Growing a STEM Team: Review of an Innovative Program for Middle School Students

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Abstract- Providing solid role models and a gender inclusive engineering curriculum are key strategies in maintaining middle school girls' interest in science and math. STEM Teams' innovative approach achieves these goals by assembling an all female team of faculty, engineers, middle school teachers and engineering students to develop and present engineering units in middle schools. The STEM Teams Program has been developed by the 4 Schools for WIE (Women in Engineering), a collaboration of 4 universities in Massachusetts (Northeastern University, Worcester Polytechnic Institute, Tufts University and Boston University). This collaboration, with support from the National Science Foundation, has created a program development guide outlining the STEM Team approach.

This program development guide was developed by the project team as a tool for WIE program directors interested in creating a STEM Teams program at their institutions. The guide includes sections on preparation of role models and teachers, creation of gender equitable engineering units, presentation of units in middle school science classrooms and program assessment and evaluation. The guide also contains sample curriculum units which have been tested in middle school classrooms. This guide serves as a compilation of lessons learned and best practices after a 2 year implementation of the program.

In this one hour workshop, WIE program directors will be introduced to the STEM Teams program. Program directors will have an opportunity to preview the program development guide and evaluate the potential of developing a similar program at their institutions. Participants will be introduced to strategies for training effective role models, and developing gender inclusive engineering curriculum units based on standards and frameworks. A new evaluation instrument designed to assess student attitudes towards math, science and engineering will also be introduced. Participants will review and discuss excerpts from each section of the guide and provide feedback on the guide. In return for providing feedback, each participant, will be recognized in the final copy of the STEM Teams guide as a reviewer and given a copy of the guide when it becomes available.

Background

The fields of science and engineering are still experiencing a gender disparity that has long been overcome in other traditionally male professions such as medicine or law. The statistics speak for themselves. Currently, 9% of the engineering workforce is female (Women in Engineering Program Advocates Network [WEPAN], 2004), 19% of engineering undergraduates are female (National Science Foundation [NSF], 2002), and science /engineering faculties at the nations' top research universities remain male dominated. (Nelson, Rogers, 2005) Although progress is being made, the progress is slow. Extensive research has been done as to the underlying reasons for this disparity. This research has shown that some major causes for this disparity can be identified. They include gender differences in expectations for learning math and science in the K-12 classrooms, and a lack of female role models for young girls. (Clewell, Campbell, 2002) In addition, the engineering profession as a whole has an image problem and stereotypes still persist. The public remains widely uneducated with regard to the "mystery" of the engineering profession, although in their daily lives they are constantly exposed to societal contributions from the engineering profession. We know through research that young women tend toward career aspirations that are "helping" in nature. They want to impact people, animals and the environment. (Baker, Leary, 1995) They are unable to see how engineering might fit into this category. Their teachers, guidance counselors and in some cases parents also remain unable to assist them in this area. Based on the research, the resulting disparity may be expected.

Significant efforts are being made to overcome the obstacles that result in so few women in the sciences and engineering. These efforts have been focused in a variety of areas and include K-12 education interventions, undergraduate student retention efforts, workforce diversity improvements and efforts to diversify engineering faculties. The National Science Foundation alone has funded over 250 different projects with over $90 million in awards. (NSF, 2003) Through evaluation of these programs as well as additional research we have identified some strategies that work to help encourage young women to consider a career in science and engineering. Among the strategies named were programs that include mentoring and role modeling and educational programs for parents, teachers and guidance counselors. (Clewell, Darke, Sevo 2002) Pedagogical innovations have also been suggested to encourage girls in the classroom. The AAUW reports these innovations include hands-on laboratory experiences, collaborative learning, an emphasis on practical applications work and "authentic instruction." (AAUW, 1999) Some research shows that students of both genders learn more in a classroom in which science is related to real life questions and problems and girls engaging in hands-on physical science laboratory experiences resulted in a reduced gender gap in learning. (Burkam, Lee, Smerdon, 1997)

Based on existing research and our own experiences in K-12 outreach, the 4 Schools for WIE (Women in Engineering) collaboration with support from the National Science Foundation has developed STEM (Science, Technology, Engineering and Math) Teams, an intervention system for middle school science classrooms. The STEM Teams program incorporates a variety of proven strategies including role modeling, teacher training and hands on collaborative learning into a unique program for bringing gender equitable engineering curricula to middle school students while broadening students and teachers understanding of engineering and engineering careers.

STEM Teams Model

4 Schools for WIE is collaboration of four main partner institutions (Northeastern University, Worcester Polytechnic Institute, Tufts University and Boston University) as well as an evaluative partner (Wellesley College). Each of the main partner institutions has a strong record of K-12 outreach and program delivery, including K-12 teacher training, as well as an accredited engineering program. Wellesley College Center for Research on Women has done extensive research on the development of women in science and technology.

Each institution has created its own STEM team. The STEM team is an all or mostly female team of highly specialized professional engineers, engineering faculty, engineering students and middle school teachers. Each team member brings her expertise to collaborate on the development of engineering curriculum units to be used in middle school science classrooms. These units are designed to be gender inclusive and meet the Massachusetts curriculum frameworks for science and technology/engineering. In addition, the STEM team members work together to deliver the curriculum in the classrooms, providing the middle school students with role models of women engineers.

The STEM team model consists of two vital elements. The first is the gender makeup of the team. In an effort to break down the traditional bias towards engineering as a male profession, the 4 Schools STEM Team program utilizes an **all-female** team both in the development of curriculum as well as in delivery of curriculum in the classrooms. In addition to the role modeling impact for female students, the young men will realize that both genders may be represented in STEM fields. For maximum impact on both the male and female students, the middle school students are only informed that they will be visited by a group of engineers with no initial reference to gender.

The second critical factor of the STEM Team model is the collaboration between the middle school teachers and the trained engineers. The book *Technically Speaking* notes that a limiting factor in developing technological literacy among students in the U.S. is the inadequate preparation of teachers to teach about technology. (2002) Teachers being educated in traditional education institutions receive little or no education on engineering and engineering concepts. A recent survey conducted by the American Society for Engineering Education Engineering K12 Center (Douglas, Iversen, Kalyandurg, 2004) reports that although teachers believe incorporating engineering concepts into their classrooms is important, they also believe that engineering is inaccessible to their female and minority students as compared to other career paths.

STEM Team partnerships lead to a valuable cross training among the team members. Teachers have the opportunity to grow in their knowledge of engineering concepts and the engineering profession resulting more confident teaching and advising on those topics. The engineers have an opportunity to act as role models for the teachers and students and prove that engineering is in fact an accessible profession for women. This collaboration is a constantly evolving relationship allowing for growth among all of the STEM Team members.

STEM Teams Program Guide

After 2 years of implementation of STEM Teams programs at 4 universities and in 7 middle schools, the 4 Schools for WIE collaboration has developed a guide to assist other institutions in developing a STEM Teams program. This guide is a compilation of the best practices of the 4 Schools for WIE STEM Teams. The STEM Teams guide will assist other institution in developing and training a stem team. In addition, the guide will introduce a new evaluation instrument designed to measure student attitudes towards science, math and engineering. Finally the guide contains several complete curriculum units which have already been piloted in middle school classrooms.

The STEM Teams program may be implemented in its entirety or specific elements of the program may be used individually. The following is a discussion of the main elements of the STEM Teams program, contained in the program guide.

STEM Team Training

The first step in mentoring students or creating gender inclusive curriculum is to ensure that all members of the team are well versed in the areas of gender equity, classroom environment, assessment techniques and creating engineering curriculum units. In the STEM Teams guide, we provide a suggested training session for **STEM Team** members. Among the sessions in this training are:

1. Technological Literacy- What does it mean?
2. Review of Massachusetts Comprehensive Assessment System Frameworks for Science and Technology/Engineering
3. Creating Effective Design/Engineering Projects
4. Gender Equity Issues
5. Assessment Techniques
6. Using Training to create Curriculum Units

Although suggested as training for a newly developed STEM Team, these training sessions could be used for educating a variety of teachers and other individuals who will be working with middle school students on engineering curriculum.

Using Role Models in Middle School Classrooms

Providing middle school students with female role models is a crucial element of the STEM Teams program. The STEM Teams guide provides suggestions on training role models, time commitment of role models and creative methods for getting role models into middle school classrooms. Based on the STEM Teams model, we suggest using a variety of role models including female engineering students, female faculty, and practicing engineers. Also outlined in the guide are some of the hurdles that must be overcome in moving from the good intentions of providing role models to schools to actually getting them into the classrooms. These include, working with school districts, teachers and industry partners.

How to Create a Gender Equitable Science Curriculum

In our program guide, 4 Schools for WIE Collaboration presents guidelines for creating gender equitable engineering activities. As a basis for these guidelines, we used Gardner, Mason, and Matyas' (1989) list of criteria for equitable science activities and the research and experience of several of the principal investigators on the team as it relates specifically to engineering. These guidelines are shown in Figure 1 below.

Guidelines for Creating Equitable Engineering Activities

Activity should:

- ✔ Provide opportunities for students to present multiple solutions to the same problem
- ✔ Expose students to the wide range of engineering fields and break stereotypes within the activity
- ✔ Be delivered by a teacher or team member who is enthusiastic and has gender equity expectations that are high, works as a coach to encourage and increase confidence
- ✔ Develop process skills, critical thinking and communication skills
- ✔ Be done in small co-operative learning groups. Groups should be monitored to ensure equal time for all students.
- ✔ Emphasize relevance of activity to the student's everyday life and to society
- ✔ Be well prepared in advance
- ✔ Include time for evaluation, reflection and redesign.

Figure 1: Guidelines for Creating Gender Equitable Engineering Activities

In addition, the guide provides a step by step procedure for creating engineering activities. Theses steps could be used by a STEM Team or by an individual wishing to create an engineering activity that is equally appealing to both boys and girls.

Assessment Instruments

A valuable product of the STEM Teams program is a new evaluation instrument developed by Dr. Sumru Erkut and Fern Marx from the Center for Research on Women at Wellesley College. The instrument focuses on student outcomes ,student attitudes toward STEM; liking math, plans for studying math, seeing the link between studying math and STEM careers, and positive attitudes toward careers in STEM. The assessment instrument was piloted several times in the middle school classrooms and showed high levels of reliability and validity.

Also included in the guide are qualitative survey instruments which may be used to evaluate the experiences of STEM Team including students, professional engineers and teachers.

For more information on assessing the STEM Teams program, please see program guide.

Preliminary Assessment Results

Preliminary assessment results suggest that the STEM Team curricula implementation had a more positive affect on girls' attitudes towards math, science and engineering relative to the boys'. A new evaluation design model including control classrooms has been implemented for the 2004-2005 school year. Results for the evaluation of the 2004-2005 school-year will be available in fall 2005 on our Web site at www.stemteams.org.

Curriculum Units

Finally, the STEM Teams program guide contains seven, gender inclusive, engineering curriculum units developed by the 4 Schools for WIE collaboration. These units are designed to be used with or independent of the STEM Teams program. Each individual unit provides a theme-based engineering activity designed to emphasis the societal impact of engineering while adhering to national and state curriculum standards.

Conclusion

The "Growing a STEM Team" workshop will provide participants an opportunity to preview and give feedback on the content and layout of the program guide. Each participant will be recognized in the guide as a reviewer. The 4 Schools for WIE Collaboration anticipates that the final manual will be complete by summer 2005. Copies will be available free of charge while supplies last. For more information on obtaining a copy of the guide or on the STEM Teams program, please visit our website at www.stemteams.org.

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