

# 4 SCHOOLS FOR WIE

## WHO TEACHES MATTERS: PROVIDING FEMALE ROLE MODELS AND GENDER INCLUSIVE CURRICULA FOR MIDDLE SCHOOL STUDENTS

*Suzanne Sontgerath<sup>1</sup>, Stephanie Blaisdell<sup>2</sup>, Katherine Youmans<sup>3</sup>, Terri A. Camesano<sup>4</sup>, Rachelle Reisberg<sup>5</sup>, Katherine Ziemer<sup>6</sup>, Meredith Knight<sup>7</sup>, Anna Swan<sup>8</sup>*  
*Worcester Polytechnic Institute, Northeastern University, Tufts University, Boston University*

**Abstract** — Providing female role models and a curricula which emphasizes the societal impact of technical fields is among the most effective strategies for encouraging women in science, technology, engineering and math (STEM). The goal of 4 Schools for WIE, a collaboration of four universities, is to encourage young women to consider STEM fields by providing them with strong female role models and a technology/engineering curriculum that is gender inclusive. This goal is achieved through the development of specialized STEM teams. These female teams consisting of engineering faculty, professionals, students, and middle-school science teachers are developing and presenting a hands-on, gender inclusive curriculum units. 4 Schools for WIE uses the advantage of its collaboration to develop “best practices” for providing strong female role models in the middle school classrooms and creating gender inclusive engineering activities. This paper discusses the STEM team model, development of the gender inclusive engineering activities, classroom implementation and expected outcomes. 4 Schools for WIE is a three year program funded by the National Science Foundation.

**Index Terms** — gender neutral, middle school, role model, STEM Team

### BACKGROUND

With women comprising only 19% of undergraduate engineering students in the U.S. [1], the gender disparity in STEM fields continues to be a pressing issue. Research has shown that successful interventions in the K-12 arena such as mentoring and role modeling for girls and professional development for teachers are helping to encourage more women to consider STEM careers [2]. Significant attention has been given to the middle school years as a critical turning point for all students in their attitudes towards math and sciences courses.[3] In the middle school years, girls

begin to perceive fields such as math and science as the domain of boys and do not see these subjects as useful to themselves or humanity [4]. Coupling this with a lack of female role models and middle school teachers who are often themselves not familiar or comfortable with engineering, the result is young women who are making personal and academic choices towards fields that they perceive to be more appropriate for women and more significant to society than engineering and technology.

### MAKING THE CASE FOR ROLE MODELS

The influence of the role model has been identified as a significant factor in career choice among women. A lack of role models limits a women’s access to vicarious learning experiences and affects a women’s career development and choices. According to Jacquelynne Eccles, as cited in Career Counseling for Women [5] this may have its most serious effect in reducing women’s “percieved field of options.” Many women who have persisted in STEM fields identify an influential person as a key factor in their decision to enter a technical field. In the WECE Project, one tenth of the students surveyed mentioned that others had encouraged them to become engineers. Of the non-parental mentors in this group about one third were engineers and those who were not engineers were most likely to be math or science teachers [6]. Same-sex or same-race/ethnicity role models increase the likelihood of identification with the role model, thereby allowing for vicarious learning to take place [5]. The number of women in the engineering profession (9%) [7] indicates a deficit of available women engineer role models. This deficit is a factor in the gender disparity in engineering fields.

<sup>1</sup> Suzanne Sontgerath, Worcester Polytechnic Institute, Diversity and Women’s Programs, 100 Institute Road, Worcester, MA 01609, [sont@wpi.edu](mailto:sont@wpi.edu)

<sup>2</sup> Stephanie Blaisdell, Worcester Polytechnic Institute, Diversity and Women’s Programs, 100 Institute Road, Worcester, MA 01609, [slb@wpi.edu](mailto:slb@wpi.edu)

<sup>3</sup> Katherine Youmans, Worcester Polytechnic Institute, Diversity and Women’s Programs, 100 Institute Road, Worcester, MA 01609, [kly2004@wpi.edu](mailto:kly2004@wpi.edu)

<sup>4</sup> Terri A. Camesano, Worcester Polytechnic Institute, Department of Chemical Engineering, 100 Institute Road, Worcester, MA 01609, [terric@wpi.edu](mailto:terric@wpi.edu)

<sup>5</sup> Rachelle Reisberg, Northeastern University, Women in Engineering, 360 Huntington Ave, Boston, MA 02115, [r.Reisberg@neu.edu](mailto:r.Reisberg@neu.edu)

<sup>6</sup> Katherine Ziemer, Northeastern University, Department of Chemical Engineering, 360 Huntington Ave, Boston, MA 02115, [k.Ziemer@neu.edu](mailto:k.Ziemer@neu.edu)

<sup>7</sup> Meredith Knight, Tufts University, Center for Engineering Education Outreach, Medford, MA, 02155, [Meredith.knight@tufts.edu](mailto:Meredith.knight@tufts.edu)

<sup>8</sup> Anna Swan, Boston University, Electrical and Computer Engineering Department, 8 St Mary’s Street, Boston, MA, 02215, [swan@bu.edu](mailto:swan@bu.edu)

## 4 SCHOOLS FOR WIE PROGRAM

The four partner institutions of the 4 Schools for WIE collaboration (Northeastern University, Worcester Polytechnic Institute, Tufts University and Boston University) have a strong record of K-12 outreach and program delivery, including K-12 teacher training. The 4 Schools for WIE program includes the development and implementation of a unique intervention system centered around highly-trained STEM (Science, Technology, Engineering and Math) Teams consisting of all-female engineering faculty, students, teachers and practitioners. The STEM Teams develop gender equitable engineering modules to be used in the eighth grade science classrooms. These modules support the Technology/Engineering component of the Massachusetts Comprehensive Assessment System (MCAS) curricular frameworks. Beginning in September 2001, Massachusetts became the first state in the nation to introduce engineering as part of a mandated K-12 education frameworks. Starting in 2002, one quarter of the questions on the science/technology MCAS test will be based on engineering concepts.

Efforts have been made to partner with middle schools in the program which represent under-served urban populations. The seven school districts participating in the collaboration represent a wide diversity of socio-economic conditions. The majority of the participating schools have a minority (African American and Hispanic) population which exceeds the 19% overall state population of these groups as reported by the Massachusetts Department of Education. For example, one of the participating schools the Grover Cleveland Middle School in Dorchester, MA is 72% African American and 19% Hispanic. 66% of the students qualify for a free lunch program.

Through participation in the 4 Schools for WIE program, middle-school science teachers have an opportunity to expand their knowledge of engineering concepts and engineering disciplines, and to see how these principles can be seamlessly integrated with their existing science curricula. Over the three-year program, the 4 Schools for WIE intervention systems will be finely tuned for national dissemination with the hope that this model will form the basis for the intervention outside of Massachusetts. STEM Teams nationwide have the potential for significantly increasing the number of girls who continue interest in STEM areas during the middle school period and consider a future in STEM careers.

Figure 1. in the column on the right shows the three year implementation plan for the 4 Schools for WIE program.

Year	Sept-February	March-August
2002- 03 Planning and Pilot	<ul style="list-style-type: none"> <li>• STEM Team selection</li> <li>• Full team meeting</li> <li>• STEM Team Training</li> <li>• Development of Curriculum Modules</li> </ul>	<ul style="list-style-type: none"> <li>• Pilot test measures of student attitudes</li> <li>• STEM Teams meet</li> <li>• Pilot curriculum modules</li> </ul>
2003-04 Implementation	<ul style="list-style-type: none"> <li>• Full Team Training</li> <li>• Pre Assessment of student attitudes</li> <li>• STEM Teams meet</li> <li>• STEM Teams present curriculum modules</li> </ul>	<ul style="list-style-type: none"> <li>• STEM Teams present curriculum modules</li> <li>• Full Team Meeting</li> <li>• Post assessment of student attitudes</li> </ul>
2004-05 Expansion and Dissemination	<ul style="list-style-type: none"> <li>• Full Team Workshop</li> <li>• STEM Teams present curriculum modules</li> <li>• Add one middle school per partner institution</li> <li>• Outreach to State University as testing partner</li> </ul>	<ul style="list-style-type: none"> <li>• Develop dissemination materials</li> <li>• Website</li> <li>• Focus group evaluation of teacher manual and video</li> <li>• Manual and video</li> </ul>

FIGURE. 1  
THREE-YEAR IMPLEMENTATION PLAN

## STEM TEAM MODEL

Based on the research regarding the importance of role models, the presence of STEM Teams in the classroom is a critical component to the success of this program. Each partner university has developed female STEM teams comprised of:

- Program Coordinator from the institution
- Volunteer engineers from industry partner/s,
- One or more engineering faculty from the institution
- Undergraduate/graduate students
- Middle-school science teachers (teachers need not be female)

There are two vital elements to the STEM team model. The first is the gender makeup of the team. Engineering is traditionally viewed as a masculine occupation [8]. As noted by Clewell and Campbell [4], the 2002 report of Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development cites research that indicates that women are consistently absent from children's drawings of scientists. 4 Schools utilizes an all-female team in an effort to break down this biased attitude. In addition to the impact on female students, the young men will realize that both genders may be represented in STEM fields.

In order to have a 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. It was felt that calling

attention to the gender of the STEM Team prior to their interaction with students would undermine the impact that unexpectedly seeing a team of all-female engineers would have on students. . Beyond gender, another desirable criteria for the STEM team design would be to have members of underrepresented populations on the team to serve as role models to those groups.

The second critical factor of the STEM Team model is the collaboration between the middle school teachers and the trained engineers. A limiting factor in developing technological literacy among students in the U.S. is the inadequate preparation of teachers to teach about technology [9]. Teachers being educated in traditional education institutions receive little or no education on engineering and engineering concepts. The STEM Team partnership leads to a valuable cross training among the team members. Teachers have the opportunity to gain a deeper understanding of engineering concepts and the engineering profession while the engineers have an opportunity to gain insight into the pedagogy of the middle school before entering the classrooms.

### **STEM TEAM TRAINING**

STEM Teams from all four university partners convened for an initial training session at Tufts University in January of 2003. During this two weekend workshop, the following topics were covered:

- Massachusetts State Frameworks for Technology and Engineering
- Gender equity issues in STEM fields
- Development of successful engineering activities
- Rubrics and assessment measures

During the workshops, teams discussed how to teach material that traditionally favors boys in a gender equitable manner, and assembled criteria for gender equitable methods. Finally, each team started to work on curriculum units to pilot in their respective middle school classrooms.

In October of 2003 a second training workshop was held for all four STEM Teams. The focus of this workshop was a cross-team training on the individual curriculum modules developed in the spring of 2003.

### **Team Training Evaluation**

An evaluation of the workshop was conducted by Tufts. Results of a pre-post survey reveal the following:

- Both teachers and engineers became more comfortable with incorporating engineering into the classroom during the workshop.
- Participants gained a better understanding of gender equity in engineering, STEM Teams and projects, and engineering education.

## **GENDER NEUTRAL CLASSROOM MODULES**

Adelman [8] states that engineering would be more attractive to women if the ways in which it is relative to the real world were part of the education framework. Women often choose professions that they believe are “helping” in nature [10]. During the training workshops, teams discussed strategies for presenting engineering related topics in a gender equitable manner. Some of the criteria identified include the following:

- Activities that have multiple solutions that appeal to all students
- Using gender neutral language
- Utilizing small, cooperative learning groups
- Emphasizing relevance to student’s everyday life and society
- Including tools to ensure all students participate equally in all tasks

Based on these criteria and the MCAS frameworks, each team has developed a gender-neutral engineering module. Below is a brief description of each module.

### **Northeastern University Project-The Great Orange Squeeze**

Northeastern University’s project has students using basic science concepts and an eight-step engineering design process to create and test an orange juice concentration process. Students are challenged to provide good-tasting orange juice to Boston Schools for \$0.15 a glass. The goals of The Great Orange Squeeze unit are to:

- Involve student interest in an enjoyable and equitable way.
- Illustrate as many engineering framework criteria as possible.
- Illustrate both the differences between Science and Engineering and their interdependence in solving technical problems that benefit society.
- Incorporate active learning, experience oriented tasks and inquiry based design.

### **Boston University’s Projects- Solar House and pGLO**

The Boston University team has focused on two activities. The first is a solar house and solar collector unit. Students were given the engineering design challenge of creating a solar house and solar energy storage. The activity conveys many important science concepts and has been incorporated in the regular science curriculum in both schools. The second project involves genetic coding and decoding. This new project stresses the connection between the codes of DNA building blocks in genes and the resulting physical traits. One of the benefits of this new project is the number of female undergraduate biomedical engineering students at Boston University interested in the planning and classroom implementation.

### **Tufts University Project – Binary in a Box**

The Tufts project introduces students to the concept of number systems and the language of computers – binary. This topic was chosen to demonstrate how engineers help people, since binary code is essential for many digital applications including cellular phones, video games, CD-ROMS, and computers. The goals of the Tufts project are to:

- Introduce concepts of binary as a language.
- Introduce the practical applications of digital and communication systems.
- Relate topics introduced to real world applications.
- Relate topic to other disciplines such as history.

Tufts is currently in the process of developing a second module which will focus on concrete. This unit will include a field trip to the university for hands-on testing of concrete.

### **Worcester Polytechnic Institute's Project– Broken Bones**

WPI's project involves exploring material properties and researching concepts to solve problems involving orthopedic casts. The goals of the Broken Bones unit are to;

- Introduce students to engineering, engineering careers and the “helping nature” of the profession.
- Present engineering to the students in a gender equitable manner by providing a hands-on activity which engages all students.
- Provide students with a comprehensive understanding of the engineering design process.
- Cover various MA engineering frameworks.

WPI is currently in the process of developing a gender neutral module on bridge design. This module will differ from traditional bridge activities as it will focus not only on bridge design but also on the artistic aspects of bridges, and need for bridges in many non-traditional locations such as theater set design, animal habitats, and amusement park attractions which may be more appealing to students of both genders.

For a more indepth discussion of the individual activities please see the paper entitled “4 Schools for Women in Engineering, Innovative Approaches to Increase Middle School Students Interest in STEM”, published in the ASEE 2004 conference proceedings [11].

### **Introductory Presentation**

In addition to the individual projects, the four universities collaborated on an introduction to engineering presentation entitled “Engineering Makes a World of Difference”. The focus of this presentation is an introduction to the real world impacts of the various engineering disciplines.

## **STEM TEAM CLASSROOM VISITS**

Due to the variety in length and subject matter in each of the team's modules, each STEM Team has developed individual methodologies for classroom visits. All teams visit the classroom at the beginning of the year for an introduction of the STEM Team. STEM Team members speak about their decisions to enter a technical field and their experiences in their field. This is followed by the presentation “Engineering Makes a World of Difference”. Students then complete an introductory activity such as building a tower using common materials such as paper or straws. During the school year, the STEM Team presents one or more of the engineering modules which range in length from several days to several weeks.

Classroom visits are coordinated through the program coordinator at each institution. Modules are taught as a joint effort between the teachers, the engineering professionals and undergraduate students. Multiple classroom visits by the STEM Team allow for the development of a relationship between the students and the role models. Regular presence of the STEM Team in the classroom supported by the teachers reinforces the concept that women are engineers and that women have opportunities available in STEM fields.

## **ASSESSMENT AND OUTCOMES**

Project evaluation is being conducted by Dr. Sumru Erkut and Fern Marx from the Center for Research on Women at Wellesley College. The evaluation focuses on student outcomes (student attitudes toward STEM; liking math, plans for studying math, seeing the link between studying math and STEM careers, positive attitudes toward careers in STEM, and performance on the 8th grade engineering portion of the MCAS test). One set of analyses will examine outcomes for all students (male and female) participating in the study. A second set of analyses will focus on the magnitude in gender differences in outcomes. Student performance will also be compared on standardized tests (MCAS) for the 2 years prior to implementation of this project [11]. The student attitude survey will consist of a pre-post survey. Initial results of the pre-survey indicate some statistical difference in gender attitudes towards engineering. A post survey will be completed by the end of the academic year. Complete evaluation results will be available in September 2005.

WPI has done an independent evaluation on the Broken Bones activity as presented in the Worcester Public Schools. A survey regarding attitudes towards the engineering activity in the classroom was administered after both presentations of the activity in the classroom (April, 2003 and November, 2004). The results of the survey indicate that females place a slightly greater value on the interaction with the professionals than on the engineering activity itself. While 17% of the boys rated the activity as having increased their interest in engineering, only 8% of the girls gave the same score (See Figure 3). However, when rating the effect of

the professionals' presence in the classroom, 32% of females said they enjoyed having the STEM Team present the activity, while only 19% of the males gave the same rating (See Figures 4).

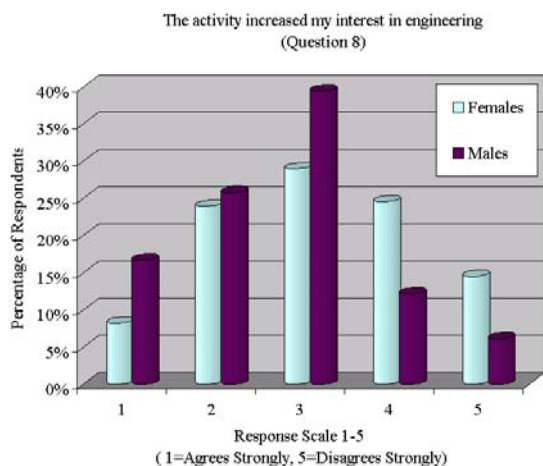


FIGURE 3  
WPI SURVEY RESULTS: ENGINEERING ACTIVITY

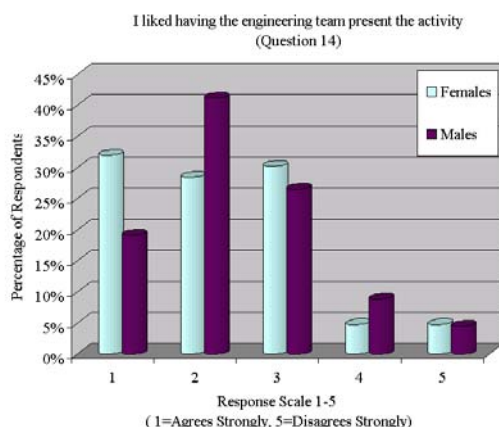


FIGURE 4  
WPI SURVEY RESULTS: RESPONSE TO STEM TEAM

While the girls' enjoyment of having the STEM Team in the classroom is not a direct measure of how the presence of these role models impact their interest in engineering, it is an indication that this component of the project is an important one. The fact that the engineering activity was not rated as highly by the girls could be an indication that the module does not sufficiently engage the girls. However, evaluation data from the overall 4 Schools for WIE will ultimately determine the effects of the intervention and their gender differences.

In addition, interviews were conducted with the teachers participating in the WPI STEM Team. Teachers reported feeling more comfortable with engineering terminology as a result of their experience with the project. Teachers also

report that they are incorporating engineering concepts and language into all aspects of their curriculum, even those not directly related to the STEM Team modules.

Tufts STEM Team has done some individual assessment of their program as well. Both of the 8<sup>th</sup> grade science teachers STEM Team members have developed an assessment plan to evaluate the 8<sup>th</sup> grade students' knowledge of binary. One teacher evaluated students' knowledge with tests and homework, and the other evaluated students' knowledge by their entries in a journal. Both teachers felt that the students were engaged by the unit, were positively impressed by the STEM Team, and were interested in learning more about engineering as a result of the classroom visits. Students were able to connect the lessons on binary to their video games, pointing out that a "64-bit" video system had higher resolution than a "32-bit" system.

## DISSEMINATION PLANS

Over the three-year program, the intervention systems will be finely tuned for national dissemination. The following methods of national dissemination are planned:

- Video – (to be prepared during the final year of the proposed work) to document the experience of students and teachers in the participating middle schools with focus on gender bias before and after STEM Team exposure.
- Training manual - (planned for development in 3<sup>rd</sup> year) to complement information presented in the video
- Website - the dissemination of the STEM teams training through the web will be linked to the Tufts K-12 Engineering Website [www.k12engineering.org](http://www.k12engineering.org). This site is a free resource for K-12 educators and administrators.

Training is an important factor in the development of a successful STEM Team. Team members need to be educated about national science standards, age appropriate and gender inclusive curriculum activities, serving as positive role models, and other issues pertaining to encouraging middle school girls in the STEM fields. Thus the training will be available through hard copy manual, the web, and on videotape.

## CONCLUSION

The STEM Team model is a highly replicable, low-cost intervention system. The regular presence of competent female role models in middle school classrooms will serve to motivate young women to view engineering and related careers as a viable option for their future. As a result of their participation on the STEM Team, middle school teachers are better educated about engineering careers, engineering

concepts, and engaging young women in STEM activities. As a result, the teachers will be better able to advise both female and male students about engineering as a possible career. The existence of STEM Teams nation-wide has the potential to significantly impact girls' attitudes towards and consideration of science, technology, engineering and math as a future career path.

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## REFERENCES

- [1] American Association of Engineering Societies, Inc., Engineering Work Force Commission Engineering and Technology Degrees (2002) Washington, D.C.
- [2] Clewell, B., Darke, K., and Sevo, R., "Meeting the Challenge: The Impact of the National Science Foundation's Program for Women and Girls", *Journal of Women and Minorities in Science and Engineering*, Vol, No. 8, 2002, pp.285-303
- [3] Haemmerlie, F.M. & Montgomery, R.L., "Goldberg revisited: Pro-female Evaluation Bias and Changed Attitudes Towards Women by Engineering Students", *Journal of Social Behavior and Personality*, Vol, No 6(2), 1991, pp.179-194
- [4] Clewell, B., Campbell, P.B., "Taking Stock: Where We've Been, Where We Are, Where We're Going", *Journal of Women and Minorities in Science and Engineering*, Vol, No 8, 2002, pp. 255-284
- [5] Osipow, S., Walsh, W. B., Career Counseling for Women, Lawrence Erlbaum Associates, 1994, p. 17, p. 249
- [6] Bittinger, K., Brennan, R. Cunningham, C., Goodman, I., Lachapelle, C., et al., "Women's Experiences in College Engineering (WECE) Project", Goodman Research Group, 2002, p. 45
- [7] National Science Foundation, Division of Science, Resources Studies (NSF), Women, Minorities and Persons with Disabilities in Science and Engineering, 1996, p. 54
- [8] Adelman, C., Women and Men of the Engineering Path, U. S. Department of Education and The National Institute for Science Education, 1998, p. 39, 58
- [9] Pearson, G., Young, A., Technically Speaking: Why All Americans Need to Know More About Technology, Committee on Technological Literacy, National Academy of Sciences, 2002
- [10] Baker, D. & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching*, Vol, No 32, pp.3-27.
- [11] Reisberg, R., Leventman, P., Ziemer, K., Blaisdell, S., Swan, A., ET. AL., 4 Schools for Women in Engineering: Innovative Approaches to Increase Middle School Students Interest in STEM, ASEE 2004 Conference Proceedings. (In Process)