidiropoulou, 2003). According to Bandura's social cognitive theory (SCT), and therefore according to SCCT, self-efficacy consists of two components. One component is confidence or self-esteem. Confidence refers to the strength of certainty of one's beliefs (Assessing Women in Engineering Project (AWE), 2005a). Some career researchers use the words confidence, self-esteem, or self-concept as synonyms for "self-efficacy" (see, for example, Phillips et al., 2002, Ochs & Roessler, 2004, and Mau, 2003). The second component of self-efficacy is belief in one's capabilities to both organize and execute the courses of action required to produce given attainments (Lent et al., 1996). Lent, Lopez and Bieschke (1991) use readiness to choose a career as a synonym for self-efficacy in a 1991 article. A comparable concept in Super's life-span, life space theory is "career maturity" or readiness for career choice.

While participating in Edmonds Community College's first annual Women's Conference in 2006, one young woman stated, "They tell me I have to have a career." In Super's terms, the work role was definitely not "salient" for this young woman. Super (1990) notes that "If circumstances suggest that work roles should be more important…then career arousal is called for" (p. 248). Some other young conference participants seemed to recognize the need to work, but were completely confused about how to proceed in deciding what to do. The tasks involved in this process are all learned, and Super (1990) suggests that school curriculum should foster "planfulness" and provide the information needed to make decisions.

Interests
Measuring and arousing interests are standard fare in career counseling. Both Super and Holland developed interest and other inventories to test their theories and to provide career counselors with instruments they could use to assess and advise their clients. Many of these instruments are still in use by researchers representing a variety of theories. For example, Betz and Voyten

(1997) use Holland's *Vocational Identity Scale* in their research on career indecision predictors among college men and women, and Lima and Guilherme (2003) use both Holland's *My Vocational Situation* and Super's *Salience Inventory*. Versions of some of both Holland's and Super's instruments have also been incorporated into on-line career counseling websites (e.g., for Holland, www.careerkey.org and for Super, http://www.cpp-db.com). These instruments were largely developed for and tested with males. However, Super (1990) points out the need for education on vocational choices before administering interest inventories. He says, "if a youth knows little about the world of work, scores on interest inventories that use occupational titles or job descriptions can be misleading" (Super, 1990, p. 244). Additionally, Ryan, Tracey and Rounds (1996) note that the structure of interests used in Holland's typology of personalities and careers may be influenced by gender. Guindon and Richmond (2005) report that Reardon, Vernick and Reed (2004) investigated gender differences in employment by applying Holland typology to 40 years of census and labor market data. Reardon et al. found that most men (between 79% and 85%) were employed in Realistic occupations, followed by Enterprising ones. Women were employed in more varied work including Conventional, Realistic, Social and, more recently, Enterprising positions (Guindon & Richmond, 2005).

Arousal of interest is considered a basic recruitment practice. Super (1990) lists many of the traditional forms used to arouse students' interest in STEM careers: pamphlets, books, filmstrips, computerized guidance, talks or demonstrations by members of occupations, exploratory courses, observation of someone at work, and field trips. Recent research has shown, however, that interest in a field, though necessary, is neither primary nor sufficient to propel women into exploration of STEM fields. According to Choudhuri (2004) and Pietsch (2003), self-confidence precedes interests and career goals for women, whereas for men, interests precede self-confidence. Additionally, Sanders (2005) reports the results of a study showing that "a female's loss of confidence in her computer abilities precedes a drop in her interest in computers" (p. 10). If this research is correct, traditional methods of arousing interest should be relatively ineffective as a way to recruit women. Additionally, M. J. Bruner (2003) points out that in her study of tenth grade girls' career exploration experiences, "personal choices of the young women evolved around life style and fit. The engineering profession they 'came to know' had little in common with their world or future" (Bruner, 2003, p. 1).

Aptitude

Career counselors and others have long depended on intelligence and aptitude tests as aids in guiding students toward or away from STEM careers. Foley (2004) notes in a summary of her research among 169 at-risk eighth graders that her results "indicated that vocational aptitudes scores cannot be adequately predicted from intelligence test scores, and that vocational interests are largely unrelated to cognitive abilities and vocation aptitudes" (p. 1). These results, she says, are consistent with the literature. Lent et al. (1994) say, "although aptitudes can be conceptualized as basic skill potentialities that may have a heritable component, the transformation of native aptitudes into career-relevant skills requires nurture as well as nature" (p. 90).

According to a recent article in *The Economist* (2007)*,* "America has long held 'talent searches,' using test results and teacher recommendations to select children for advanced school courses, summer schools and other extra tuition. The philosophy behind a talent search is that ability is

innate; that it can be diagnosed with considerable accuracy; and that it is worth cultivating" (pp. 62-63). Several articles reporting on the use of special programs to interest women in STEM fields state that applicant selection was based on measured aptitudes, grades and/or teacher recommendations (Phillips et al., 2002; Nave, Frizell, Obiomon, Cui, & Perkins, 2006). Additionally, a number of programs advertised through the WEPAN electronic mailing list also include one or more of these requirements. For example, the SUPERB program requires an overall grade point average of 3.0 or above, two recommendations—one of which must be from faculty, and official transcripts (Humphreys, 2006). The Innovations in Nanotechnology program requires a grade point average of 3.0 or above, standing as a junior or senior in a related science or engineering field, two faculty recommendations and official transcripts (Trenor, 2007). Finally, the Research Experience for Undergraduate (REU) in Sustainability program requires two recommendations from faculty and official transcripts (Suryanarayana, 2007). These types of programs meet the ATE goal of recruiting people into advanced technology fields. However, we still need to arouse interest in STEM fields in the first place. *The Economist* article points out that in Finland, where "people flinch from the idea of treating brainy children differently," and in Japan, where "there is a widespread belief that children are born with the same innate abilities," mean mathematics scores of 15 year olds in 2003 were much higher than those achieved in the U.S (Gifted Children, 2007, pp. 62-63). According to Nauta and Epperson (2003), "math and science ability generally account for a relatively small proportion of variance in women's consideration of SME [science, mathematics, engineering] majors or careers." (p. 448). Moreover, one does not need to be a mathematical wizard to successfully fill many lower level technical positions. Screening by supposed aptitude is exclusionary and may therefore not be the best approach for increasing recruitment into STEM fields.

Barriers

Research has pinpointed many economic and social barriers to the participation of women in both STEM and other careers. These are generally grouped under the rubric of "context." Context consists of the web of cultural, social, psychological, economic and political factors into which someone is born. Holland's idea of person-environment fit and Super's life-span, life-space theory emphasize the large role of context in career choice and development, while SCCT largely assigns the influence of these factors to the individual's early developmental environment. The various gender theories—dominance, deficit, similarity, and difference theories—have guided research in identifying barriers, explaining their effects, and providing possible solutions for recruitment problems.

Economic Barriers

Many recruitment efforts include financial assistance in order to remove economic barriers to participation. The provision of scholarships, internships, and direct pipelines to jobs are all of continuing value. Interventions targeting removal of economic barriers constitute one way of, to use a male-oriented analogy, "leveling the playing field" (Bateson, 1989, pp. 105-106).

Stereotyping and Bias

Stereotypes of the essential nature of males and females and the proper behavior for each of them ("gender schema") are learned by age three (Sanders, 2005; Bussey & Bandura, 1999) and may vary by race and/or ethnicity (Hanson, 2000). Sex-role stereotyping has been identified as a

source of both conscious and unconscious discrimination against girls in the classroom— encouraging boys more than girls and answering boys' questions more fully (Blickenstaff, 2005, Perez, 2004). Adya and Kaiser (2006) report Culley's (1998) finding "that teachers in primary schools often considered boys to be more interested in computers, and these teachers enjoyed teaching computer-related subjects to boys more than girls" (p. 236). One of the participants in Smith's (2000) study of women in mathematics, science and technology careers noted that, in graduate school, instructors referred to men by their last name and to women by their first name. The participant said, 'the ideas of men were already classified as having authority' (Smith, 2000, p. 11). Fassinger et al. (2004) point out that micro inequities—small devaluations of women that may appear insignificant in isolation add up over time and result in cumulative disadvantages for women. Adya and Kaiser (2005) sum up the situation by saying, "Research findings lean towards the negative regarding the role of teachers and counselors on MST [mathematics, science, technology] career choices" (p. 237).

Sanders (2005) suggests that one way to counter these effects is through staff development workshops for faculty and counselors so they are able to recognize stereotypes both they themselves and their students have internalized. Jones, Evans, Byrd and Campbell (2000) conducted a study with four teachers (two elementary, two high school, gender unspecified) to test the effectiveness of gender equity training. The researchers videotaped student-teacher interactions in the classroom before the intervention and again eight weeks after the intervention, and analyzed the tapes using the Sex Equity in Classroom Teaching Observation Scale. The intervention consisted of a separate meeting with each teacher during which the teacher completed the Louisiana Gender Equity Quiz and discussed the analysis of the pre-intervention tape with researchers. Each teacher was then given an individually tailored "self-directed gender resource module" consisting of a summary of 20 years of gender equity research, descriptions of classroom activities aimed at reducing gender bias, and a self-evaluation worksheet. By comparing analyses of the pre- and post-intervention videotapes for each teacher, the researchers found that their intervention strategy did indeed affect student-teacher interactions. At $time_1$ girls participated in fewer interactions with their teachers than did boys, while at $time_2$, the girls achieved parity with the boys in total number of interactions. Additionally, while boys and girls had approximately equal numbers of positive and negative interactions with their teachers at $time_1$, the number of positive interactions of girls with their teachers increased at $time_2$. For boys, the number of negative interactions with their teachers at $time_2$ increased fourfold. The researchers attribute the boys' increase in negative interactions to boys' tendency to call out answers, act out, interrupt, and generally misbehave in order to attract attention. They say, "These behaviors…are an important element in gender-related activity in the classroom that must be understood by teachers and accounted for in striving for gender equity in total interactions (Jones et al., 2000, p. 5).

Occupations are gender-stereotyped as well, with STEM fields generally typed as masculine. Sanders (2005) reports a finding that "teachers stereotype computing as a male domain (Huber & Schofield, 1998)" (p. 20) and others report that engineering (Emerson, 2004) and mathematics (Adya & Kaiser, 2005) are also considered male professions. It has been suggested that counselors or other staff, in addition to providing career information, could also be engaged in countering common stereotypes of STEM fields (Adya & Kaiser, 2005) and provide students

with training on the factors and processes involved in both choosing a career and reaching their goals.

The personalities of those who go into STEM fields are also stereotyped. For example, a 2006 *Dilbert* calendar portrayed engineers as dull, boring, and lacking in social graces. Steinke et al. (2006) report on a 1957 study in which "students described scientists as neglectful toward their wives, children and friends (Mean & Metraux, 1957)" (p. 3). Smith (2000) mentions two more recent studies illustrating that this image of STEM professionals as cold and non-nurturing has not changed. Steinke et al. (2006) conducted their own study on the image of scientists with three 7th grade science classes in the Midwestern U.S. Two of the classes received media literacy interventions, and the third did not. One day after the intervention, when students in all three classes were asked to draw scientists, the largest percentage of drawings included stereotyped elements such as male gender, wearing glasses and a lab coat, having "crazy hair," and working in a laboratory (Steinke et al., 2006, p. 8). The authors conclude that the media literacy interventions did not work.

One off-shoot of the research on the effects of occupational and sex-role stereotypes is the role of the media in presenting and perpetuating them. Media representations are not only a reflection of social norms but also reinforce them. Steinke et al. (2006) found that the largest percentage (40%) of the 304 middle school science students in their study derived their ideas about what a scientist looks like from television and films. Only 8.3% of the 161 girls, and none of the boys named a science teacher as the source of their images. Since one of their media literacy interventions included video clips, the authors wonder about the impact of intervention programs using media sources, such as educational videos and computer games, on girls' perceptions of scientists.

Representations of female scientists and engineers in the media generally emphasize physical attractiveness and romance, although these women may also be depicted in high status, professional positions (Steinke, 2005). The types and content of stories appearing in the media may also have an effect. In an interview with Koennen (1989), Cynthia Fuchs Epstein noted that there was an increase in stories in the media about women returning to 'traditional values.' Epstein says, "I see in the press quite a lot of attention to the problems women are facing coming into positions of power and effective careers, but not many devoted to successes" (Koennen, 1989, p. 16).

Elements of Interventions

Besides counteracting barriers, researchers and intervention specialists have been exploring a number of ways to attract women to STEM careers. Although some of these elements may have been developed within the context of gender difference theories, they are probably equally applicable to both girls and boys.

Positive Environment

Many studies point out the need for positive training environments for women and minorities (Choudhuri, 2004; Michie & Nelson, 2006; Pietsch, 2003; Stern, 2006). According to Sanders (2005), "Cohoon reported that females' retention in CS [computer science] is positively related to their professors' positive attitudes toward women students and negatively related to their

professors' belief that female students are not well suited to their major. (Cohoon, 2001, 2002)" (p. 20). Attention to eliminating or at least controlling interpersonal games of inclusion and exclusion based on bias, and to deflecting aggression in the form of bullying away from vulnerable students would contribute to creating a positive atmosphere. According to Sanders (2005), women feel more comfortable performing a non-traditional activity if they are part of a "critical mass" of women. At higher educational levels, interventions aimed at providing support to women in STEM fields include newsletters, student organizations, gatherings, retreats, and living-and-learning centers specifically for women. These practices relate more to retention, but knowledge of their existence may help in recruitment. More research needs to be done on the effectiveness of these various procedures.

Self-Confidence

Research has identified self-confidence, one of the two components of self-efficacy, as a critical factor in recruiting women into STEM fields. Researchers have shown that even though girls perform at the same level as boys, girls have lower opinions of their abilities (Pajares & Valiante, 2001; AWE, 2005a; Sanders, 2005). Britner and Pajares (2006) found that middle school girls' higher levels of success in science did not result in the development of stronger science self-efficacy. Hawks and Spade (1998) report that women in engineering think of themselves as less bright than other engineering students even when their performance is the same or better than their male peers. Another study reported by AWE (2005a) found that many women enter undergraduate engineering programs with a high amount of self-confidence, but that it "declines precipitously during the first year and, although it does begin to elevate, it will never again reach the same heights (Brainard & Carlin, 1998)" (p. 8). Other research has found that high risk boys--boys who are already gang members and prone to violence--have no sense of self-efficacy whatsoever (Navarro, 2006).

Various explanations have been provided for these findings. Women's lower scores may simply reflect less familiarity with a topic or activity (Dagley & Salter, 2003), or women may lack opportunities to develop skills and have mastery experiences (Lent et al., 2002). Other researchers suggest that women judge their capabilities against different standards than do men, and that boys may overestimate their abilities when they are actually not able to perform to the level they assume they can (AWE, 2005a).

Many researchers break general self-efficacy down into domain-specific self-efficacy. Quimby and DeSantis (2006) did this in their research on the effect of confidence on career choice among 386 undergraduate college women, using Holland's RIASEC typology. RIASEC stands for Holland's six career types -- Realistic, Investigative, Artistic, Social, Enterprising, and Conventional. STEM fields fall largely into the Investigative and Realistic types. Realistic occupations are those involving manual, mechanical, agricultural, electrical, or technical skills. The Investigative type includes scientists. They found that confidence explained 14% of the variability in career choice for Realistic careers, 23% for Social careers, 26% each for Investigative and Enterprising careers, 31% for Conventional careers, and 37% for Artistic careers (Quimby & DeSantis, 2006, p. 302).

Hands-On Workshops

One way of increasing confidence is through providing girls with access to the content and skills of STEM disciplines through hands-on learning experiences (Dyer, 2004, p. 14). Several other studies of young women in MST fields found that women enjoyed highly challenging but low-threat experiences (Adya & Kaiser, 2005; Smith, 2000). According to SCCT, mastery experiences are a primary source of learning self-confidence. When one carries out a task, one not only learns how to do it, one gains a feeling of success (or failure). When one repeats a task, one increases his or her skills in it. Mastery of difficult tasks builds more confidence than does the completion of simple tasks. One of the assumptions of SCCT is that people will pursue activities in which they can be successful and not pursue activities in which they do poorly. In a study of middle school students (155 boys, 164 girls) in a small Midwestern city, Britner and Pajares (2006) found that mastery experiences contribute the most to science self-efficacy in both boys and girls, but particularly in girls.

Given these research results, interventions such as special programs, courses and camps especially for women should increase self-efficacy and therefore heighten interest in STEM careers. In their study of 32 high school girls' participation in a ten-day residential summer program, Phillips et al. (2002) compared the results of the 1994 Strong Interest Inventory Investigative scales administered prior to the intervention and then again one year later. They found that as a group the girls' interest in STEM fields remained stable. In a smaller sample of 6 drawn from the larger sample, the researchers found that on an individual basis the program raised both the self-confidence and interest of some girls while decreasing the interest of others (Phillips et al., 2002). Phillips et al. (2002) also note that those who said the program increased their interest mentioned the program's hands-on activities while those whose interests decreased focused more on the knowledge aspect of science.

Working Cooperatively

The difference theory of gender assumes that women prefer to work cooperatively or collaboratively rather than competitively (Goodwin, 2006; Smith, 2000). Sanders (2005) mentions a study conducted in England in which female children did computer tasks collaboratively, regardless of the instructions they were given. Eccles (1987) cites several studies showing that "girls have more positive attitudes toward math in classrooms characterized by low levels of competition among the students, high levels of cooperative learning or individualistic learning structure, and high levels of teacher communication of both the intrinsic value of math and the link between math and various interesting occupations (Casserly, 1980; Eccles, MacIver, & Lange, 1986; Eccles & Blumenfeld, 1985)" (p. 158). Wasburn and Miller (2004) note that the group projects "that are the hallmark of science, engineering, and technology classes" can be challenging for women (p. 163). Some of the women in their study reported that the men either did not want to work with them, or took over the groups and allocated lesser tasks to the women. It is interesting to note that this exclusion of girls on projects is quite similar to what Goodwin (2006) describes in her study of girls' games. The 4th grade girls said they disliked playing with boys because 'they [the boys] invade and they never pass to you. They never let any girls play' (Goodwin, 2006, p. 97). Goodwin (2006) also notes that in boys' play, skill leads to authority to direct others, whereas in girls' play, leadership is more diffuse and girls make extensive use of "practices of exclusion" of those less skilled (p. 138-140). In a study of female academic chemists, Fassinger et al. (2004) found that participants "rejected an

achievement approach based on besting others and winning external accolades" (p. 313). Rather, participants favored "task mastery and performance excellence, leadership of others, and internal standards of judging one's success," and secondarily, by taking charge in leadership positions (Fassinger et al., 2004, p. 313). Finally, Smith (2000) says that women are more concerned than men with the social dimensions of activities. This idea is supported by a study reported by Dyer (2004). Briefly, the study found that in mixed sex engineering teams, the men became more task-focused while the women became both task-focused and group-oriented.

Practical Utility

Sanders (2005) mentions that women prefer contextualized curriculum as well as learning things they perceive as useful. In support of this statement, Sanders (2005) notes that in a study by Jessup and Sumner, an undergraduate course in which students created software for local community social service agencies attracted "a higher proportion of females than other CS [computer science] courses (Jessup & Sumner, 2005)" (p. 19). Phillips et al. (2002) note that six separate studies concluded that "boys more than girls thought that science would be useful to them in the future" (p. 236). However, the results of a survey carried out among 804 undergraduate engineering students in the UK found that both men and women would prefer redirecting course emphases from theory to practical applications (Bagilhole, Dainty, and Neale, 2006). To address the issue of practical utility, Smith (2000) suggests showing the relevance of mathematics, science and technology (MST) to everyday life "by introduction of age appropriate discussions concerning ethical, cultural and societal issues that surround MST fields" (p. 16).

Role Models

Since Bandura's social cognitive theory designates role models as a source of learning, many interventions attempt to incorporate role models—women and/or minorities--in positions deemed atypical for them according to stereotypes. Research results on the influence of non-familial role models on career choice are mixed. Quimby and DeSantis (2006) report that a number of studies have found that role models affect career maturity, career aspirations, career indecision, attitudes toward non-traditional careers and career choice. In their own research with 386 undergraduate college women, they found that "the levels of self-efficacy, role model influence, and career choice consideration differed across RIASEC [Realistic, Investigative, Artistic, Social, Enterprising, and Conventional] types" (Quimby & DeSantis, 2006, p. 301). They also found that, after eliminating the influence of self-efficacy, the explanatory contribution of role models to career choice ranged from 0% for Investigative careers, 2% each for Realistic, Conventional and Artistic careers, and up to 4% each for Social and Enterprising careers. Thus, the unique explanatory capacity of role models in career choice in this study is rather low. Phillips et al. (2002) evaluated the impact on interests of a residential summer program on science and technology for high school girls. From their description, role modeling appears to have been a significant component of the program. All 32 participants completed the Strong Interest Inventory both before and one year after the program. "No significant differences were found in any of the pre- and posttest comparisons, indicating that the participants' interests remained stable as a group over the 1-year period" (Phillips et al., 2002, p. 242). Qualitative interviews with six of the participants one year later found that five of them thought the program had a positive effect on them. "The students with increases in their overall interest scores did not mention personnel but instead credited the activities of the academy with increasing their confidence in their physical science-related abilities" (Phillips et al., 2002, p. 244). In her review

of the literature, Sanders (2005) also reports there is little evidence that role models have any positive impact on STEM career choice.

In social cognitive career theory, role models are seen as a contextual support. As such, it is said to affect self-efficacy which in turn affects career choice. However, except in the case of familial influence, research illustrating this is lacking.

Family

More than two decades of research has shown that family support is crucial for women to excel in engineering and other technical fields (AWE, 2005b). The more educated the parents, and particularly the mother, the less likely they are to adhere to stereotypes of STEM fields and women's abilities. The Assessing Women in Engineering project (AWE, 2005b) reports that "in Boswell's 1985 study, two factors that influenced a female's underachievement in mathematics were the female's stereotyping of mathematics and her father's stereotyping" (pp. 2-3). Mothers influence their daughters' attitudes toward mathematics and enrollment decisions. Fathers and other male relatives serve as role models in girls' choice of non-traditional and STEM careers (Adya & Kaiser, 2005; AWE, 2005b; Gates, 2002; Smith, 2000). Several studies conducted during the 1980s found that "the math level of the father's occupation was correlated with the amount of math taken in school by the daughter (Wise, 1985; Jagacinski, 1987)" (AWE, 2005b, p. 5). Additionally, the daughters of parents who value education and expect their daughters to do well are more likely to persist in math courses.

Mentoring

According to Sanders (2005), mentoring "has real evidence in its favor" (p. 18) and is thus a proven practice for retaining women in STEM fields. Dyer (2004) mentions projects using cascading mentors, in which faculty mentor undergraduates who in turn mentor high school students, and cross-generational mentoring, which has been successfully used in rural and tribal areas to increase retention of female students. Other types of mentoring arrangements mentioned in the literature include traditional one-to-one mentoring, peer mentoring, and tiered mentoring, in which mentors from several educational levels mentor a younger group. The type implemented may differ according to local circumstances. Meetings between mentor and student can be regularly scheduled or impromptu, in person or conducted by telephone or internet. Smith (2000) notes that one-on-one interaction may be a necessity. Because no personal relationships are involved, meeting "role models" in workshops or lectures is not considered mentoring. Additionally, Dyer (2004) notes that mentors need to be trained, as "training has been recognized as instrumental for the success of mentoring projects" (p.16-17).

Mentoring can also be used as a recruitment tool. Goforth (2005) describes an after-school program in which 4th and 5th grade girls were paired with teenage students from a mathematics and technology high school. The pairs met together throughout the year to perform hands-on experiments illustrating the scientific method. At the end of the school year, when compared with a comparable group of 4th and 5th graders who had not participated in the program, participants showed "a marked increase in enthusiasm, confidence and science skills at the end of the year"(Goforth, 2005, p. 2). The experience also had a positive effect on the teenage mentors. When having problems in their own studies, the teenagers thought twice about dropping out.

Conclusion

This review has presented STEM recruitment strategies currently described in the literature. Some of these practices have been thoroughly tested (e.g., the usefulness of internships), and others need further testing (e.g., women's attraction to projects having practical utility). The use of non-family role models has been a standard recruitment practice, yet testing has shown that, by themselves, non-family role models provide little motivation for women to enter STEM fields.

A number of recruitment strategies focus on engaging young women's interest in STEM careers through interpersonal and/or hands-on experiences (for example, increasing women's self-confidence in STEM fields through cooperative and/or hands-on workshops). As Choudhuri (2004) and Pietsch (2003) note, for women, self-confidence precedes interests and career goals. Women must feel confident in their abilities before their interest is aroused.

One significant barrier that still remains, at least at lower educational levels, is the use of aptitude or mathematics scores to screen out potential candidates for STEM careers. If students' interests in STEM fields are aroused, the students may become motivated to increase their mathematical skills. Further, while growing up, children learn the American tenet that some people have the innate ability for certain activities and others do not. Mathematical ability is one of those abilities considered to be innate. This can lead children to say, "I can't do it" rather than "I can do it if I try." The use of mathematics scores as a screening tool is most likely appropriate in selecting graduate students for advanced programs. Yet, if the goal is to increase interest in and recruitment to STEM fields, it might be wiser to open the floodgates and provide the necessary training rather than screen out those who have not yet acquired skills. As a professor of non-western languages once said to a frustrated student, "You learned one language. You can learn another."

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