

## **Women, Water & International Experiential Learning**

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Recruiting women for engineering and science programs is a major focus for many U.S. universities and for our nation in general. Studies have shown that there are specific actions that can be taken to improve those recruiting efforts including K-12 outreach, presenting engineering and science as “caring” professions, and providing hands-on opportunities for students. An academic program at the University of Missouri – Rolla incorporates these concepts in a program focused on development of safe water supplies in the highlands of Guatemala. Women As Global Leaders is a multi-year learning community class that has local and international experiential learning elements. Students from a variety of engineering, science, and business programs participate in an interdisciplinary class which includes fund-raising, community outreach and awareness including K-12, and data collection and analysis. Students in the course may elect to travel with upper division students from a capstone engineering design class to Guatemala to participate first hand in the international experience. Safe water supplies are an ideal topic for women students in the U.S. because women are traditionally responsible for supplying water for their families in many developing countries. Cultural awareness of water-based gender roles in other countries may be a unifying theme for women across national boundaries. The results of a pre-college yield analysis indicate that 71 percent of high school senior females participating in a K-12 outreach event eventually enrolled in a science or engineering program at the University of Missouri – Rolla. The Guatemala water supply experiential learning class provides additional opportunities for K-12 outreach including international correspondence (pen pal) experiences between Guatemalan and U.S. students. Perhaps the most important result is that, in collaboration with the capstone design class and U.S.-based non-government agencies, two safe water supplies have been developed in Guatemala and additional efforts to reduce infant-mortality and other water-borne disease are in progress.

## **1.0 Introduction**

Why are so few academically prepared girls not interested in pursuing engineering and science careers? The Extraordinary Women Engineers Project (EWEP 2005) report funded by the American Association of Engineering Societies, the American Society of Civil Engineers and others, surveyed high school girls ages 14-17 about what they thought of engineering as a career choice. Less than 10 percent report being interested in becoming an engineer. Most respondents indicated that engineering was for people who love both math and science, but they did not really know what engineers do. They also indicated that for a career choice, the things that mattered most to them were enjoying what they did, having a good working environment, making a difference/helping others, a good income, and flexibility relating to family issues. Results and recommendations from the study stated that the engineering community, including educators need to redefine how engineering is portrayed and to convey messages that engineering compliments and supports community interests, family interests and self-interests.

A study by Jacobs et al. (2002) evaluated changes in self-perception with time of students in first through twelfth grades. For example, younger students believe that they have greater athletic ability and are more likely to participate in team sports compared to high school students. An interesting finding was that boys' self-competence beliefs for math declined more rapidly than girls in high school. There were indications that girls' math self-perceptions were greater than boys in 12<sup>th</sup> grade. This would suggest that we should not give up on math and science outreach to girls in high school, as many have not yet ruled out a career in math or science-related fields.

In a related study on the prediction of college plans by sixth grade students by Eccles et al. (2004), 681 Michigan K-12 students and their mothers were surveyed on what predicts sixth-graders' college plans. The strongest predictors were the mother's college valuing and the youth's own academic values. The results suggests that it is a good idea to develop pre-6<sup>th</sup> grade outreach that increases the value both mothers and students put in going to college.

One of the methods that have been used to attract women to engineering and science programs is K-12 outreach, and this outreach has been extended to both students and K-12 teachers. Poole et al. (2001) describe a study which concluded that students were more interested in performing hands-on activities compared to sitting in lectures.

In this paper we describe our attempt at addressing some of these issues to encourage women to study engineering and science using international experiential learning.

## **2.0 Women As Global Leaders Class**

Living and learning communities are among the top three contributors to student recruitment and retention at four-year institutions, according to an ACT (2004) report that surveyed 2,995 colleges and universities. As a strategic recruitment strategy to increase the number of female students enrolling at the University of Missouri – Rolla, a living/learning community called the Women as Global Leaders class was formed in 2004. The program is open to all students in all majors that the university offers, and was developed to identify and strengthen the leadership qualities of all students, but with a

particular focus on female students. At that time, 40 percent of the student organization leadership positions on the campus were held by females although the student population was 77% percent male, so this program was developed to enhance opportunities for women to succeed and help others in the process. Another purpose of the program is to help recruit and retain more female students to the University of Missouri-Rolla. In the initial class from the fall of 2004, 39 females enrolled in the class, and 37 of those 39 returned to UMR in the fall of 2005.

## **2.1 Women As Global Leaders Class Objectives**

The objectives for the Women As Global Leaders class are to provide various activities such as open discussions, self assessments, out-of-classroom activities including service-learning projects, writing assignments, cultural exchanges, guest speakers and role models to help students learn what real-life leadership practices mean and how to apply them to their lives and careers.

## **2.2 WAGL Class Activities**

The class is focused around various learning activities including:

- Team building activities such as an introductory welcome picnics, ropes courses, and etiquette dinners
- Role models, usually female alumna from different various career backgrounds including engineers, astronauts, entrepreneurs, lawyers, research faculty, or elected officials speak to the class to give their perspectives on various subjects such as work/life balance, international experiences, overcoming glass ceilings, and other pertinent topics.
- Local service activities include projects connecting the students to community organizations such as a home for abused women or the local animal shelter.  
Groups are expected to incorporate each of the following into their projects:
  - Fund-raising: students are asked to plan a small event to provide assistance to the organization.
  - Experiential learning-students make all the contacts with the local organization and arrange events, and research the organization so they can educate the campus community.
  - K-12 outreach-involving a local classroom
- Global service activities
  - Using many of the same elements of the local service project, but applied to another culture. This includes researching women's roles in daily life, and experiencing other countries through collaboration with the International Engineering and Design class. The project is designed to increase awareness of women's leadership roles from a global perspective.

## **2.3 Women and Water**

The United Nations Population Fund report (UNFPA, 2003) describes the traditional role of women and young girls in developing countries, particularly in rural areas, as the collectors of water for drinking and other household uses. Many spend considerable effort and time on these tasks, which prevents them from doing other activities such as

obtaining an education or helping provide income for their families. The report suggests that if adequate and safe water supplies were available for these populations close to where they are located, women may become empowered to participate more in water resource development and management of water supplies within their communities, plus it would help eliminate health problems from carrying heavy loads of water and allow them more time for rest and leisure. Thus, women and water is an appropriate subject for female engineering and science students to study.

Students in the Women As Global Leaders class have the opportunity to experience first-hand the roles of women and water in Guatemala by choosing to accompany the International Engineering and Design class at the University of Missouri - Rolla. Since 2004, five students from the class have made the trip to Guatemala over spring break. Four of them are females, and one of these is making her second trip.

### **3.0 International Engineering and Design Class**

The World Health Organization (WHO, 2000) cites the availability of clean drinking water as a growing concern in developing nations, especially in Latin America. The lack of adequate safe drinking water supplies causes widespread waterborne illnesses and gives Guatemala the highest infant mortality rate of any country in Central America and the problem is particularly acute among the indigenous population (WHO, 2000). An estimate by the U.S. Army Corps of Engineers stated that only 54 percent of the population of Guatemala had access to potable water (Spillman et al, 2000). Elmore et al (2005) found that the predominant water quality issue associated with traditional water supplies in the highlands of Guatemala was the presence of pathogens associated with fecal contamination in excess of drinking water standards established by the WHO. The study of water supplies in the highlands of Guatemala has been and remains the focus of study at the University of Missouri-Rolla.

#### **3.1 Class History**

The study of international water supplies may be chronicled as undergraduate and graduate research projects as well as capstone engineering design class projects.

#### **Undergraduate Research**

In 2002, a nongovernmental organization called Samaritan Hands, Inc. of Maryville, Tennessee approached the University of Missouri-Rolla for technical assistance in improving a water supply system for an orphanage in the rural highlands of Guatemala which served the local indigenous population. That request eventually led to a research project in UMR's Opportunities for Undergraduate Research Experience (OURE) program by Ms. Erin Lepper. Ms. Lepper continued the project as a part of her Masters of Science study program, and the results of her work were published as Lepper & Elmore (2005).

Another OURE water-supply based project was initiated for an orphanage in Zimbabwe, but that project was suspended indefinitely due to the unfavorable political climate in Zimbabwe which eventually precluded field research.

The Guatemala OURE project led to another OURE project performed by UMR psychology students regarding the characterization of water use attitudes among the indigenous population. Two psychology-based OURE projects have been completed to date which is of interest because UMR does not offer a graduate program in psychology. The results of the water use attitudes study is documented in Elmore & Martin (in review).

### **Undergraduate Studies**

The success of the initial OURE project led to the development of an international studies class which was offered as a combination on-line and international experiential learning class as described by Elmore (in press) in 2003. Subsequent to that effort, the class has been modified to serve as capstone design credit, credit that is required by the national engineering accreditation board for all baccalaureate engineering students. The course is offered for 3 credit hours in the winter semester, and the field trip to Guatemala during Spring Break for all class members has been retained. The current course title is International Engineering and Design.

### **Graduate Studies**

The 2003 offering of the international studies class focused on quantifying the quantity and quality of water sources available to the indigenous population in the study village of San Sebastian de Lemoa. The data collected by the members of that class indicated that water quality was generally acceptable with the exception of fecal coliform bacteria. Additional samples were collected during subsequent trips by UMR graduate students to evaluate the temporal nature of pathogenic contamination in the traditional water sources, and the results of that work is presented in Elmore et al. (2005).

## ***3.2 Opportunities for Multi-Disciplinary and International Collaboration***

Students from the following majors have been or are participating in the water supply study in Guatemala:

- Geological engineering
- Psychology
- Environmental engineering
- Petroleum engineering
- Biological sciences
- Civil engineering
- Electrical engineering
- Geology
- Ceramic engineering
- Metallurgical engineering

Future collaborations are explicitly being developed with economics faculty and students so that micro-loans or micro-financing may be studied. This type of economic analysis is necessary if any water supply support system is to be perpetuated in a developing country.

It should also be noted that the UMR team is developing a future collaboration with faculty from the Universidad de San Carlos de Guatemala Centro Universitario de Occidente (CUNOC-located in Quetzaltenango) to understand design constraints related to local geology, water-borne pathogens, and cultural factors that impact the solution. During the implementation of the water disinfection pilot system(s), the principal investigators will work with the CUNOC faculty to evaluate local responses to the pilot system(s) such as water use statistics, changes in local population, and health statistics.

The goal of the international partnership between UMR and CUNOC is to achieve a mutually-beneficial fraternal relationship. UMR's Office of International Affairs will support the collaboration by providing assistance with insurance for UMR faculty and students traveling to Guatemala, identifying appropriate health care issues such as vaccinations, and coordinating visa and other travel document requirements for Guatemalan collaborators visiting UMR. Furthermore, the UMR School of Materials, Energy, and Earth Resources International Visiting Scholar Program has extended support to our collaborators for the 2006-2007 academic year, and this offer is renewable for a total of three years. This program provides funding for Dr. Cajas and a student to visit the UMR campus to conduct a short course or seminar series regarding water resource research in Guatemala.

### **3.3 Current Class Activities**

Henderson et al. (1994) listed six principles for increasing women's participation in the classroom and reinforce their interest in engineering. While the International Engineering and Design class is comprised of both male and female students the ratios are typically high for engineering classes – 50/50. So the Henderson et al. principles are generally applied for the class as discussed below:

1. Get acquainted early – students are asked to prepare “non-technical” introduction pages during the first day of class. A short not-for-credit quiz is prepared based on the introduction pages, and the students generally respond well to these simple introduction activities.
2. Expose the students to good role models – both male and female faculty and staff are asked to support the students in their design activities, and both male and female faculty and staff are recruited to participate in the field trip to Guatemala.
3. Let students explore their own feelings and attitudes – the students are required to keep a journal during their trip to Guatemala. Journal entries are to include both technical data and personal observations. To encourage the personal aspect of the journaling, students are required to record names of both their peers and the Guatemalans that they work and interact with.
4. Discover the physical world – the students are required to build the experimental apparatus in the UMR laboratory prior to the trip to Guatemala. The type of hands-on laboratory activity is essentially a function of the individual students' majors. The

students are typically highly motivated to perform well while in Guatemala, so the ungraded lab work provides a fun, low-stress environment in which to prepare.

5. An all-woman classroom – while Henderson et al. (1994) makes a good case for an all-woman classroom, we do not believe that it is practical to expect people to live their lives in single-gender situations. For example, men are permitted to enroll in the Women As Global Leaders class.
6. Create a low-stress educational environment – the nature of conducting a capstone design class typically creates some stress for all students due to the indeterminate nature of the design process, instructors may elect to adopt instructional attitudes suited to their individual personalities which are intended to reduce the students' stress levels.

The previous work described above indicated that ground water is a cost-competitive alternative to constructing the traditional spring-based, gravity fed water system found throughout the Guatemala highlands. Furthermore, ground water has the advantage that it is less likely to be contaminated with fecal coliforms and other pathogens relative to spring systems. However, it is recognized that funding will not be available to replace the thousands of spring-based systems found throughout the highlands. Therefore, the focus of the current International Engineering and Design class is the development of a practical disinfection system for individual indigenous households.

## **4.0 Collaboration Between Classes**

One of the critical aspects of any water study is the collection and subsequent analysis of data. For example, little is known about the per capita consumption of water in the highlands. Another important data need is the evaluation of any disinfection system's effectiveness as a function of the quantity of water treated or the time since system installation. The collection of these data requires a site presence. The collaboration between the International Engineering and Design class and the Women As Global Leaders class is summarized as:

- The capstone design class designs the experimental system and specifies the data collection needs
- The Women As Global Leaders develop a data transmittal system that satisfies the data collection needs, provides a means of education intervention for a portion of the local population at the study site, and as K-12 outreach for both students in the U.S. and students in Guatemala

Women As Global Leaders students address the following issues to support the collaborative activities listed above:

- Support during the establishment of a bi-lingual website for transmitting project data from Guatemala to the U.S. Internet cafes are available in the vicinity of the Guatemalan study area.
- Development of a K-12 outreach program in Guatemala. In particular, local children and school teachers will be recruited and trained to collect water meter readings and field measurements of water quality using pictographs, videos, and

skits. The Guatemalans will periodically be transported to an internet café to upload the data on the website described in the bullet above. This program will have a three-fold purpose: 1) it provides for a means of data transmission to the U.S.; 2) education and intervention regarding drinking water quality with the local population; and 3) outreach regarding the importance of education in general and specifically science education to the local population

- Development of a K-12 outreach program at schools in the Rolla area. In particular, students will be asked to run experiments on their family water supplies for comparison to the Guatemala experiments. The students will also be asked to develop pen pal “fact sheets” and introduction videos to share reciprocally with the Guatemalan students. This program will have multiple purposes: 1) introducing U.S. students to another culture; 2) reinforcing the importance of math and science studies; and 3) providing effective female role models through interaction with the Women As Global Leaders students.

## 5.0 Pre-College Yield Analysis

The process of recruitment of female students to enroll at the University of Missouri – Rolla begins with data collected annually from UMR pre-college programs directed at recruiting females into science and engineering fields, as well as from state and regional sources and analyzed to find out keys to the successful recruitment of female engineering students.

One of the first steps to planning for this recruitment involves performing a yield analysis for admissions. The yield analysis is the percentage of students who eventually enroll at a university after applying and being admitted. The yield analysis may be modified to track how many female students who have attended a pre-college event(s) eventually enroll at UMR. Results from the pre-college events indicate that since these events began in spring of 2002 and through the fall of 2005, 71 percent (59 out of 83) high school senior girls, who attended one of these on-campus programs enrolled at UMR. Also, 47 percent (23 out of 49) of the high school junior girls who attended these events enrolled at UMR. The total yield for this pre-college program that introduces girls to careers in engineering and science was 62 percent since the program’s inception.

It can also be applied to other data in a funnel application such as how many students in the state of Missouri were females, how many sent their college placement exam ACT scores to us, how many were interested in the engineering field and how many actually enrolled in an engineering field at UMR.

Approximately 75 percent of UMR’s students are Missouri residents. The following is a funnel analysis for 2004 Missouri female high school seniors:

- Missouri female high school graduates: 28,903
- High school female seniors that took the ACT college placement exam: 23,571
- Seniors with an interest in studying engineering who  
Sent their ACT test scores to UMR: 236



- Seniors with engineering interest, and sent scores to UMR, with an ACT composite score (average of English, Math, Science and Reading scores) of 21 or greater, (the average composite score for high school students in Missouri): 182
- Seniors with engineering interest, sent scores to UMR, with ACT composite score of 24 or greater (minimum requirement for automatic admission to the UM System schools): 138

For the fall of 2004, 88 out of those 138, or 64 percent of the senior Missouri female students interested in pursuing engineering, enrolled into an engineering program of study at the University of Missouri-Rolla. A total of 168 freshman females in all majors enrolled in the fall of 2004.

## 6.0 Conclusions

The yield analysis results indicate that if female high school students participate in an on-campus event designed to give them hands-on activities in engineering and science, the chances of getting these students to enroll at the University of Missouri-Rolla are greatly increased. Normal yield of total female students in a freshman class is about 54 percent. As a result we have increased the number of programs of this type offered to K-12 female students starting with the middle school level and going up through the senior year. The key is getting more students exposed to these programs at younger ages and having other programs to attract them as they progress through school to increase the interest in the science, technology, engineering and mathematics fields. We feel that by integrating the International Engineering and Design experiential learning course, the Women As Global Leaders course, and by including educational hands-on activities in the K-12 pre-college programs that focus on the global importance of safe water that more girls and women will want to pursue science and engineering careers. They will see that these professions help people and communities throughout the world with various projects, and can also help recruit and encourage other females to want to follow in their footsteps.

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