EVALUATION OF SUMMER ENRICHMENT PROGRAMS FOR WOMEN STUDENTS

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Abstract

In spite of the fact that in the last two decades both boys and girls' participation in high school mathematics and science courses has generally increased and more girls are taking advanced mathematics and science courses in high school, women are not an equitable segment of the STEM workforce. The status of women in the workforce shows females still occupy stereotypical roles, such as secretaries, nurses and elementary school teachers.

Much has been done to address the needs of women and girls in STEM areas. Programs, especially summer programs, have been implemented that are designed to encourage female students to pursue STEM careers and address their attitudes towards such fields. However, while such programs have achieved success, both actual and perceived, evaluation of such programs is difficult. For example, these programs are usually of short duration making the assessment of student learning under these circumstances problematic.

The Center for Pre-college Programs at New Jersey Institute of Technology (NJIT) has offered the Women in Engineering and Technology program (FEMME) since 1981. Started as a program for 25 ninth graders, the program now serves 125 post-4th through post-8th grade students each summer. In that period of time since the initial program, an assortment of program evaluation instruments have been developed and implemented. This paper will discuss these instruments, some successes and some failures, and some of the results that have been obtained.

Introduction

Studies over the past twenty years on the relationship between gender and achievement in SMET fields have shown that the most striking difference between boys and girls in the science and mathematics area is not the level of academic achievement, but the attitude towards such fields[1]. A large number of people, particularly women, feel relatively uninformed about engineering and engineers. Girls and boys enter school roughly equal in measured ability and remain so through elementary school[2]. Then from ages twelve through seventeen girls consistently underestimate their abilities and acquire an increasingly negative view of SMET careers even when they have similar exposure to science and mathematics courses and are academically performing at par with boys[3]. Thus they graduate from high school with out the necessary pre-requisite skills to study engineering in college[4-5].

In the past 20 years there has been a proliferation of programs designed to promote interest of young women in STEM careers. Yet, women hold only 12% of the science and engineering jobs in business and industry. Unfortunately, it is evident that trying to interest students in STEM careers is not easy. Most of these programs are excellent programs. However, since these programs are usually of short duration, evaluation of the programs and specific components are difficult, and reports of evaluation efforts are limited. Thus, it is difficult to know what works and what doesn't work, and what the best practices that should be replicated are.

The Center for Pre-College Programs at NJIT has sought to become a driving force in providing increasing access to scientific and technological fields among traditionally underrepresented populations. The Center's focus has evolved from working with 40 Newark high school students to serving a widening geographical audience of over 4,000 New Jersey students, teachers, parents and educational professionals from kindergarten through twelfth grade[6-7].

Women in Engineering & Technology Initiative-FEMME at NJIT

To help counteract the disadvantage that girls experience, NJIT first offered the Women in Engineering & Technology Initiative-FEMME program in 1981. FEMME, an intensive summer and academic year program, was designed to improve the science and mathematics backgrounds of academically talented ninth grade girls and encourage them to pursue careers in scientific and technological fields[8-9].

While highly successful in encouraging and retaining those self-selecting high school students in technological careers, NJIT believed that earlier intervention was crucial and girls should receive science, mathematics, engineering and technology (SMET) enrichment and encouragement prior to ninth grade[10]. Therefore in 1992, with initial NSF funding, the Women in Engineering & Technology-FEMME program was expanded to incorporate post fourth and five grade female students. There are currently five FEMME groups in the Women in Engineering and Technology initiative, 4th through 8th grade, which allows for a true continuum from elementary into secondary level[11]. The Women in Engineering & Technology Initiative-FEMME programs are designed to increase the flow of women entering and completing engineering and scientific careers by:

- Enhancing girls' science and mathematics achievement while developing their problem solving & critical thinking skills.
- Encouraging girls to take advanced science and mathematics placement courses in secondary school, and maintaining girls' interest in engineering, mathematics, science and technology during the secondary school years.
- Encouraging girls to learn about careers in SMET fields in which women are traditionally underrepresented, pursue studies in science, mathematical, engineering and technological fields.

Academic curricula provides participants with opportunities to master higher level problem solving skills in mathematics, science and technology, learn about computer science and engineering principles and prepare and motivate them to choose mathematics, science and technology college preparatory courses in high school. Counseling and mentoring sessions with female scientists and engineers in industry and academia are offered for students to learn first-hand about career opportunities available for women in SMET fields. Current intervention initiatives, including NJIT's, are designed to enhance girls' academic skills accompanied by interventions that focus on enhancing students' sense of self-efficacy.

All activities utilize non-biased "gender friendly" instructional methodologies, problem solving cooperative techniques, and a teamwork approach. Students learn by "*doing rather than viewing,*" the best methodology for all students, but especially for girls who tend not to have as many opportunities or to be as encouraged as boys to work with their hands, use tools, equipment or any type of scientific apparatus.

Although FEMME goals are common for all grade levels; the implemented objectives such as classes, laboratories, hands-on activities, field trips, mentoring sessions etc. are specific to appropriate grade course work. Each group has a main thematic unit linking all other subjects and activities. Each group thematic unit and academic curriculum is aligned with the New Jersey Core Curriculum Standards for appropriate grade levels providing students with prior knowledge upon which we could build. FEMME groups and their thematic focus are as follows:

- FEMME4--Environmental Science
- FEMME5--Aerospace Engineering
- FEMME6--Mechanical Engineering
- FEMME7--Chemical Engineering
- FEMME8—Biomedical Engineering

Looking at FEMME7 (Chemical Engineering), as an example, the seventh grade girls learn about chemical engineering and chemistry, in particular how the world looks through the lens of a chemical engineer Topics covered include chemical kinetics, chemical equilibrium, and separation methods and how they affect our everyday life. They learn topics such as cosmetics and household products and create their own formula for toothpaste, testing for smell, taste, texture and color. As a final project, the students test claims made by manufacturers about a chemical product in their laboratory experiments. For example, students were involved in toothpaste development, where they experienced first-hand manufacturing their own toothpaste. They first tested toothpaste ingredients to determine their individual attributes. Upon completion of their investigation, they formulated their own toothpaste based on the desired qualities.

Evaluation Methodologies

Through trial and error, we have learned in the past twenty years how to increase women and girls' participation in STEM. This knowledge is now being fully implemented to help more young women to become interested in engineering as a career, and to pursue and successfully complete degrees in engineering. But in terms of evaluating the success of our programs, we are still expanding our repertoire of instruments.

During our early experiences with these programs, our primary instrument was a post-program evaluation to assess the program components and the impacts of the programs on the participants[8-9]. We also recognized the need to follow up with participants after the program to assess long-term impact on their career goals and aspirations. These tools provide valuable information and are still prime instruments for assessment[12-14].

Outcome measurements and assessments are an integral part of all pre-collegiate initiatives as well as the Women in Engineering & Technology Initiative-FEMME programs. Traditional program evaluation methodologies are part of the assessment process of the programs. Program participants complete evaluation questionnaires regarding academic curricula, teachers and methodology at the end of each program, as well as questions on how the programs impacted on their career goals and aspirations. Instruments for assessing student learning have become a major component of the assessment process. An evaluation coordinator is on staff to analyze and develop appropriate tools to determine student's quantitative and qualitative skills, basic process skills, establish guidelines and modify curricula if necessary to accomplish program goals. Prior to the start of each summer program, directors, teachers and teaching assistants meet with the Center's Evaluation Coordinator, to analyze and develop appropriate tools to determine student's quantitative and qualitative skills and establish guidelines. Traditional methods of measurement are utilized to assess written assignments including standard and multiple choice tests and essays, the use of rubrics, student journals, student portfolios, and pre and post test results are utilized as valid methods of measuring process skills

As an example of the results of the pre- and post-tests, we can look at the pre- and post-tests for one of the FEMME Programs. The FEMME7 program for post-seventh grade girls focused on chemical engineering. For the summer 2003 FEMME7 program a comparison of students' individual scores in the pre and post-test indicated that students scored significantly higher in the post test. Both exams contained the same content. For creditability, the format and sequencing were changed. The results were remarkable given that it was a four-week program and the diverse pool of student participants. On the pre-test, the highest score was 38. The average of the pre-test scores was 10%. On the post-test, 6 girls scored above 80% and 7 between 70 and 80%). Of the 24 students, only 2 students scored below 50% (a 48 and a 49. Scores on the post-test ranged from 89 to 48 with an average grade of 70.

Another assessment of student learning is based upon a protocol developed through the Center's professional development activities[15]. The protocol links the state science content standards and the specific knowledge and skills students are expected to acquire with the learning expectations of the students by the teachers. The program instructors plan standards-based lessons that include the learning expectations of the standards, and assessment of student work in relation to the expectations of the standards. The procedure allows the instructors to write and implement standards-based lesson plans that include the assessment and documentation of students' achievement of the standards in these lessons. Program instructors develop rubric assessment instruments to evaluate the extent to which their students demonstrate the skills and knowledge defined by the state content standards. Documentation of achievement includes:

1) Standards-based lesson plans.
2) Documentation in which the instructor analyze the student work for evidence of achievement.

Completed rubrics assessing individual student's performance in group activity work and portfolio sampling of the work done by the students in class are also included.

However, our recent studies as well as studies reported elsewhere point to the need for interventions that can overcome obstacles that exist on a continuing basis. For example, interventions by universities must take into account what occurs during the year at schools and at home. Resent research on students' career decision-making behavior and women in engineering suggests that proper counseling and perceived barriers by adults and peers to career attainment play an important role in career planning and possibly persistence and should be considered in any intervention to gender inequity in careers such as engineering[16].

It has become recognized that successful outcomes should show increased knowledge about engineering careers and more positive attitudes to engineering in students[17-20]. As part of our activities a survey has been developed with attitudinal scales to measure high school students' attitudes towards engineers and engineering as a possible career, their engineering skills self-efficacy and their level of academic self-confidence, their academic history as well as a measure of their knowledge about engineering careers and pertinent demographic information[16]. The survey was developed as part of a State funded project to increase the knowledge and awareness of engineering in high school students, their teachers, parents, and school counselors and to promote more positive attitudes to engineering. Information from this survey is being used to shape program interventions and provides data to determine whether high school students' attitudes to engineers and opinions and knowledge about engineering as a career are changing in a more positive direction. More specifically the survey sought answers to the following questions:

- What positive and negative impressions do high school students have about engineers and engineering as a possible career for themselves?
- What is their self-efficacy for engineering-related skills?

- What is their academic history and level of self- confidence in the appropriate academic subjects?
- What do they know about engineering careers?

As a result the survey has five measures: 1) the Attitudes to Engineering Scale, 2) the Engineering Skills Self-Efficacy Scale, 3) the Self-Confidence in Academic Subjects Scale, 4) an Academic History, 5) a Knowledge about Engineering Careers measure and a short demographic section.

An interesting aspect of the responses from the participants in the Summer 2003 programs relates to the question asking students to name 5 types of engineers. Almost 42% of the summer participants were able to name all 5 types while 79% were able to name 3. This is compared to a study of 381 high school students (male and female) who indicated their interest in engineering by attending an engineering career day at NJIT ( ). Of the students in this population, only 25% could name 5 types of engineers, and almost 30% would not or could not provide a single correct response. It should be noted that most of the FEMME participants return for a second or third program appropriate to their grade levels. Thus, the results of this survey can be attributed to the continuing interventions with these students.

Most important to the pipeline issue is the tracking of participants after completion of the student program. All participants are followed-up on long term basis to determine: students' progress in middle and secondary school, choice of courses, personal development, and choice of career and institution of higher education. The Center for Pre-College Programs has in place a computer database for the purpose of research and to accurately track all pre-college participants. Statistical information is currently available for students who participated in programs between 1981 and 2000.

As we continued to have earlier interventions with the female students, it was recognized that some of the information requested in this type of survey would vary with the location of these students in the educational/career pipeline. Thus, we use four different surveys for students who have not yet completed eighth grade, students in high school, students in a post-secondary institution, and students who have graduated with baccalaureate degrees.

The total number of CPCP alumni of FEMME programs operated between 1980 and 2003 was 900 students. All were sent questionnaires in 2002. We received responses from 298 former participants, a response rate of over 33%. For these types of surveys, 33% is considered a very good response rate.

Of the responses received, 202 (67.8%) were either graduated from a post-secondary institution or still in an undergraduate program. The remaining 96 respondents (32.2%) were still attending an elementary or secondary school and had not indicated a career choice at this time. About 66.7% (135) of respondents have selected a technological career (engineering, science, computer and information systems, math, or architecture).

The primary career options of the respondents were Engineering and Technology (19.1%), Science (36.9%) and Mathematics (10.7%).

Conclusion

Current intervention initiatives, including NJIT's, are designed to enhance girls' academic skills. Over the years, these programs have had important implications for removing some barriers that prevent women from pursuing careers in mathematical, scientific and technological fields. Research has shown that young women still avoid advanced mathematics and science related courses and careers because they underestimate their capability and not because they lack competence or skill. The lack of knowledge about engineering careers, the absence of engineering role models and mechanical activities prior to college, in concert with overt and covert gender bias as well as differences in socialization, further exacerbates the problem of women not pursuing careers in STEM fields.

Although single gender programs are not the only answer, they are invaluable initiatives in providing high quality educational opportunities to all students. Anyone who feels these single gender initiatives can be discontinued, should consider the Association to Aid Scientific Research by Women. Started in 1898, it dissolved itself in 1932 because *"the object for which this Association has worked for thirty-five years has been achieved, since women are given opportunities to engage in scientific research on an equality with men, and to gain recognition for their achievements."*

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