2006-516: A HANDS-ON APPROACH TO INCREASING ENGINEERING DIVERSITY: ERAU'S ALL-WOMEN MINI-BAJA PROJECT

Darris White, Embry Riddle Aeronautical University

Darris White is an Assistant Professor in Mechanical Engineering at Embry Riddle. His research topics include: Robotics, Vibrations, High Performance Vehicles and Control Systems.

Heidi Steinhauer, Embry-Riddle Aeronautical University-Daytona Beach

Heidi Steinhauer is an Instructor in the Freshmen Department at Embry Riddle. Her focus area is Computer Aided Design and Manufacturing.

Lisa Davids, Embry-Riddle Aeronautical University-Daytona Beach

Lisa Davids is an Instructor in the Freshmen Department at Embry Riddle. Her focus area is Fluid Mechanics.

A Hands-on Approach to Increasing Engineering Diversity: ERAU's All-Women Mini-Baja Project

Abstract

While demand is typically very high for engineers, many segments of the US population are not being attracted to the engineering field. 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[1]. 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.

To promote more female participation in the engineering curriculum, the Embry Riddle Mechanical Engineering program has created a student project where undergraduate women design and build an off-road race vehicle for the SAE Mini-Baja competition[2]. The project is integrated into the Mechanical Engineering curriculum and is funded by a generous grant from The Boeing Company. The project has increased women participation in the project by 10 times compared to last year.

This project has three goals. The first goal is to increase retention of women in the curriculum. Potential women students turn away from engineering for a variety of reasons, which are typically related to their perception of the engineering field[3]. Many female students view engineering as a male dominated, non-creative field that is hostile to women[3]. To change these perceptions, it is necessary to demonstrate that engineering can be creative and receptive to female students. Studies indicate that cooperative group projects are a positive tool for attracting and retaining women [4-6]. The baja project is open to women at all academic levels and most of the participants are underclassmen. The second goal is to increase awareness of women in engineering at the high school and middle school levels. Our all-women's team is traveling to local middle and high schools with the baja car that they have built to promote awareness of women engineers. The third goal is to increase the number of women entering the engineering workforce. By raising community awareness of women in engineering and making the curriculum fun and exciting for women, it is our belief that more women will graduate and enter the workforce. Statistics will continue to be collected each year to measure effectiveness and a survey of the students will be conducted at the end of each year. This project is in the first year of a long term study and the goal of this paper is to establish a dialogue with other interested groups to share information about similar projects and to discuss potential metrics that can be used to evaluate the project over an extended period of time.

Background

Embry Riddle recently formed a Mechanical Engineering program and does not have a long history of participating in mechanical competitions. Since the Mechanical Engineering program is new, accepting students for the first time in Fall 2005, an opportunity exists to create an inviting culture for women within the program from the

onset. The women's mini-baja team is one of hopefully many initiatives that will be implemented over the next few years to attract women and minorities to the engineering field.

Each year the Society of Automotive Engineers (SAE) sponsors several student competitions including the SAE mini-baja series which students design and build an off-road car, shown in figure 1. The SAE Mini-Baja project was chosen as the basis for this diversity study for several reasons. Female participation in the project is traditionally low. The student competition has existed for almost 30 years and the project guidelines are well established. The rules of the competition allow a school to bring two teams, which means that an all-women's team does not preclude male participation in the competition. The project is technologically challenging and requires the application of sound engineering principles. The project is also very rewarding since the students eventually get to drive a vehicle that they have designed and built from scratch.

Figure1: SAE Mini-Baja Vehicle

Since the inception of the all-women mini baja team coincided with the formation of the Mechanical Engineering program in 2005, there is currently not a lot of data on this project. A team from Embry Riddle participated in the 2005 mini-baja competition for the first time as a co-ed team. This study will have the on-going goals of monitoring the level of women involvement in the program, monitoring retention rates for women involved in the project and refining the project as more information is available. Since the project is new, there is a limited amount of data but so far the results look very positive.

Project Organization

Participation in the motorsports project is not mandatory and women who choose to work on the project have the option to participate as part of the all-women team, or as part of a similar co-ed team. Mechanical and Aerospace Engineering students have the option to take the project for credit, as a technical elective if they meet certain prerequisites. Predominately, the women working on the projects have chosen not to receive academic credit for the project and have worked on the project for the challenge associated with the task. As shown in figure 2, a significant number of female students are interested and engaged in the project.

Figure 2: 2006 ERAU Women's Mini-Baja Team

The project team was divided into several groups that are each responsible for a specific area of the vehicle's design and a team captain and a co-captain to manage the overall project. There is a group leader for each of the groups. The design groups are; chassis, suspension, steering, braking and floatation. Although graduate students are allowed to participate in the project, all of the team members and leaders are currently undergraduate students. Since the project spans two semesters, the group leaders and members vary as some team members leave for internships or graduate.

Each team is responsible for the design and manufacturing of specific regions of the car. For most of the women on the team, this experience is the first time that they have welded, fishmouthed tubing, and worked as a team with a diverse group that includes all academic levels and varied backgrounds. As shown in figure 3, the chassis design team worked together to build a PVC mock-up of the design they had spent months designing in CAD. After the mock up of the chassis was completed, each team member took turns fitting in the chassis, which after some discussion, resulted in design changes.

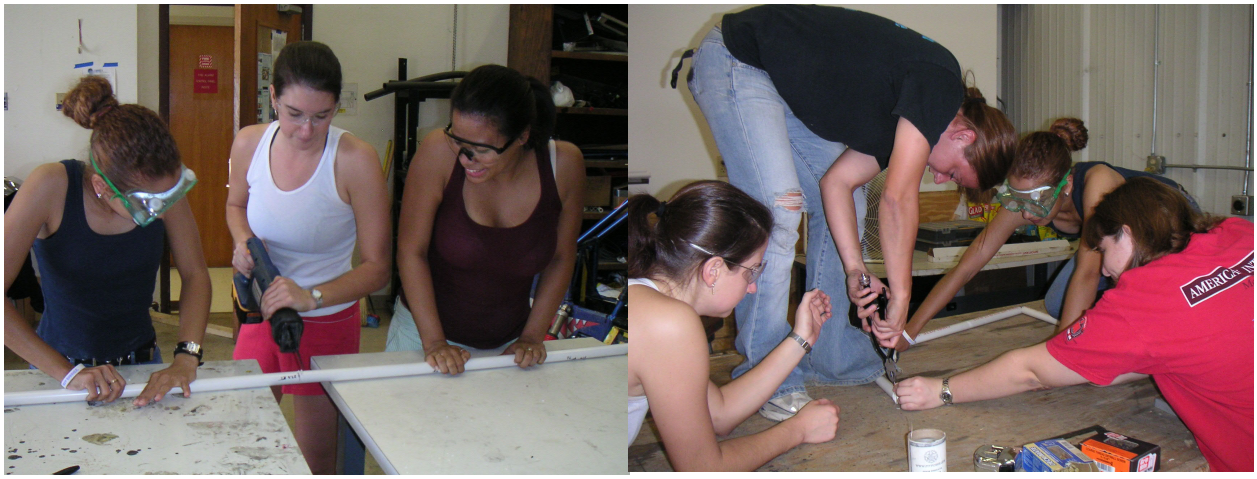

Figure3: Members of the Chassis Group Build a Mock-Up of the Frame

Since none of the women had welded prior to this project, some of the team members spend hours learning and practicing to weld. The task of learning to weld was less intimidating to the women since all of the members started with a similar skill level and several of the women became very proficient at welding while other became proficient at metal working. As shown in figure 4, the final chassis design was completed and double check for ergonomics.

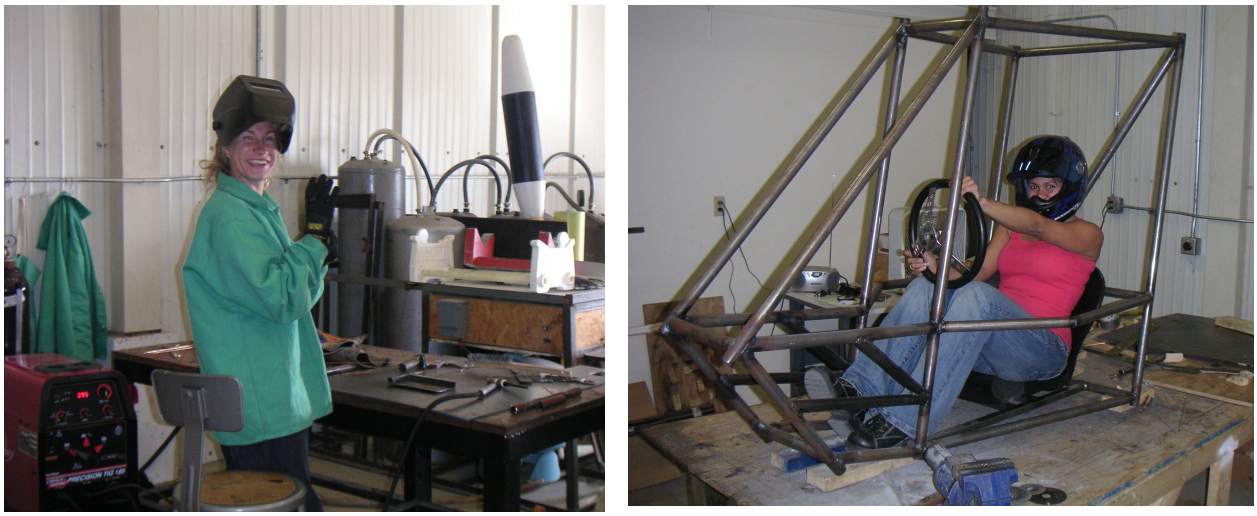

Figure 4: Welding and Ergonomics Testing

Metrics

Of the 216 women currently enrolled in Mechanical and/or Aerospace Engineering, roughly 18 are participating in one of the two groups; 16 in the all-women group, figure 2, and two in the co-ed group, not shown. Last year only one female engineering student participated in the motorsports projects. Approximately 8.3% of the total number of women engineering student are engaged in the projects and almost 90% of participants chose to work in the all-women group. An increase from 0.5% to 8.3% female

engagement is a very significant result in just one year. Four of the students have chosen to work on the project for academic credit.

Since the purpose of this project is ultimately to change the perception of women in engineering, the best measurement of this project's success or failure is a survey of the participants of the project. To evaluate how the project was perceived by the participants a survey was given and 13 women responded. The surveys were anonymous.

Survey Results

The survey consisted of several short answer questions and a couple of multiple choice questions. The students could write in answers for any of the questions. The results to the multiple choice questions and a few of short answer questions, whose answers can be summarized, are shown below.

When asked: What kept you from joining last year's co-ed Mini-Baja team? Of the women who were students last year; 60% didn't know about it, 20% were too busy and 20% were too intimidated or felt that they weren't knowledgeable enough.

When asked if they would participate next year, 100% of the eligible students indicated that they would, as shown in figure 3. Two students will not be able to participate again because they are graduating.

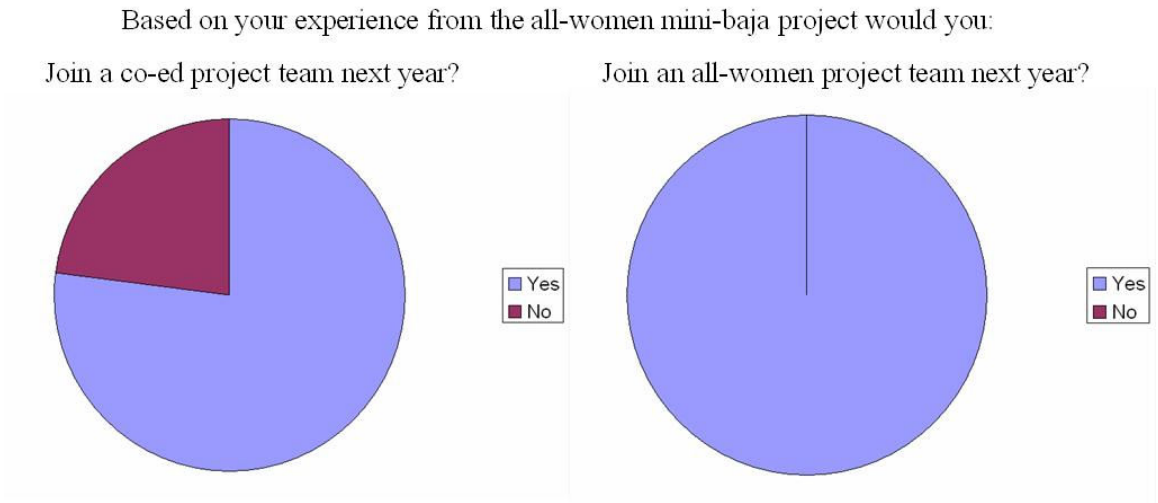

Figure 3: Survey Results

When asked: How would you feel about joining a co-ed team now? 77% said they would be more confident and would join a co-ed team. 23% said they would rather not join a co-ed team. Some of the students that would join a co-ed team noted that they would prefer to join an all-women team.

When asked why other women haven't joined the project; 37% said not enough time, 42% said intimidated or shy, 21% said other women didn't know about the project.

The answers to the first four questions indicate several trends. Efforts to attract women to the mini-baja team this year were very similar to efforts made last year but having an all-women team caught the attention of more women while 60% of women who are now participating in the project where not even aware of it last year. Now that the women are engaged in the project, they are interested in continuing with the project. The women that have participated in this project are more confident about joining other projects. Having an all-women team made it possible to catch the attention of more women and get them involved with the project and once involved, the students are likely to stay involved.

Several short answer questions were asked which could not be concisely summarized because of the diversity of answers. The following questions are designed to determine what the participants believe about the all-women mini-baja project and subsequently what they are communicating to other prospective women engineering students. The complete and unedited answers to the questions are shown below.

Do you think being a part of this team has helped you?
Responses:

- Less intimidated by workshop environments, knowledge on working with other girls (not typical at this school), patience attributed and process associated in tackling subject matter (project) of foreign type engineering venture.
- It has helped me. I've almost forgotten what it was like associating with more than 5 girls in my classes. It helps to enhance people skills.
- Yes. It has brought the interest of engineering back and has become a great plus on why to stay at Riddle
- Yes, great opportunity to utilize leadership skills in area of personal knowledge and interest.
- Yes! I have learned so much about the mini-baja and cars as well. I was able to learn how to weld using both TIG and MIG.
- Being a part of the team has helped me so much. I got to take what I was learning and actually apply it. I also got to learn a lot of new things along the way.
- Yes, I am meeting new people and learning more about the subjects I am studying.
- Yes. It's a great opportunity to get hands-on experience with design as well as assembly.
- Yes. I learned a lot. I want to participate more in the shop, but don't have enough time for it.
- Yes, it made me realize that much of the engineering theory I have learned actually has a practical application.
- Yes. How to work with people and how to manage my time for extra activity.
- Yes. It showed me that I can learn a lot on my own about something I never knew anything about.
- Yes. It taught me the most about design process, being a good leader and how to prioritize.

How has your experience been with this year's team (please describe and give examples)?
Responses:

- Very much a learning one – challenging, since process involved all of us in the same boat → knowing very little about how things should be tackled, software, etc. A lot of fun in learning shop tools and new skills.
- I think the girls are super cool. I had so much fun cutting PVC for the mock-up and attempting to put it together. It was more fun than work. Working in the CATIA lab with the other girls was productive and very entertaining, (work and play is fun) ☺
- Great, team work was the biggest factor in the design aspect of the baja car and every one in each team worked equally hard to get it together. Not to mention help from both Katie and Crystal and the lab assistants. (CATIA)
- Unique perspective because of position (co-captain) – great cooperation from most girls; have had to confront others on performance. Overall enjoyed the experience, lots of responsibility because of level of knowledge.
- It has been a good experience. I was able to work in the chassis subgroup. In this group we had to make decisions before knowing some pick-up points – this was hard! But we pulled through! ☺
- My experience so far has been a pleasant one. All of the girls, especially Crystal, have been extremely supportive of everyone else. We help each other help ourselves.
- This is the beginning of my membership, so thus far I have only attended 2 meetings.
- Learned machining, got valuable research experience and learned about other aspects of the car.
- I knew nothing about baja or car assembly, but learned a lot of things, especially suspension. Learned good things and bad things about teamwork and timeline
- I have generally liked it, but I wish communication could be a little more effective. Sometimes there are group meetings I want to attend but don't know about.
- Excellent! I liked learning manufacturing and working with people. But I couldn't help out a lot on designing.
- Great learning experience. I've enjoyed forming relationships with team members and advisors
- Challenging and fun. Every member had little knowledge and experience, which made for some stressful moments. The effort and design choices made by the members have been exciting and always with good intentions.

The results of the survey were very positive. Participation was optional and during a busy time for the students but most of the student completed the survey. The responses were overwhelmingly positive. The most common aspects of the projects that were mentioned were team work / getting to meet and work with other women, application of course work / bring fun into engineering, learning new skill and being less intimidated.

Project Analysis

Based on the results of this survey, it appears that the project will succeed in retaining women in the engineering program. The project needs to be evaluated over a longer period of time to determine how much of an impact it will have on the attraction and retention of women but the initial results are very positive.

Since the all-women project has a large impact on the perception of women in engineering, it would be beneficial to give a similar survey to both the all-women and co-ed motorsports teams at the conclusion of the baja project in April.

To measure the impact that the project has on middle school girls' perception on women in engineering, the team is participating in a number of local events in the coming months. At these events surveys will also be given to determine what impact the project may have.

If other universities create women's teams and wish to share statistics on attraction and retention, it would advantageous to all parties.

Conclusions

The ultimate goal of this project is to attract and retain women to engineering. Based on the success that the project has had so far with engaging our women engineering students in the all-female mini-baja project, the project is expected to have an impact on the recruitment of women to engineering. The project will continue to monitor its influence using enrollment statistics and surveys for several years. The initial survey results indicate significant interest in the project and a very positive perception but the results will be compiled for several years before any conclusions are made. Increasing the participants in the survey to middle and high school girls will provide a greater indication of the project's potential.

Bibliography

1. US Department of Labor website, http://www.dol.gov/wb/factsheets/nontra2003.pdf, last updated: March 2003.
2. Society of Automotive Engineers (SAE) website, http://students.sae.org/competitions/minibaja/, last updated: September 2005.
3. Jayaram, U., "Increasing Participation of Women in the Engineering Curriculum," ASEE/IEEE Frontiers in Engineering Conference, 1997.
4. Springer, L., Stanne, M., and Donovan, S., "Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis," *The College Mathematics Journal* 1999.
5. Terenzini, P. T., Cabreta, A. F., Colbeck, C. L., Parente, J. M., and Bjorklund, S. A., "Collaborative learning vs. lecture/discussion: Students' reported learning gains," *Journal of Engineering Education*, Vol. 90, No 1, 2001, 123-130.
6. Rosser, S. V., *Female-Friendly Science: Applying Women's Students Methods and Theories to Attract Students*, 1990.