A Contemporary Science and Engineering Program
for Middle School Girls

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Abstract

Various research literature shows that women face numerous workplace related problems ranging from sexual discrimination and inadequate work skills to balancing work and family life. Although women are working hard to meet the workplace demands and challenges, they still face the need to acquire workplace “survival” skills. Basic educational skills are sufficient only for a limited number of jobs in the future workplace. More effort is needed to raise women’s skills in mathematics, science, and technology if women are to be able to compete.

This paper describes a pre-college science and engineering education program conducted every year at Penn State Altoona for middle school (7th and 8th grades) girls and their teachers. The program is designed to address each one of the above mentioned skills. The objective of the program is to expose middle school girls to careers in science and engineering. In addition to providing a detailed description of the program, the paper analyzes the outcomes of this program. Recommendations for further improving the effectiveness of the program are also given.

I. Introduction

Various research literature shows that women face numerous workplace related problems ranging from sexual discrimination and inadequate work skills to balancing work and family life. Although, women are working hard to meet the workplace demands and challenges, they still face the need to acquire workplace “survival” skills. Because women are underrepresented in the workplace and are a disadvantaged group, they need encouragement to be able to decide and stand firm in their decisions to enter and fit in to the workplace. They must rely on themselves rather than on institutions to create careers. In addition, they must have portable career assets, skills, and professional reputations that can be applied anywhere. Basic educational skills are sufficient for only a limited number of jobs in the future workplace. More effort is needed to raise women’s skills in math, science, and technology if women are to be able to compete. More specifically the skills that women need to succeed in the public domain of work include:

1. Proficiency in basic math, sciences, and technical skills
2. Creative thinking
3. Goal-setting
4. Learning to learn
5. Personal and career development skills
6. Leadership skills
7. Teamwork
8. Communication skills
9. Interpersonal skills
10. Information and technology related skills

This paper describes a pre-college science and engineering education program conducted every year at Penn State Altoona for middle school (7th and 8th grades) girls and their teachers. The program is designed to address each one of the above mentioned skills.

A major problem that currently exists in the schools in the United States is the lack of appropriate methods and tools which should be used to motivate students to explore careers in science and engineering (Anwar, 1998). In most of the schools, excellence in mathematics is regarded as a key to success in science and engineering. Students are taught numerous mathematical concepts without teaching them how these concepts are put into application in the real world. Many math teachers are unfortunately unaware of how engineers and scientists use mathematics to solve real-world problems (Mowzoon, White, Blaisdell, and Rowland, 1999). By infusing science and engineering problem solving concepts into mathematics curricula, students may be provided with a context for the material they are learning. Demonstrating how engineers and scientists use mathematics to solve real world problems would encourage students to continue their math and science studies. Such demonstrations would also motivate students to consider careers in science and engineering. The objective of the program described in this paper is to expose middle school girls to careers in science and engineering.

II. Institutional Background

Penn State Altoona is one of 24 campuses making up the Pennsylvania State University system. It is the second largest of the 24 campuses and is a full-service residential campus located 42 miles from the research campus at University Park. Penn State Altoona became a four-year college within the Pennsylvania State University system in 1997 and offers baccalaureate degrees in eight majors. Penn State Altoona also offers associate (two-year) degrees in nine majors. Additionally, Penn State Altoona provides two years of course work for more than 160 Penn State majors. More than 3800 students attended Penn State Altoona during Fall 1999. During the 1999-2000 academic year, 239 minority students attended Penn State Altoona.

III. Program Components

The science and engineering program described in this paper consists of hands-on interactive classroom sessions involving exciting applications of mathematics, science and engineering. The key components of this one-day program are:

- Hands-on interactive classroom session on lasers and fiber optics = 1.5 hours
- Hands-on interactive classroom session on science = 1.5 hours
- Hands-on interactive classroom session on engineering design = 1.5 hours
- A panel discussion sponsored by Penn State Altoona Chapter of the Society of Women Engineers (SWE) = 1 hour
- Electronics technology showcase = 45 minutes

IV. Detailed Program Description
A detailed description of each key component of this program is as follows:

1. Hands-On Interactive Classroom Session in Engineering Design

   Duration: 1.5 hours

   Skills Addressed: Proficiency in math, sciences, and engineering; creative thinking; goal-setting; learning to learn; teamwork; information and technology related skills.

   Session Description: The program on engineering design will begin by introducing students to the profession of engineering. The essence of being an engineer will be described through exploring the engineering design process, beginning with a statement of the problem to be solved, following with development of approaches and selection and testing of the best approach. To help the students understand the process, and gain an exposure to working in a creative capacity as an engineer in a design team, the problem of the inadequacy of current automobile restraints will be given to the class. The class will explore the Internet to look for background information and identify potential approaches to solve the problem, and will then brainstorm for approaches and select the best. Discussion on the selected approach will then be undertaken.

2. Hands-On Interactive Classroom Session in Science

   Duration: 1.5 hours

   Skills Addressed: Creative thinking, experimental design, reverse engineering, learning to learn, teamwork, leadership, interpersonal skill, and communication skills.

   Session Description: This hands-on classroom session will involve exploration of the thinking styles and skills employed by scientists. Various characteristics of scientific thought and the scientific method will be investigated through a series of min-laboratory experiences. Skills such as sequencing, hypothesis formation, lateral thinking, inductive and deductive reasoning, and dealing with uncertainty will be practiced through games, experiments and simulation exercises.

3. Hands-On Interactive Classroom Session in Lasers/Fiber Optics

   Duration: 1.5 hours

   Skills Addressed: Proficiency in math, science, and engineering; creative thinking; goal setting; teamwork; leadership; interpersonal skills; and communication skills.

   Workshop Description: This session consists of selected inquiry-based exercises in the topical areas of lasers and fiber optics. Lasers/fiber optics technology is one of the most rapidly growing fields in science and engineering. Lasers are used for a wide variety of industrial, medical, telecommunications, and entertainment applications. The hands-on activities in this session are developed around the following concepts:
4. Panel Discussion

Duration: 1 hour

*Skills Addressed:* Personal and career development information; communication skills; goal setting; and interpersonal skills.

*Panel Description:* As a portion of the program the students will have the opportunity to discuss concerns and issues of women who are considering entering the field of science or engineering. This opportunity will be in the form of a panel discussion. The panel will consist of a moderator and three to four panelists. The individual panelists will represent current students and/or recent graduates in the fields of mathematics, engineering and natural sciences. Members from the Society of Women Engineers (SWE) will be participating in the discussion. The panel discussion topics will include:
- Advantages and disadvantages of academic endeavors in a male dominated field.
- The role of women’s professional societies and organizations for mentoring and support for female students in the fields of science and engineering.

5. Electronics Technology Showcase

Duration: 45 minutes

*Skills Addressed:* Creative thinking

*Session Description:* Selected 2EET students will show real-life applications of digital systems and linear electronics by conducting hands-on demonstrations related to their final semester projects. Examples of such projects include digital controllers, mathematical calculations systems based on digital electronics, and audio amplifier systems. It is expected that this showcase of real-world applications of electronics technology will serve to increase female students’ interest in pursuing college level studies in science and engineering.

V. Facilities for Conducting the Program

The program described in this paper is held in the Ralph and Helen Force Advanced Technology Center Building. This building provides students with the opportunity to take engineering and technology courses in the two-story 15,000 square feet, state-of-the-art facility. The Advanced Technology Center Building contains a CAD/CAE laboratory, an electronics/communications laboratory, and a project laboratory to allow students to experience hands-on learning in a modern learning environment.

VI. Recruitment of Program Participants
The above mentioned one-day program for middle school girls was conducted for the first time at Penn State Altoona in April 1999. For the recruitment of program participants brochures were developed by the Penn State Office of Continuing & Distance Education during Fall 1998. Program brochures were distributed to the career guidance counselors and the science teachers in the middle schools of a five-county area, which includes Blair, Bedford, Cambria, Huntingdon, and Somerset. The middle school science teachers and the career guidance counselors were requested to provide information regarding the program to female students in 7th and 8th grades. The science teachers and the career guidance counselors nominated female students for participation in the program. Based on the number of available (20–24) spaces in the program, students nominated by the school science teachers and the career guidance counselors were selected to participate in the program. If a parent, student, or teacher requested more information, he/she was encouraged to contact the Penn State Altoona Office of Continuing and Distance Education where a full-time staff member was available to answer any inquiry regarding the program.

A total of 29 middle school girls and their 7 science teachers attended the program in April 1999. Two full-time faculty members (Dr. Andrew Vavreck and Dr. Sohail Anwar) in the Division of Business and Engineering and one full-time faculty member (Dr. John Lennox) in the Division of Mathematics & Natural Sciences conducted the program. The faculty advisor and several student members of the Society of Women Engineers (SWE) participated in the panel discussion, which turned out to be a very lively event. Program participants showed keen interest in Electronics Technology Showcase where several students in the Electrical Engineering Technology Program of Penn State Altoona presented their projects. Projects included arithmetic calculators, opto-electronic circuits, and microprocessor based systems.

VII. Program Evaluation

A questionnaire was administered to the program participants (middle school girls and their science teachers) at the end of the program. The participants’ responses to this questionnaire were very encouraging. Some of the responses were:

1. What did you like?
   Lasers
   Hands-on experience
   Using Internet
   Using lasers and fiber optics
   Problem solving
   Projects
   Calculator

2. What would you like to change about the class?
   I don’t know of any changes
   Add laser show
   Add electronics
   More time
3. What did you like best about the teachers?
   They were very helpful.
   They were experienced.
   They explained everything.
   The activities they gave.
   They could always help us when we were confused.

VIII. Areas of Improvement

The above mentioned science and engineering program for seventh and eighth grade girls and their teachers will be repeated in April 2000. Based on the participants’ written responses and verbal suggestions, the program will be enhanced in the topical area of lasers and fiber optics. In April 2000, the session on lasers and fiber optics will include a demonstration of an automated laser light show system consisting of lasers, motors, power supplies, and mirrors. This demonstration will show program participants how to integrate lasers with electronics. In addition, display booths will be set up by local student chapters of various organizations such as the Society of Manufacturing Engineers (SME), ASME (American Society of Mechanical Engineers), and SWE (Society of Women Engineers). Program participants will be provided an opportunity to visit these booths and obtain information regarding engineering and science careers for women.

IX. Conclusions

A contemporary one-day science and engineering program for 7th and 8th grade girls and their teachers was described in the paper. The program is conducted at Penn State Altoona and consists of several hands-on interactive classroom sessions involving exciting applications of mathematics, science, and engineering. The program also includes a panel discussion and an electronics technology showcase. Female science and engineering students, recent female graduates of Penn State science and engineering programs, and members of the Society of Women Engineers (SWE) participate in the panel discussion. Development of formal evaluation procedures for this program is currently in process.

Bibliography

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