# A Theoretical Basis for Recruitment and Retention Interventions for Women in Engineering

Stephanie Blaisdell, Catherine R. Cosgrove

Arizona State University

While women have dramatically increased their representation in many professions over the past three decades, they continue to be underrepresented in engineering[1]. LeBuffe, in her annual survey of engineering enrollments and degrees for the Engineering Workforce Commission of the American Association of Engineering Societies, found that roughly 16% of all bachelor degrees in engineering were awarded to women in 1993[2]. In 1993, women received only 9% of the doctoral degrees in engineering[3]. In the first quarter of 1994 there were 127,000 women employed as engineers, which was roughly 7% of the engineering work force[4]. The future does not seem much brighter, either. In 1990, senior males in public high schools were more than three times as likely to choose a career in science, math or engineering than women[5]. In January, 1994, only 2.9% of all women entering college planned to major in engineering, compared to 11.8% of men[6].

In an effort to increase the number of women in engineering, numerous programs have been put into place. However, few of these programs take advantage of the literature provided by counseling psychology and other fields that study career development. These theories can inform interventions designed to recruit or retain women in engineering. One such theory that has been empirically supported to explain why women tend not to enter non-traditional fields such as engineering is Social Cognitive, or Self-efficacy, theory.

Bandura[7] defines self-efficacy as one's belief about how well she or he can perform a given task or behavior. One builds self-efficacy through four sources of information: Past performance accomplishments, vicarious learning (seeing others model the behavior), encouragement and support, and physiological arousal (such as lowered anxiety)[8]. Self-efficacy expectations are viewed as mediators of behavior and behavior change. The level of self-efficacy expectations, the degree of difficulty of the tasks the individual feels capable of attempting, influences the kinds of behaviors attempted and avoided. In addition to self-efficacy expectations, an individual also holds an outcome expectation, a belief about what consequences performing that task or behavior will have. Perceived outcome expectancies need to be sufficiently positive to motivate an individual to perform a given behavior. For example, a woman might have high self-efficacy for becoming an engineer, but sees the uphill struggle as too big an effort for the perceived pay-off, so she decides to go into business instead. However, of the two, outcome and self-efficacy expectancies, self-efficacy is presumed to have the more powerful influence on the initiation and persistence of a behavior[9].

Betz and Hackett [10] applied Bandura's self-efficacy theory to women's career decisions. They proposed that the socialization of women provides them with less access to the sources of information important to the development of strong expectations of efficacy with respect to their tamers. In fact, research has supported the idea that the sex-role socialization of females is less likely than that of males to facilitate the development of strong career-related self-efficacy expectations, particularly for nontraditional fields[11]. Women and girls today are either not encouraged, or are actively discouraged, from engaging in a variety of activities that serve to increase and strengthen their expectations of personal efficacy. Therefore, women's continued underrepresentation in professions such as engineering may be due to low self-efficacy expectations with regard to behaviors required for the successful pursuit and performance of those occupations.

Research has shown that occupational self-efficacy (one's confidence in one's abilities to perform a particular occupation), along with gender and interests, predict the range of occupations students consider [12]. Additionally, research suggests that gender influences past performance accomplishments (number of math courses taken), which affects math achievement and math self-efficacy, which predicts the choice of a math/science major [13]. In fact, self-efficacy has found to be a stronger predictor of those who enter engineering majors than interest or academic achievement [14]. However, self-efficacy appears to have a curvilinear relationship with choice of an engineering major, exerting it's greatest effect on those students with moderate ability (those with high level ability can succeed without self-efficacy, and those with low level ability won't be helped by self-efficacy) [15].

Because the four sources of self-efficacy are known, the theory readily lends itself to the design of interventions. To increase a young woman's self-efficacy for engineering, or those components that makeup engineering (math and science), one must provide her with opportunities to experience performance accomplishments, vicarious learning, encouragement and support, and lowered physiological arousal. Research in this area has found that performance accomplishments are the most important source of self-efficacy, followed by vicarious learning, encouragement and support, and finally, physiological arousal[16].

Research also provides information on what kinds of experiences within the four sources of self-efficacy information are most helpful. For example, it is important that a performance accomplishment experience be challenging, but a great likelihood for success should exist [17]. Also, there is an important distinction between simply providing models and having vicarious learning occur. To increase the likelihood that vicarious learning does occur, models should be as similar to participants as possible (e.g. same gender, ethnicity, age, socio-economic background, etc.) [18]. Additionally, coping models, or those models who are seen to face and overcome obstacles with a struggle, are more helpful than mastery models, individuals who seem to sail through difficulties without a hitch [1]9.

Self-efficacy theory is the basis for the programs offered by the Women in Applied Science and Engineering (WISE) Program at Arizona State University. By way of example, self-efficacy theory informed the program methodology for the Women in Engineering and Technology (WIET) Day, an outreach program for community college women interested in engineering.

WIET Day is held in the Women in Engineering and Applied Science (WISE) Center, located in the engineering complex on campus. Participants are mailed maps to the room and parking prior to the event. At the start of WIET Day, participants complete a pre-questionnaire, sign in, get a name tag, and enjoy a continental breakfast. The women meet each other through a mini civil engineering lab where, in teams of four or five, they utilize a limited supply of marshmallows and drinking straws to construct structures that must stand one meter high for 15 seconds (performance accomplishments). After a welcome by the Associate Dean of the College of Engineering and Applied Sciences (a woman), the women then participate in a cooperative learning computer lab (performance accomplishments) entitled "The Thirsty Executive".

For this lab, students pair-up at computers and reason through how to maximize the efficiency of chilling down a hot beer for a boss at his/her cabin for the weekend. Before the lab, the women are introduced to the concept of cooperative learning by a faculty member who uses the techniques in his classes. The emphasis of the lab is not on determining the solution, but on the process by which the problem is solved. Participants are encouraged to make flow charts, eliminate unnecessary information, and take whatever other steps are necessary to solve the problem. Participants are shown how to apply their problem-solving method to other situations and other problems they will face in their classes. This lab is held in the campus' computer center and has the added benefit of introducing participants to this facility and the computer equipment.

Participants then meet in groups with current female students for a discussion session (vicarious learning; encouragement and support). Small group facilitators are trained in advance, receiving information about self-efficacy and how to maximize vicarious learning. Facilitators are chosen for their ability to relate to the participants, and are as similar as possible in age, academic status (average students as opposed to "super-stars"), and background (female transfer students in engineeringh.ethnology). Facilitate are taught attentive listening skills and are instructed to focus on what barriers they themselves faced and how they overcame them, as well as what fears, concerns or problems the participants are facing as a result of the transfer process.

During lunch, female faculty from the College of Engineering and Applied Sciences join the participants for informal discussions (vicarious learning; encouragement and support). There is also a keynote speaker during lunch. Last year, a (female) NSF Visiting Professor from the Physics department and a representative from Career Services spoke (encouragement and support).

After lunch, participants hear from women engineers from local industry to discuss their potential futures (vicarious learning; encouragement and support). Next, they are given a tour of campus highlights, including engineering facilities (physiological arousal reduction). Participants then have an opportunity to clarify their career goals by hearing about various engineering and technology fields from female students in those fields (encouragement and support; vicarious learning).

Finally, a representative from the admissions office fields questions regarding the transfer process and is available on. a one-to-one basis after the program (physiological arousal reduction; encouragement and support). Participants complete a post-questionnaire including a program evaluation.

Overall program evaluations of WIET Day were positive, consistently receiving ratings of "very valuable" and "very well organized". All but one participant indicated that she would "absolutely" recommend the program to a friend. Of the individual components of the program, highest marks went to the small group discussion, followed by the computer lab, contact with industry and the career information session. In keeping with the research, which suggests that physiological arousal is the least important source of self-efficacy, the campus tour was rated lowest, as only "somewhat" helpful,. Follow-up data indicate that while some students remain at the community college, 50% have transferred into the College of Engineering and Applied Sciences at Arizona State University.

The pre- post-questionnaire consist of the Career Decision-Making Self-Efficacy Scale (CDMSE)[20], the Mathematics Self-Efficacy Scale21 and the Occupational Self-Efficacy Scale[22]. The CDMSE Scale measures an individual's belief that she can successfully complete tasks necessary for making career decisions. The scale is based on Crites'[23] model of career maturity. Five behavioral domains are measured: Accurate self-appraisal, gathering occupational information, goal selection, making plans for the future, and problem solving. The scale consists of 52 items (e.g. How much confidence do you have that you could: Choose a career in which most workers are the opposite sex), rated on a ten-point scale (O= No confidence, 9 = Complete confidence)[24]. On the Mathematics Self-Efficacy Scale, participants are asked to rate how confident they are that they could successfully complete everyday math tasks (e.g. Compute your income taxes for the year), and complete specific math courses with a grade of "B" or better (e.g. Calculus). The scale has 34 items, also rated on a ten-point scale 25. The Occupational Self-Efficacy Scale measures that, assuming she was motivated, how confident is the participant that she could successfully complete the educational requirements and job duties for 15 traditionally male occupations (e.g. Electrical Engineer), as well as how confident she is about general academic milestones (e.g. How confident are you that you could successfully:

complete some technical or science degree). The scale consists of 41 items[26]. Each of the three scales have been found to have adequate test-retest reliability and construct validity.

Participants' scores on each scale increased from the pre- to post-questionnaire. Since the participants are self-selected on the basis of their math and science interests, as expected, the women began with a higher than average score on the Mathematics Self-Efficacy Scale. Despite that, average scores on this scale increased by 3.1%. Scores on the CDMSE Scale increased by 5.3%. However, the most dramatic change was in participants' scores on the Occupational Self-Efficacy Scale, which increased by 10.3%. Translated, these increased scores indicate that by the end of WIET Day, the participants were more confident in their math and career decision-making skills, their ability to complete the educational requirements and job duties of a number of engineering and other non-traditional occupations, and their ability to complete general academic tasks to succeed in engineering.

Unfortunately, because so few of the existing efforts to increase the number of women in engineering avail themselves of the above research, there is little to compare these results with, since self-efficacy measures are not utilized. In fact, few pre- post- measures are ever utilized in such programs. Of the two recruitment/retention programs for women in engineering included in the 1985 ASEE Proceedings, only one utilized a pre-test, and it apparently asked only about engineering interest[27].

In conclusion, there are many advantages to using a theory such as self-efficacy in program development First, it ensures that a program includes all the components important to enacting change. The alternatives, using common sense or experience, may lead to utilizing only a portion of those interventions research has found to be useful, resulting in limited effectiveness. Second, a theory guides the measurements used to determine program effectiveness. Pre- post-measures, as well as long-term follow-upon actual major/career selection are important in evaluating programs. Finally, a selected theory should already have supporting research, just as self-efficacy has already been found to be effective in recruiting and retaining women in engineering. By using self-efficacy theory, one does not have to wait until the program is over to determine whether or not it will be effective.

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STEPHANIE BLAISDELL
Stephanie is the Acting Director of Women's Programs for the College of Engineering and Applied Sciences at Arizona State University. Stephanie previously served as the Assistant Director for the program since it's inception in 1993. Stephanie holds a Master's Degree in Counseling and is a Ph.D. candidate in Counseling Psychology at ASU. Her research focuses on women's career development in nontraditional fields.

CATHERINE R. COSGROVE
Catherine was formerly the Director of Recruitment and Women's Programs for the College of Engineering and Applied Sciences at Arizona State University. Catherine served in this position from the program's inception in 1993 until November of 1995 when she took a position as a Biologist with Apache County in Northern Arizona. Catherine holds a Master's Degree in Environmental Resources from ASU.