

# **AC 2007-428: THE INFLUENCE OF HANDS-ON FEMALE STUDENT PROJECT TEAMS ON THE CONFIDENCE OF WOMEN ENGINEERING STUDENTS**

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# The Influence of Hands-On Female Student Project Teams on the Confidence of Women Engineering Students

## Abstract

Based on recent statistics by the US Department of Labor, only eleven percent of Aerospace Engineers and only 5.6% of Mechanical Engineers are women<sup>1</sup>. Over 85% of the engineering students at Embry Riddle Aeronautical University are in one of these disciplines. Considering that 47% of the general US workforce is comprised of women, continued and increased efforts are needed to increase the number of women entering the engineering workforce. Like many institutions, Embry Riddle has struggled to attract women to our engineering programs. The university is working to increase female participation in all aspects of the engineering program. As shown in figure 1, a component of the multifaceted EmpoWER (Empowering Women at Embry Riddle) program to attract and retain young girls to the engineering field is to provide role female models to dispel the perception that engineering is a male dominated field.

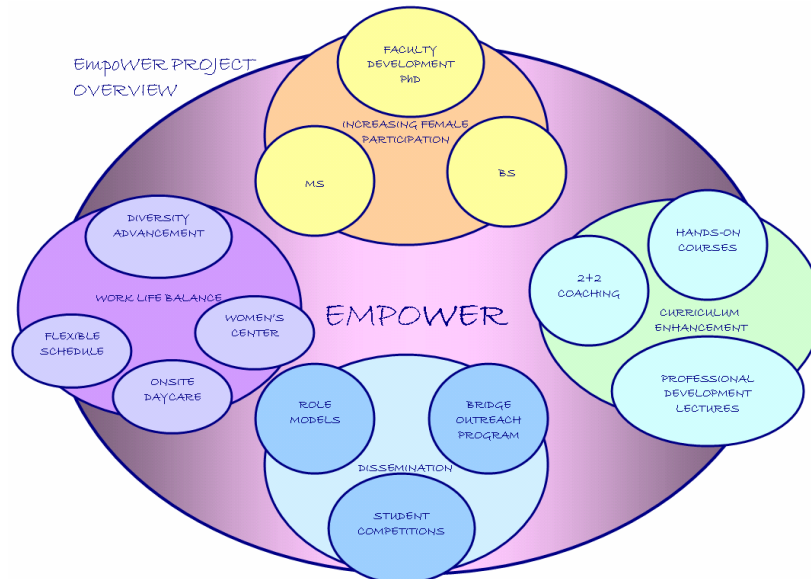


Figure 1: Components of EmpoWER Project

The EmpoWER project has the objective of increasing the number of women at all levels, including undergraduate students, graduate students and faculty. A component of this project is a hands-on all-female student design project. The purpose of this project is to provide a concrete representation of women engineers to prospective female students. Embry Riddle chose to field an all-female team for the Baja SAE competition. Other projects could also satisfy the EmpoWER project objectives. Female involvement in the Baja SAE design project has skyrocketed since the all-female team was established. In 2005-2006, roughly 20 women participated in the first year of the all-female project, which was 10 times the number of female students on the previous co-ed Baja SAE team. In 2006-2007, almost 80 women signed up for the project, which is almost 30% of the total number of female engineering students at Embry Riddle.

## Introduction

The under representation of women in STEM fields, such as engineering, is a well known problem. Institutions that focus on historically male dominated degree programs, such as Embry Riddle, have the additional problem of under representation of women on campus. As shown in figure 2, the U.S. workforce is almost evenly split between male and female employees, in general. Ideally, the percentage of women in the engineering workforce and engineering programs would mirror the national workforce statistics.

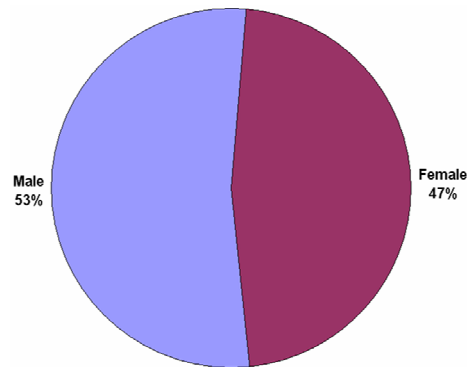


Figure 2: Percent of Women in U.S. Workforce

The statistics for Aerospace Engineering and Mechanical Engineering, which are the two largest engineering programs at Embry Riddle, have a significant fewer female student than male students, as shown in figure 3. These values, 10% female and 5% female respectively, are below the national average for female participation in these programs.

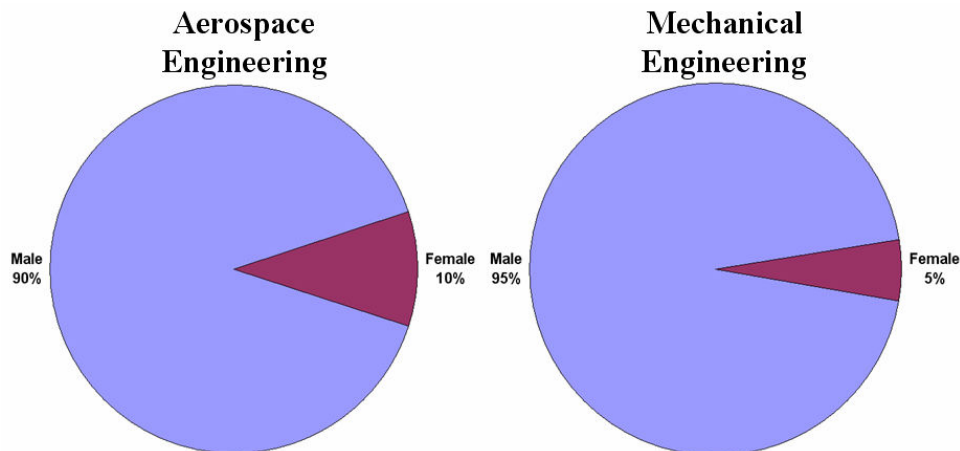


Figure 3: Percent of Women in U.S. Engineering Workforce

As shown by figure 4, Embry Riddle has a large engineering population and low overall female population. As a private institution, only degree programs that fit within the mission of the university are offered. Some degree programs, such as communications, that have traditionally appealed to female students are not offered. Because the overall female population is small, there are limited opportunities to recruit female students into

the engineering fields. As a result, efforts to increase the number of women in engineering at Embry Riddle are focused on recruitment of external candidates.

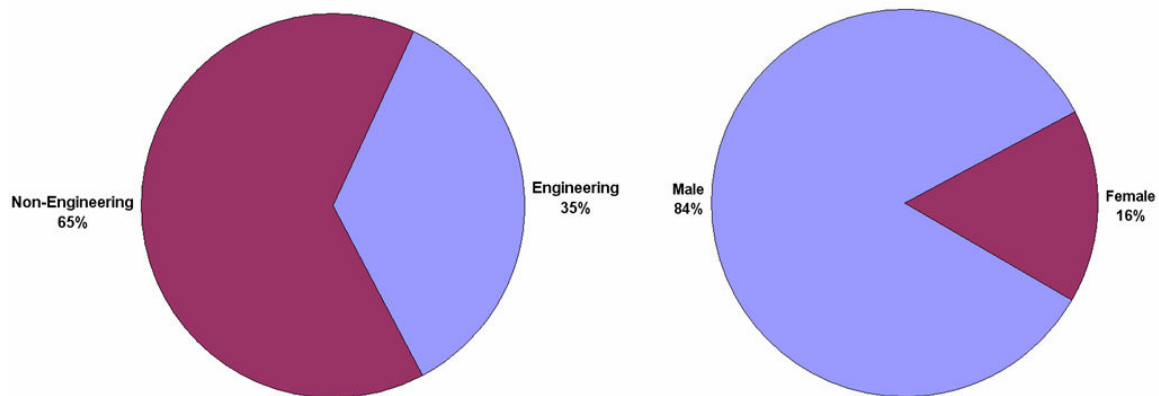


Figure 4: Percent of Women Students and Engineering Students at Embry Riddle

As shown in figure 5, the total percentage of women in the college of engineering is about 14 percent. While a 14% female enrollment isn't unusual for engineering programs, it is below the national average.

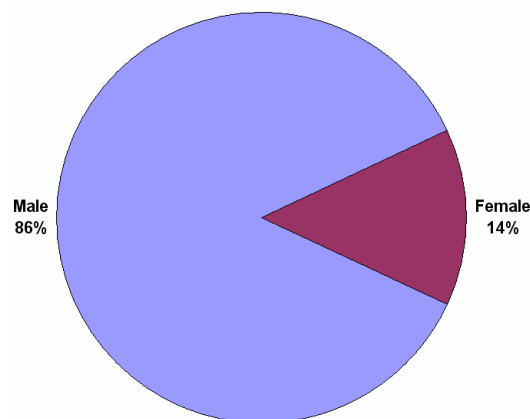


Figure 5: Percent of Female Engineering Students at Embry Riddle

After researching the issue, it was decided that improving the number of female engineering students required a broad effort. This effort is defined as the EmpoWER project. Most of the program is based on established methods for attracting female faculty and students; improving work-life balance, conducting research appealing to women, and revised recruiting materials. EmpoWER also features a new mentoring program to improve female retention and a hands-on all-female design project to promote engineering to prospective students.

### Baja SAE Competition

The SAE (Society of Automotive Engineers) International sponsors a series of engineering competitions called the Baja SAE series formerly known as SAE Mini-Baja. The Baja SAE project requires student teams to design, analyze, fabricate, test and race a

single seat, all-terrain vehicle. The competition is very demanding on the team and vehicle. The car must endure a rigorous obstacle course including three foot drops, railroad ties, logs, thick mud-bogs, and rocks. The competition attracts over 100 North American teams. The competition includes static events (design report, safety inspection and brake demonstration) and dynamic events (log pull, acceleration, top speed, land maneuverability, water maneuverability, and a suspension test course). The competition concludes with a five hour endurance race. One of the three North American Baja SAE competitions requires the vehicle to be amphibious.

The Embry Riddle women's Baja team was organized as part of a club, the ERAU Mini-Baja Club. Students may work on the project as an extra-curricular activity or as a special topics project. The club is closely affiliated with two professional chapters on campus; the ERAU SAE chapter and ERAU Society of Women Engineers (SWE) chapter. Membership in the SAE chapter is required by the rules of the competition.

### Baja SAE Team

The number of women participating in the project has grown significantly since the all-female team was introduced in 2005-2006. As shown in figure 6, the number of women participating on the co-ed Baja team has remained small over the same period. The only female student participating on the 2006-2007 co-ed Baja SAE team also participated on the 2004-2005 co-ed team.

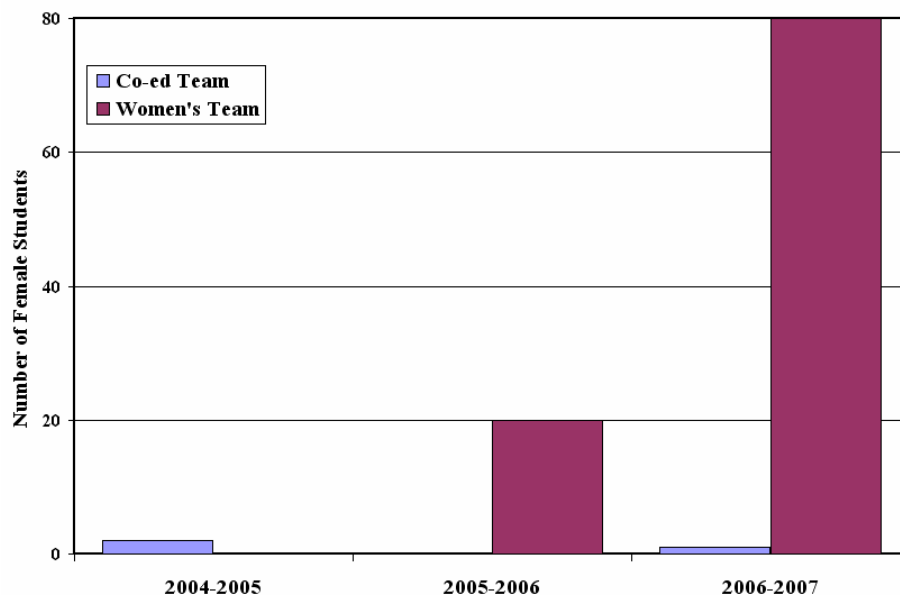


Figure 6: Number of Female Students on Baja SAE Teams

### Team Organization

The ERAU Mini-Baja Club includes the co-ed team and the all-female team. The ERAU women's baja team is currently the only all-female motorsports team competing in the United States. The 2005-2006 academic year was the time that any of the all-female

team members had participated on any motorsports project. Under the circumstances, the team performed phenomenally, placing in the top 30 in each of the dynamic events, and placed 44th overall out of the 65 teams. These results were slightly better than the results for the previous ERAU co-ed Baja team.

Since the all-female team members are in different degree programs, have different schedules, and are at different academic levels, the organization of the project can be complicated. The design of the vehicle must be structured around the skills and interests of the team members. The most successful team structure attempted so far allows the students to select a from a list of focus areas including frame design, suspension kinematics and design, engine and drive system, steering, brakes, floatation/water propulsion and manufacturing. Ideally, a student will be included in a focus area related to classes they are taking or have recently completed. For example, a student who has recently completed fluid mechanics could work on the floatation and water propulsion focus area. This structure reinforces the engineering curriculum and allows the students to make a meaningful contribution to the project.

#### Relationship to EmpoWER Objectives

The Women's Baja team has been a huge success in creating an opportunity for women engineering students to learn, flourish and succeed without help or interference from male students. The fact that the project is single gender gives the students a feeling of independence and confidence. The project and resulting Baja SAE competition created a unique bonding experience for many of the women on the team. Since the project creates a fun, educational and encouraging experience, the project will also result in increased success in each student's field<sup>2</sup>. Figure 7 shows some of the 2005-2006 women's Baja SAE team at the 2006 Baja SAE competition hosted by Auburn University.



Figure 7: Women's Team at 2006 Baja SAE Competition

The goal of the outreach program is to educate young girls about engineering and to demonstrate that engineering can fun, creative and empowering. The Women's Baja SAE team participates in a number of outreach initiatives. For example, the team travels

to regional elementary, middle, and high schools to demonstrate that women can be engineers and to demonstrate the types of projects that women in engineering can accomplish. Through these demonstrations, the women's Baja team provides role models for prospective female engineering students. The exhibit includes interactive displays, a presentation on engineering as a career, a description of the Women's Baja SAE project, and a description of the role of engineering in modern society. During the presentations, the entire design cycle of the Baja SAE vehicle is described from paper design to fabrication. At the end of the presentation, attending prospective students are given the chance to ask questions and each team member provides insights on their experiences. The presentation concludes with a demonstration of the actual competition vehicle. Prospective students have the opportunity to sit in and inspect the vehicle. The enthusiasm of the Baja team is transferred to the prospective students, which is apparent from the prospective students' reactions to the exhibit. Figure 8 shows the women's Baja SAE team at an outreach exhibition at Sculptor Charter School. To further disseminate information about the program, a documentary DVD is being developed that will be distributed nationally.



Figure 8: Women's Baja SAE Exhibit at Sculptor Charter School

### Team Survey

The surveys were used to assess the impact the Women's Baja SAE project has had on the students. A series of statements were given to the women's baja team members. The students were asked to indicate if they "Strongly Agree", "Agree", "Neutral", "Disagree", or "Strongly Disagree" to each statement. Some of the responses are presented below.

The basic concept of the all-female Baja SAE project is to provide a new experience for of the female students at Embry Riddle. The first question was designed to determine if this women's Baja project actually results in a new experience or if the students already have an opportunity to interact with other female engineering students as part of the engineering curriculum. As shown in figure 9, all of the team members indicated that class related project teams were predominately male. So, the all-female Baja SAE project is meeting its objective of creating a new opportunity for interaction between female engineering students.



My project teams are predominantly male in classes.

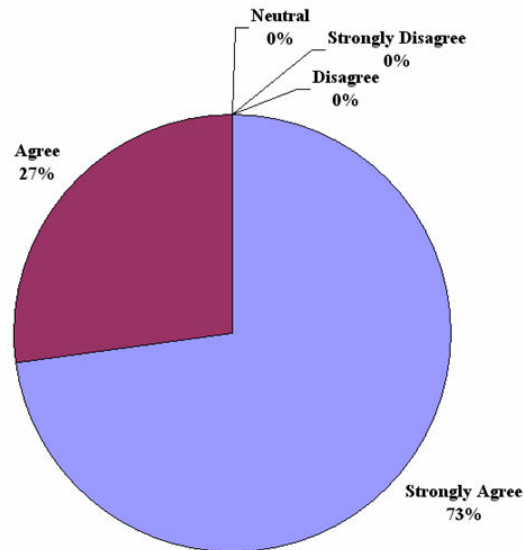


Figure 9: Survey Results - Predominately Male Project Teams

Another goal of the project was to create a new bonding experience between the female engineering students. There were already organizations for women on campus, such as SWE and Women in Aviation. The Baja SAE project was not intended to duplicate these groups. As shown by figure 10, the women participating in the project felt that the Baja project created a new bonding opportunity that did not previously exist. So, the students believe the project has increased both interaction between female engineering students and created new bonding opportunities.

This team provided an opportunity to bond with other women engineers that I would not have had otherwise.

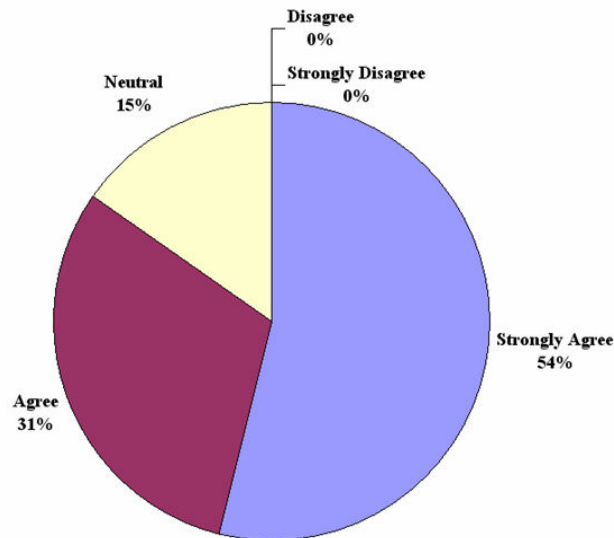


Figure 10: Survey Results - New Bonding Opportunity



Creating a pleasant experience for the female engineering students should increase retention. Some students even indicated that they would have transferred out of the engineering program without the Baja SAE experience. In addition to creating a new bonding experience for the students, the project also promotes self-confidence. As shown in figure 11, 85% of the team believes they are more confident as a result of the project. 15% of the women felt that they already had the self-confidence to attempt new challenges.

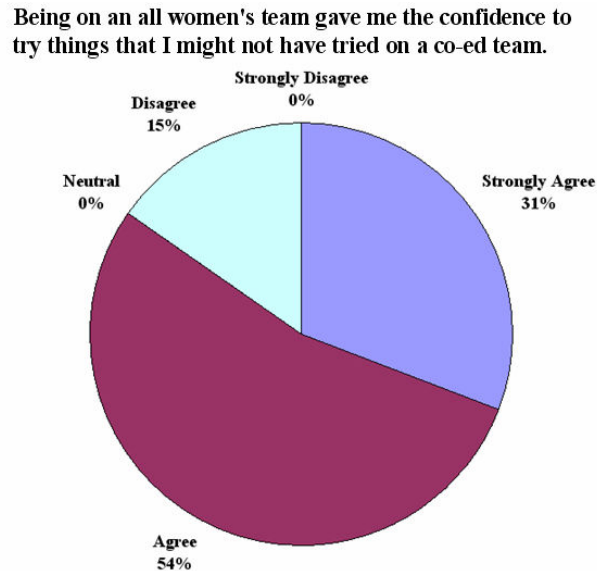


Figure 11: Survey Results - Confidence

The students also felt that the project would help them do better in their engineering degree program. Over 90% of the students believe they will do better academically as a result of the project, figure 12. It was not clear if improved self-confidence or the knowledge gained through the design of the vehicle was responsible for the positive outlook.

Being a part of this team is important to my success in the engineering program.

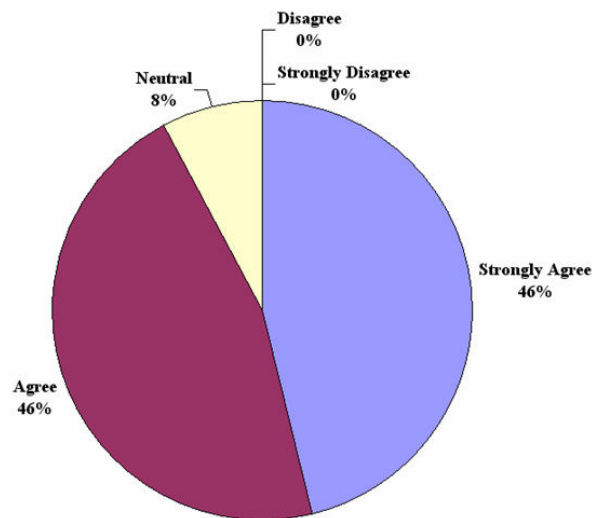


Figure 12: Survey Results - Success in Engineering

Interestingly, the student did not conclusively believe that they would do better in their engineering classes as a result of the project. As shown in figure 13, 46% of the women thought the project would help them succeed in their engineering classes. Some of the women felt the project would reduce the time available for course work and subsequently result in lower grades. 69% of the team indicated that the project improved their understanding of engineering. These results show that the project organization could be improved. These results could be improved by more closely relating the vehicle design projects to specific courses.

Being a part of this team is important to my success in my engineering classes.

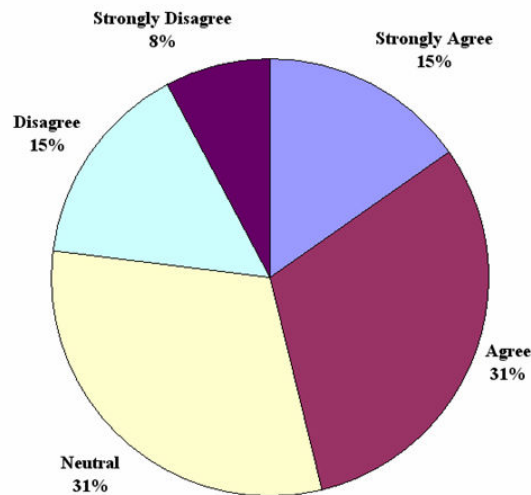


Figure 13: Survey Results - Success in Classes

The project attracted a large number of freshmen students. Relating the Baja project to first year courses can be challenging. Many of the analysis tools used for design and build the vehicle are discussed starting in the sophomore year. Since the Baja SAE project is not capable of accommodating an increase in students, without building a another vehicle, there may be an opportunity to build initiate a similar but less intensive all-female project for first year students. Ideally, the freshmen project would encourage development of the skills required for the Baja SAE competition, especially communication and teamwork skills.

#### Project Facilities and Budget

While the project shows great benefits, resources required to operate the project are significant. The CAD modeling, and engineering analysis conducted by the team utilized existing campus computer labs and software, including CATIA, Matlab, and Nastran. The design and construction of the vehicles required a student machine shop and a construction area. Embry Riddle recently acquired a four-axis CNC mill, CNC lathe, laser cutter and TIG welder, which were utilized for the project. The project was time consuming for faculty and a course release was award to the advisors. Each SAE team currently has one or more faculty advisors. The table below shows the budget for this

year's all-female Baja SAE team. Including travel expenses to regional schools and to one competition, the total cost for the project is approximately \$13,500 per year.

Tooling	\$2500
Vehicle	\$5000
Travel	\$5000 per competition
<u>Travel</u>	<u>\$1000 outreach</u>
Total	\$13,500

### Conclusions

The use of an all-female team to promote increased involvement of female students in the engineering program has proven to be very successful. The number of female students participating on the women's project is much higher than originally anticipated. Almost 30% of female engineering students at Embry Riddle signed up for the project. The number of female student participating on the co-ed Baja SAE project has not increased and is much smaller than the number of female students on the women's team.

92% of the women Baja SAE team members believe the all-female Baja SAE project is important to their success in the engineering program. 85% of participants indicated that they have more self-confidence as a result of the project. 100% of participants believe this opportunity is important for women and 100% of the non-graduating students plan to work on the project and remain in the engineering program next year.

The all-female Baja SAE project is a unique experience that enhances the education and perceived retention rate of participating women. The project results in a group of empowered role models that appeal to potential engineering students. As part of a broader effort to improve female representation in engineering, all-female projects have the potential to create a lasting impact.

### References

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<sup>1</sup> US Department of Labor website, <http://www.dol.gov/wb/factsheets/nontra2003.pdf>, last updated: March 2003.

<sup>2</sup> Ginoria, Angela. Warming the Climate for Women in Academic Science. American Association for Colleges and Universities, 1995