

AC 2007-2951: INTERSECTIONS BETWEEN SCIENCE AND ENGINEERING EDUCATION, AND RECRUITMENT OF FEMALE AND NATIVE AMERICAN STUDENTS

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Intersections between Science & Engineering Education and Recruitment of Female and Native American Students

Abstract

Authors will present an extensive overview of women and minorities in science, technology, engineering and math; provide discussion of the importance of multicontextuality as a tool in the use of effective pedagogy, particularly in regards to Native American women in a pre-college program and present information on the successful development of the Northern Arizona University STEP UP (Summer Technology and Engineering Program and University Preview) Engineering camp for high school age female students.

The Northern Arizona University (NAU) Multicultural Engineering Program embarked upon the development and implementation of the STEP UP (Summer Technology and Engineering Program and University Preview) camp for high school age female students. After a pilot year in 2005, the STEP UP camp implemented a full scale camp in summer 2006. Garnering support for the first ever engineering camp on the NAU campus through college and university support as well as faculty and industry support; the STEP UP camp was a success. The majority of young women in attendance were Native American, which presented an opportunity to positively influence their pre-college decisions and provide an access point to considering career paths toward science, technology, engineering and math disciplines. Assessment, evaluation and tracking are a part of this initiative.

This paper will discuss the successful dynamics used and pedagogical approach toward nurturing the female participants' interests in engineering and science through hands-on activities, personal and team dynamics, faculty and current engineering/science student instruction and industry participation; the creation of personal connection to the Multicultural Engineering Program and the relevance of this for female recruitment and retention towards STEM disciplines will also be discussed. In addition, practical information regarding the scoping, development, trial and error, and full implementation will be discussed.

In addition, this paper will address possibilities for the future of recruitment and retention of female engineering and science students at Northern Arizona University and the sustainability of the existing program.

Introduction

Despite two decades of advancement of women in the areas of science, technology, engineering and math (STEM), women are still sorely underrepresented both in academia and in industry when compared to their male counterparts. Women in science and engineering (S & E) have experienced some gains in areas of undergraduate and graduate enrollment, earned baccalaureate degrees, graduate and doctoral degrees and even in the workforce. However, this somewhat "rosy" picture, does not however tell the complete story. Women continue to significantly lag behind men in S & E fields in almost all categories mentioned. Why are women still in the back of the pack and what role has the academy played in these outcomes? More importantly, what

role can the academy play for the next two decades that would significantly support gender equity in the entrance and progression of women in STEM disciplines.

Undergraduate enrollment in engineering programs by women steadily increased from 18.1 percent in 1994 to 19.2 percent in 2002, while minority (Black, Hispanic Native American) have experienced more ups and downs throughout the same time frame and much lower percentages ranging from 0.6-8.0 percent.¹ Since 1995, the proportion of women and minority freshmen in engineering have been declining while men and non-minority freshmen have been increasing at a significantly faster pace. These declines could constitute declines in the proportion of degrees earned by women and underrepresented minorities in the coming years.²

Historically, about one-third of all bachelor's degrees are awarded in science and engineering. Since 1970, the number of bachelor's degrees in science and engineering to men fluctuated around 200,000, while the number of science and engineering degrees earned by women steadily increased reaching majority status in 2000. In 2001, women earned 50.6 percent of the baccalaureates in science and engineering.²

Ethnic groups, including Hispanic, Black, non-Hispanic, have steadily increased in the percentage of S & E bachelor's degrees earned from 1990-1998. In 2002, these groups have experienced slight declines. For Native Americans, S & E bachelor's degrees earned from 1990-1998 remained virtually flat, hovering around 0.4-0.6 percent and in 2002, continue to remain in that state.³

In terms of the minority and women's shares of S & E master's degrees awarded during the period of 1989-2001, all minority groups (Hispanic, Black and Native American), and women increased in this area. The number of women earning doctoral degrees in S & E rose between 1966 and 2001. By 2001 women earned 37 percent of S & E doctoral degrees.¹ Underrepresented minorities over the 30 year period 1973-2002 only increased their proportion of the S & E doctorates minimally from 1.3 percent to 5.5 percent.²

It is not surprising that the significant under representation of minorities and women in S & E disciplines impact their participation in the workforce as well as in academia. Women occupy 29% of science and engineering positions at U.S. educational institutions. But they fill only 15% of those positions at the top 50 research universities in these fields. In government and in industry, women occupy just under one-quarter of science and engineering jobs. As in the academic world, men dominate jobs in the physical sciences and engineering.⁴

Interest in S & E among high school students is rising:

Since the early 1980's, when states began to increase the number of required courses to receive a high school diploma, the percentage of high school graduates completing advanced coursework in science and mathematics has increased. In 1982, 35 percent of high school graduates had completed advanced science coursework (i.e., at least one course classified as more challenging than general biology); this percentage had increased to 63 percent by 2000. Most of this increase is attributable to increases in the rates at which graduates completed

chemistry I and/or physics I because the percentage who had completed at least one course of either chemistry II, physics II, or advance biology increased only from 15 to 18 percent between 1982 and 2000.⁵

The combination of these data on high school interest in S & E, enrollment data, and freshmen interest in S & E suggests that more women are receiving degrees in S & E because the number of women attending postsecondary institutions has risen--rather than the proportion of collegiate women interested in S & E. The distribution of women's interest in particular disciplines has not changed much, and women still prefer the biological sciences over engineering.⁵

The National Research Council identified two obstacles that play a role in recruiting more women to undergraduate study in S & E: differences in preparation for such study and negative attitudes about S & E. According to the NRC, the first factor--differences in preparation--results in women facing more of an uphill battle to succeed in an S & E program because they have to absorb more information in less time--not because of a difference in aptitude. While both men and women take S & E courses in high school; there is an important difference in the kinds of courses the take. Women tend to take earlier math courses (i.e. geometry, algebra II and trigonometry), while men tend to not take mathematics earlier in their education, and are more likely to take pre-calculus and calculus, which suggests that they may be more prepared to enter S & E fields of study.⁵ The second obstacle--negative attitudes toward S& E--encompasses women tending to have less interest, expectations for success, and confidence regarding S & E than men. In short, many young people view S & E as something men do.⁵

Although gains for women and minorities are a hopeful sign of continued advancement in S & E disciplines, these gains do not constitute significant gender equity across STEM fields of study overall. Frankly put, science and engineering *is still* a "man's world. This paper examines the implications of a female-focused pre-college program for increasing the number of women in engineering and science.

Why Do Women and Minorities Leave SME Disciplines?

Elaine Seymour and Nancy Hewitt identified 23 issues which contribute to why students switch out of the Science, Math and Engineering (SME) disciplines.⁶ The top twelve reasons cited are shown in Table 1. Students listed an average of at least four factors which contributed to their decisions to change majors and leave SME disciplines:

Table 1. Top issues contributing to decision to switch out of Science, Math or Engineering majors for female and male students.

Rank	Issue	All, contributed to switching decision, %	Female, contributed to switching decision, %	Male, contributed to switching decision, %
1	Lack of/loss of interest in SME	43.2	43.0	43.8
2	Non-SME majors offer	40.4	46.2	34.8

	better education/more interest			
3	Poor teaching by SME faculty	36.1	33.3	39.3
4	Curriculum overloaded, fast pace overwhelming	34.9	29.0	41.6
5	Feel SME career options/rewards are not worth effort to get degree	31.1	26.9	36.0
6	Rejection of SME careers/associated lifestyles	29.0	37.6	20.2
7	Shift to more appealing non-SME career option	26.8	26.9	27.0
8	Inadequate advising or help with academic problems	24.0	29.0	20.2
9	Discouraged/lost confidence due to low grades in early years	23.0	19.4	27.0
10	Financial problems of completing SME majors	16.9	10.8	23.6
11	Inadequate high school preparation in basic subjects/study skills	14.8	15.1	14.6
11	Morale undermined by competitive SME culture	14.8	4.3	25.8

This study also compared the differences in responses for female and male students, as reflected in Table I. In general, women indicated they were interested in a better overall educational experience and valued personal and job satisfaction more than the possible material rewards associated with a certain career. Women also receive more support from parents and peers to switch out of SME majors, according to the authors of the study. Interestingly, fewer women than men switched majors because of poor performance in the early years and about the same percentage both men and women who switched indicated poor high school preparation as a factor—but the percentage is slightly higher for women than men. There was a similar response between the two groups regarding the pace and load of the SME majors, however women cited the competitive SME culture at a much lower rate than men as a reason to switch. Notably, almost nine percent more women than men listed inadequate advising as a reason for switching

This study also compared the differences in responses between minority (Native American, African-American, Hispanic, and Asian) and white students, noting that minority students leave SME majors at a much higher rate than white students. In fact, in the 1980s, only 35.6 percent of minority engineering freshman completed degrees in engineering, compared to a degree completion rate of 68.4 percent for white students. These two groups show marked differences in the factors for switching. For instance, the number one reason cited for switching out of SME

programs for Caucasian students was a lack or loss of interest in SME (48.9%), compared to only 28.9% for minority students. Minority students indicated conceptual difficulties with one or more SME subjects (30.8%) at a much higher rate than white students (5.3%), as well as inadequate high school preparation in basic subjects and study skills (34.6%) (compared to 6.1 % for white students)⁶

For years, the debate over why women are underrepresented in S & E both in higher education and professionally has centered around two predominant theories. Many contended that the situation was a natural condition—a result of the fact that far fewer women had the natural cerebral abilities necessary to succeed in such fields. Men, on the other hand, did have the abilities required. A companion argument explaining the differences held that men tend to be more achievement-oriented than women, including the willingness of men to make sacrifices, such as working long hours. The gender disparity in representation in the S & E fields, then, was simply a natural occurrence.

While numerous scholars have refuted such arguments, the nature versus nurture debate recently received new life from Harvard University President Larry Summers during his comments at a diversity conference in January 2005. Summers declared that the three most likely explanations for the continuing under representation of women in the top level of science professors are that: 1) women remain unwilling to make the sacrifices required by working in these demanding fields, 2) men may simply have more “intrinsic aptitude” for high level science and finally 3) (and least likely among the explanations, according to Summers) women pursuing these fields may be experiencing discrimination. Although President Summers indicated in his remarks that he clearly ranked discrimination as the least important factor explaining the low numbers of women in S & E, survey data indicate that discrimination is still a significant problem for women in these fields. In the 2000 American Society of Engineering Education survey⁷ of women in engineering departments at colleges and universities across the country, women representing nearly every level of teaching and academic administration responded to various questions related to their experience in academia. Nearly 30 percent of the respondents said they frequently or very frequently experience discrimination as a woman in engineering academia, while 42 percent said they have rarely or never had to deal with gender discrimination. Moreover, many respondents report that the discrimination is often so subtle that it would be impossible to prove.⁷ Furthermore, this data comes from the women who remained in the field, leaving us with no indication of how many former female college students in S & E may have experienced discrimination before they left the major and whether or not discrimination played a part in their decision to change their programs of study.

Women of color in S & E academia and professions outside of academia face these barriers and arguments as well as additional obstacles that confront persons of color. A familiar refrain attempting to explain the under representation of people of color in S & E is that students of color are not academically prepared to study in these fields and/or that certain cultures simply don't value education. This argument, exemplifies the “cultural-deficit” model, and can influence student achievement as minority students often are branded as “at-risk” or “low ability” students, then grouped together and identified as being in need of “fixing”.⁸ The label then serves as a catalyst for the self-fulfilling prophecy—resulting in low expectations for both the students and their teachers.⁸

Few critics of the “nature” arguments, including the cultural-deficit model, deny that physical differences in the brain exist between men and women. However, difference does not equal superiority or inferiority when comparing female and male abilities in S & E. Studies have found, for example, that the parts of women’s brain that deal with spatial reasoning develop at *different ages* than those of their male counterparts, *but over time become equal*. Additional studies discovered that upon use and practice, those areas of the brain actually developed further in both girls and boys. Similar studies in primates echo these findings. It’s not necessarily nature vs. nurture, but rather a combination of the two and understanding how the various aspects of biological difference and socialization factors can affect both women’s interest in S & E fields and whether or not they achieve success.

Gender and Cultural Contextuality in the Classroom

Some scholars using surveying data and focus group information have found that while women that are both academically and intellectually capable, they lack confidence in their abilities in S & E.⁶ Reasons for lack of self-confidence included feelings of isolation, negative experiences in laboratory classes, lack of role models and a cold classroom climate.⁹

In short, current curriculum and teaching practices may leave women in a position where they don’t “see” themselves in engineering. Classroom examples don’t include them, and for women of color, the same examples may also be of an exclusive cultural context as well. The picture of future engineers and scientists seems to be one in which people like them are conspicuously absent. The implications of such an exclusive picture may be profound as articulated by sociologist Ronald Takaki:

What happens....when someone with the authority of a teacher describes our society and you are not in it? Such an experience can be disorienting, a moment of psychic disequilibrium, as if you looked into a mirror and saw nothing’.¹⁰

Robert Ibarra’s work on multicontextuality in higher education is helpful in understanding the role that pedagogy plays in a multicultural classroom.¹¹ Ibarra describes an individual’s cultural context, as “learned preferences that influence how they interact and associate with others, use living spaces, perceive concepts of time, and include many other factors that were imprinted upon them in childhood by family and community and continue to help shape their world view”.¹¹ Ibarra contends that in today’s multicultural world, many individuals, especially ethnic minorities and women have multicontextual learning styles. That is, their ways of knowing, learning, and understanding are a result of their cross-cultural experiences between majority and minority cultures. Those who are multicontextual, according to Ibarra learn better in classrooms where multiple ways of knowing are embraced, yet the STEM disciplines have been reluctant to embrace these changes:

While the ethnic markers disappeared long ago, the cultural contexts in higher education, such as preferences for individual learning over group work or technical teaching styles over informal styles, as well as many gender preferences have not. They have been incorporated into our science, math and engineering disciplines, remaining relatively unchanged and unnoticed by nearly everyone.

Therein lies the conflict. Multicontextual students and faculty, and that includes some majority males as well, reveal preferences for cultural contexts and ways of knowing that are often the antithesis of academic culture.¹¹

Additionally, understanding the “rules of the game” may be critical when it comes to achieving equity for women and persons of color in the S & E disciplines. Monhardt notes that understanding the rules of the game are important in notions of fair play, and that outsiders or those new to the game have no such understanding. When it comes to S & E fields, then, both women and minorities are relative “outsiders” as those fields traditionally were dominated by Anglo males.⁸ As Monhardt discusses, as a newcomer or outsider, it is critical to have someone on the inside to help one understand the “rules of the game” if one is to have a fair chance of winning (or in this case, succeeding). Even if someone attempts to learn the rules of the game, but without insider perspective and/or assistance, a description of the rules may not be helpful, according to Monhardt. In illustrating of her argument, Monhardt offers the example of the Navajo Shoe Game, a traditional cultural game of the Navajo people, the largest Native American tribe in United States; located in the Southwest. As a highly educated and accomplished Anglo woman, Monhardt explains, even upon reading the “rules of game” as written down and provided to her, she still felt confused and unable to participate meaningfully. For example, the game requires the use of yucca leaves. Where does one get yucca leaves, she wonders? And even if she found a person willing to tell her where to find the items needed to play the game, Monhardt realized she still didn’t understand the significance of the songs which are an integral part of the games or even the point of it. The Navajo Shoe Game was not part of a knowledge context familiar to her. To truly participate as an equal, or have a fair chance or doing so, she needed an “insider,” someone who truly understood the game, to help her.⁸

The example of the Navajo Shoe Game and Ibarra’s discussion of multicontextuality are obviously helpful in understanding and explaining the feeling of isolation and the “cold climate” experienced by women and minorities in S & E classrooms, labs, and by female S & E faculty in academia. Without help from “insiders” women, especially women of color in the STEM disciplines are operating without a fair chance of winning. While some succeed despite such obstacles, indications are that many women and minorities who have the intellectual aptitude necessary for S & E fields leave due to social factors. Nurture, then in this context, may indeed play a critical role in determining why so many women leave these fields.

What Can Universities Do To Increase the Number of Women in Science and Engineering and Why Is Change So Important

“Tinkering” with Institutional & Pedagogical Change

Perhaps most important is the recognition that universities can be a catalyst for positive change. Classroom environments can be changed by altering teaching methods in small but important ways. Evidence suggests that women need to be able to connect engineering and science with the greater good for society.^{8, 12} “In testimony to the Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, William Wulf, the president of the National Academy of Engineering, said: ”I believe more women will enter engineering when they begin to recognize engineering as a creative, interesting, rewarding

career, when they see it as a way to improve people's lives."^{12, 13} For instance, classroom examples and language need to be that which is inclusive of women's experiences and context of knowledge in order to make connections to a world in which they see themselves, their families, and their communities. Pre-college programs that adopt this concept could be very instrumental in impacting recruitment of women in S & E fields:

In order for these fields to be equally open to women and men from all racial/ethnic groups, a fundamental (re)gendering needs to take place- not only do women need to be represented in equal numbers, but also institutional structures and disciplinary cultures and practices need to change so that they do not provide an advantage for any particular gender (as well as race, class, or sexual orientation) over other(s). Activists and policymakers have thus increasingly recognized what many women's studies scholars have been advocating for some time now: That the (remaining) barriers to women's progress in academia are systemic and rather than trying to change women to fit the sciences and engineering, these fields need to be changed in order to accommodate women.¹⁴

There are numerous factors that play into the different experience that some women may face within S & E fields. Often women can feel unhappy, uncomfortable, and isolated in "cold" environments found in S & E fields. Some characteristics of a cold environment that have been identified are:

- Erroneous assumption by lecturers that all students have prior "tinkering" experience
- Lack of excitement in the content or presentation of the course
- Teaching methods that are appropriate for only a very limited range of learning styles
- Disruptive behavior of majority groups
- Classroom atmosphere uncomfortable for some students because of racism, sexism or similar attitudes¹⁵

Universities can commit to positive change that would be inclusive. Rosser identified elements of inclusive curriculum development as typically occurring in universities committed to improving the representation of women in their science programs.¹² These suggestions could have significant impact upon furthering the value of diversity in the academy, *if* the varying levels of academia embrace and envision its full potential.

- Acknowledge gender influences, and seek ways to incorporate them appropriately in the curriculum.
- Explore issues of social concern.
- Set open-ended investigative-type problems.
- Consider the learning environment as well as entry issues; remove the "chilly climate" experience by many women students.
- Teach cooperative and interdisciplinary ways.

- Discuss the social benefits of technological progress.
- Encourage the development of theories and hypotheses that are relational, interdependent, and multicausal.
- Use qualitative and quantitative methods in data gathering.
- The philosophy, aims, objectives, and content of the curriculum must be based on the principles of inclusivity, as well as the way the curriculum is delivered.^{12, 15}

Using a Pre-College Engineering Program as a Tool for Increasing the Number of Women and Native Americans in S & E: The Use of Relevant Examples and Concepts in Teaching Science and Engineering

The National Research Council⁵ (NRC) identified three principal strategies used to recruit greater numbers of female undergraduate students: increasing preparation in secondary school, replacing the negative views and attitudes about S & E education (and careers) with positive ones, and creating a more female-friendly educational environment. Pre-college engineering programs that serve to motivate female students and Native American students to take more science and engineering classes in high school, encourage interest in science, math and engineering, and use teaching styles that engage students from these groups in solving problems relevant to their lives may be an effective tool for motivating them to pursue a college degree program in the SME fields.

Pre-college Engineering Programs by Type

Pre-college engineering programs fall into three main categories: after-school programs, commuter camps and residential camps. While some programs are open to students of any ethnicity and gender, a number of programs target students underrepresented in engineering—potential first-generation college students, minorities, and women. Some programs target specific underrepresented populations, such as minorities or young women. Very few target specific minorities—such as Native Americans or combine two underrepresented categories of students into one program (i.e. Native American young women).

The following sections discuss brief programs targeting young women and those impacting Native American female high school students. Few pre-college engineering programs target specifically Native American high school students. The Siemens Corporation has launched a number of after-school programs targeting various high school student populations, such as inner-city high school students and Alaskan Native youth. The Siemens program, a semester-long program, delivered science and engineering curriculum in a manner that was culturally relevant for the indigenous community in which the program operated. After-school programs offer the opportunity to introduce students to the STEM disciplines and nurture interest in science, engineering and technology and some, (such as the Siemens program) operate throughout the entire semester--a much longer time period than any residential summer camp. Many after-school programs, however, such as Math, Engineering, and Science Achievement (MESA) do not focus specifically on young-women.

Commuter summer engineering camps often incorporate many of the same components and activities as residential summer camps. Some commuter camps feature hands-on learning activities, an introduction to different STEM disciplines, information on specific careers in engineering, science, and technology and interaction with industry professionals. Commuters, or day camps, also offer certain advantages in reaching younger populations, as obstacles that arise in relation to dealing with younger children in residential settings are not an issue.

However, female-focused residential summer engineering camps offer additional advantages in terms of recruiting young women into college engineering and technology programs. Residential camps can still feature hands-on learning activities, interaction with industry professionals, and opportunities to explore careers in engineering and technology. Additionally, participants become familiar with life on a college or university campus, experience living away from home, and learn how to use campus resources. Camps that utilize an all-female format may also tend to produce an environment where participants feel empowered, and less self-conscious than in mixed gender learning environments. This in part addresses the obstacle of counteracting negative attitudes towards STEM disciplines as previously mentioned and potentially counters the “cold climate” issue. Additionally, female-focused camps may utilize female faculty, women professionals, and female college students who can serve as role models for participants. Campers have the opportunity to “see themselves” as future engineering and technology professionals. Additionally, the residential format provides a setting for participants to interact together socially outside of classroom experiences.

STEP UP Engineering Camp at NAU

The goal in designing NAU’s STEP UP engineering camp encompasses each of the three strategies identified above by the NRC. Prior to embarking on the creation of NAU’s first engineering camp a brief study was conducted that surveyed similar summer programs at other universities. Preliminary research was conducted to gain an understanding of the varying programs that provided high school aged women the opportunity to explore STEM disciplines. It was apparent that there were several programs throughout the country that introduced the STEM fields to an underrepresented population in those areas of study.

Thirty-one summer programs were reviewed and surveyed with intention of finding existing programs within similar institutions. As expected, the summer programs were quite varied in size, cost, timeframe of the program and activities. Programs ranged from grades 4-12, some included activities or programs during the academic year or after school, some were residential or commuter summer experiences or both. The most significant differences were found in the cost and length of each program, and whether they were residential or commuter camps. The majority of summer programs had a tuition fee, and ranged from in length from three days to one week. Many, of the programs offered financial aid; however not all did, meaning that only those who could afford to attend those programs would be able to, and those who may have had an interest but could not afford to attend would be left out. Program content also varied, with some programs focusing on activities such as job shadowing of professionals while others concentrated more on hands-on project based learning.

The goals for NAU's STEP UP Engineering Camp were to stimulate and nurture interest in S & E careers through hands-on activities, providing multiple points of interaction with female engineering professionals who would be strong role models for participants, and allowing participants to get a glimpse of college life. Additionally, as Northern Arizona University is located in Flagstaff, Arizona, adjacent to a number of Native American communities and has a relatively high Native American enrollment (over 6% of the total student population) it was reasonable to expect some Native American applicants. However, given the distance of NAU's campus from other Northern Arizona Universities, commute times from all but two neighboring communities exceed one hour (and, in fact, many of our participants lived in communities that were more than five hours away). Therefore, given our campus location, developing a residential camp rather than a commuter camp not only dovetailed with our goals of giving campers a bit of "the college experience," but also ensured that the camp would be accessible to young women from communities throughout northern Arizona and the four-corners region.

Development of Pilot STEP UP Camp – 2005

In partnership with the NAU Educational Support program, the NAU Multicultural Engineering Program (MEP) took the lead in the development of the first NAU engineering camp. Due to significant interest from the Siemens Corporation and support from the NAU Hewlett Engineering Talent Pipeline, the pilot camp was developed for implementation in summer 2005.

The planning team comprised of MEP staff (1 full time employee, 1 graduate assistant, 2 student workers) and Educational Support staff (2 full time employees) and engineering faculty (1) who met over the course of seven months developed the week long residential camp based upon hands-on activities, week long design challenge, industry panel and workshop sessions, and extra-curricular activities.

Fundraising was a significant part of the planning, including long- range planning for sustainability of the program beyond the initial seed monies. This included discussions with the NAU College of Engineering & Natural Sciences Development Coordinator about fundraising in general, what potential donors to approach, in what manner, importance of identifying a shared interest and an action plan to address the current summer program needs, as well as any subsequent camp. Additionally, campus grant opportunities were explored and submissions made for the 2005 and 2006 camps; all requests for such funding were granted (i.e. Office of the President's Recruitment and Retention grants, NAU Marketing Fund grant).

In July 2005, the Summer Technology and Engineering Program and University Preview (STEP UP) was launched as a one-week residential camp which introduced engineering concepts and careers to 9th-12th grade young women through hands-on activity based learning. The mission of the camp was to provide an opportunity for participants to imagine, or "see themselves" as engineers or scientists, as well as an opportunity to become familiar with Northern Arizona University in particular, with a college experience in general, and to have an opportunity to interact with engineering and science faculty/staff and current engineering students.

STEP UP 2005 had a total of 25 participants from: Arizona (22), New Mexico (1), Utah (1), and Massachusetts (1). Participants would be entering grades in fall 2005: 9 freshmen, 3 sophomores,

7 juniors, 6 seniors, and represented a range of ethnicities. A particularly strong interest came from Native American young women. Participants included: 17 Native American, 4 Caucasian, 2 Hispanic, 1 Native American/Caucasian, and 1 Asian. Initially, we anticipated interest from communities in the region, but to the planning committee's surprise we received significant interest nationwide. Of the 6 seniors who participated in STEP UP 2005, 4 applied to S & E university programs, 3 were accepted and enrolled in fall 2006.

Feedback received indicated that participants found the all-female format and use of female role models and hands-on activities empowering. The format also enhanced their interest in S & E by helping them see connections between important issues relevant to their lives and in their world.

Young women are drawn to disciplines that have an obvious altruistic quality to them, such as environmental or biomedical engineering.^{6, 15, 16, 17} According to Grose, Eccles' 2003 Michigan study found that girls who are confident in their math abilities tend to want to improve society and place more value on fields they think are people-oriented. "The profession needs to do a better job of showing girls that degrees in, say mechanical or electrical engineering can be wonderful gateways to medical or environmental work."¹⁸ This desire to work in careers that are connected to solving important problems in society and making those connections to S & E careers as an important piece of the recruitment and retention puzzle for women in S & E was demonstrated by the experiences of STEP UP campers both years and is exemplified in some of the participant comments included in a subsequent section below.

Evaluation information from the 2005 camp indicated that participants were somewhat overscheduled, and had too little free time. Evaluations from staff also revealed a few logistical issues. For example, not enough time was scheduled for transportation from one activity location to another. Additionally, while STEP UP 2005 included a number of hands on activities in addition to the design challenge project, it also featured a few lecture-style modules. Participant as well as staff evaluations indicated that the young women learned more from and remained more engaged with the hands-on activities, and small group interactions with engineering professionals. Based on the evaluation information, changes were made to the schedule and program content for the 2006 camp as discussed in subsequent sections below.

2006 STEP UP Camp

STEP UP had 17 participants in 2006 from: Arizona (13), Idaho (1), California (1), New Mexico (1) and Utah (1). Participants would be entering the following grades this fall: 6 sophomore, 4 juniors, and 7 seniors, demographically speaking, 12 were Native American (two identified themselves as multi-ethnic), 2 Hispanic (one identified as multi-ethnic), and 4 Caucasian. Three of the 2006 participants were returning campers from 2005. We received interest from across the nation as well as the states represented by the accepted 17 participants.

The camp featured interaction with professional engineers—primarily female engineers and faculty across different engineering and science disciplines, including computer science. Workshops covered a variety of engineering and science topics and team building activities as well as fun "camp" activities in the evenings. NAU engineering students also assisted in

workshop presentation and supervision of the design challenge project. This was especially valuable for the NAU students as the camp furthered their overall professional development.

Based on the evaluation data from the previous year's camp, we incorporated the "Engineering Industry Round-Robin Seminars," breaking participants into small groups and creating short round-robin sessions with female engineers and computer scientists who would talk with each small group for about 20 minutes. Presenters were asked to explain their jobs, educational background, describe interesting projects they had been part of in their careers, what they found most rewarding about their careers, and answer questions from the students. Representatives from the medical products industry, aircraft industry, environmental regulatory agencies, mathematicians and scientists involved in the aerospace industry, along with computer scientists participated in this event, which was scheduled early in the program in an effort to energize participants and open up the world of career possibilities in engineering and science and realize how those professionals were engaged in solving important problems in the world. The feedback received from this particular session, including participant comments in journals (some of which are included below) indicated that the session was effective in meeting one of the overall goals of STEP UP—stimulating and nurturing interests in S & E careers.

Another change in the 2006 program based on evaluation of the 2005 camp was to utilize more and varied venues across campus. As discussed earlier, one of the goals of the camp was to give students a glimpse into the life of a college student. In adding more variety into the locations of activities, students had an opportunity to become familiar with the campus in general, locate resources they would need or want to utilize as college students (i.e. the library, computer labs, the financial aid office, and the recreation center), and developed a sense of what it would be like to maintain a fast-paced daily schedule of classes, project assignments, and the responsibilities associated with living independently.

The final morning of camp is devoted to presentation of each team's design challenge project in a design showcase, attended by parents and other relatives, faculty, staff, university administrators, professionals, and possibly corporate sponsors. Each team offers a presentation describing the challenges of the design project itself as well as any communications or personal team dynamics they faced throughout the project, strategies they developed for overcoming obstacles and difficulties, and project results. Teams are judged on the presentation as well as the results of the design project itself, and each member from the team with the highest score receives a college scholarship. An additional scholarship is also awarded to one individual who demonstrated outstanding individual achievement and leadership throughout the week.

Evaluation information was gathered through individual evaluations of each session, journaling and focus groups conducted by the NAU's Center for Science, Teaching and Learning. Assessment information indicated that the participants adamantly favored the all-female format and felt empowered to explore engineering in an all-girl environment. They also felt that being all-girls allowed them to bond better with one another and boys would interfere and could be a "distraction".

Parental and family influence was the main reason girls attended the camp. Also, several said that they wanted to explore engineering and get a feel for what different types of engineers do.

Camp participants interacted with women engineering professors and women in industry (some of whom were alumni). Camp participants were very engaged and liked those opportunities to interact with female professionals for two reasons: 1) exposure to women who are role models for them and 2) getting a feel for what the day-to-day work life of an engineer is like. One young woman commented, "I didn't know there was so much about engineering...it was inspiring that there were so many women..."¹⁹

The Design Challenge involving Legos was a strong motivator for the campers; they were unanimous about enjoying the chance to work on something "hands-on" and designing a project from start to finish. In general, sessions where they were able to manipulate, build or otherwise DO something were the ones that were most meaningful to them. Overall, assessment thus far indicates that STEP UP camp is serving its purpose as a motivational experience for these young women. Participants came in with either no or limited knowledge of engineering or with some understanding of what engineering is – but not a great understanding of the sub-disciplines of engineering. This year's campers felt that they gained a realistic sense of what an engineering profession entails and also gained a feel for what engineering as a major would be like. NAU engineering and science student assistants and counselors were instrumental in giving an engineering student perspective of the field and major.

Some memorable comments from STEP UP 2006 participants included:

"I didn't really know that there were so many engineering fields you could go into and now I have a new perspective of the world around me – like how everything is built precisely by people. It's really interesting."¹⁹

"Before I thought I could make money being an engineer, but now I'm more excited about it. Like after talking to the Gore lady I know what I want to do. *You can help people*. Now we've talked to these ladies and we know it can be done, we know what their life is like and it makes you want to go for it (emphasis added)."¹⁹

"It has erased any doubt I had. I've been thinking for a long time that I may want to be an engineer, but now I'm sure. All those doubts are gone now and I'm just going to do it."¹⁹

"You solve your own problems; you don't have teachers running up to you and telling you how to do it. You get to figure it out for yourself. There's different ways to do it. Like the Lego design project – it opens your mind a lot."¹⁹

From a participant who came both last year and this year:

"I didn't do well in my freshman and sophomore years in high school- I was kind of slacking. Then I went to STEP-UP camp last year and I raised my GPA six or seven (*tenths of a*) point(s) this past school year. I did a really good job in school and I think the camp had something to do with it. *I had an "I can" kind of attitude after being at camp*. I have more of a goal in mind (emphasis added)."¹⁹

Participation in STEP UP to date is as follows: 42 participants, 19 potential first-generation college students, 71% Native American, 19 graduating seniors have decided to major in engineering or science and 12 have applied to or been admitted to NAU.²⁰

Building upon our success with the STEP UP camp, we want to continue this positive outreach experience for potential women engineers by continuing to offer and enhancing the existing format of the camp. One of our goals is to make the STEP UP camp a platform for the recruitment of women into the engineering and science fields in general, rather than only for recruitment into NAU engineering programs. To that end, a longitudinal assessment is underway and is tracking participants' academic choices in high school, in college, and their professional choices as well. Participants answer questions about the types of science, math, and engineering courses they take, and the grades they receive in those courses. Additionally, the post-secondary academic choices each participant will answer questions, including the type of institution they select, the choice of major, any changes in the choice of major that occur, completion of the degree, and their career choices.

Planning is currently underway for STEP UP 2007, including marketing, recruitment and programming. We anticipate a rise in cost for programming, per student cost, supplies, and operations. We want to offer proven successful programming next year, such as the women's panel, the engineering industry seminars and the design challenge. Additionally, we would like to employ current NAU engineering and science students as student instructors and camp counselors. STEP UP camp takes a significant amount of effort and therefore support for the camp director, camp counselors, staff and faculty is also necessary. Although STEP UP camp is a successful endeavor, funds for scholarships for the winning design challenge team, promotional material or advertising and food costs (i.e. catered luncheon for women's panel, awards luncheon) are areas where monetary gifts were most needed and we anticipate will continue to be needed for STEP UP 2007.

Use of Relevant Examples for Multicontextual Learners—STEP UP

STEP UP offers an example of a pre-college program that uses relevant examples in teaching S & E concepts and connecting them to issues and communities of interest to women and Native Americans

Beyond those activities included in STEP UP, other successful models for using relevant examples to connect S & E with Native American communities exist. For example, Jane Mt. Pleasant offers one example of how traditional agricultural practices of many native peoples, known as the three sisters technique, can be useful in bridging the gap between western science and indigenous communities:

“Beans, because they are legumes, add nitrogen to the soil that the other two plants need. In other words, they add free fertilizer. The corn, in turn, provides physical support for the beans. The Iroquois used pole beans, and if you have ever grown them in your garden, you know you're supposed to put a pole in each one of those bean plants for it to twine up around. In this particular system, you do not need to add poles; the corn plant provides it as it grows. Now the squash

because it grows low to the ground and has very big leaves, reduces the ability of weeds to grow and interfere with the food crops. Finally, the three crops eaten together provide a very balanced diet of vitamins, minerals, carbohydrates, and the full complement of amino acids for protein.”²¹

“Natural sciences...can be used to engage Native youth and educational pursuits that have enormous relevance for Indian people. Understanding the science-based principles for resource management will allow Indian nations to effectively manage their own forest, fish, wildlife, and agricultural and mineral resources. On the other hand, understanding traditional Indian approaches to natural resources has value for both Native and non-Native people”²¹

Use of teaching examples and activities such as the one described are useful, as Mt. Pleasant notes, for making scientific knowledge accessible and relevant to indigenous youth, and in turn, stimulating or nurturing students’ interest in chemistry, agricultural science, or botany. Other examples where engineering and science intersect with native knowledge include the use of timber from hazardous fuel reduction in building traditional-design homes, such as Navajo hogans, and the engineering principles and techniques involved in such designs, and activities connecting mathematics and environmental science to basket weaving materials and designs utilized by traditional weavers. Several of those examples have been incorporated into STEP UP camps so far, and even more activities utilizing such examples are being developed for future camps.

The need for Native American scientists and engineers is clear. Many native communities face a range of environmental issues, from exposure to toxins that threaten human health, subsistence activities or the loss of medicinal plants used in traditional healing, threats of uncharacteristic high-intensity running crown fires (referred to by some as catastrophic wildfires) from public lands adjacent to Indian reservations. Some remote native communities still lack access to electricity, reliable safe water supplies, irrigation systems for gardens, and a wide disparity remains between native families’ access to the internet relative to other groups in the United States.^{22, 23, 24} As Thomas notes, engineers solve problems:

“Engineering needs to be integrated into some systems that will build individual Indian nations and the nation of Native America. Engineering to me is a building profession. It is a building discipline. I think we need to continue to try to get more of our people to be engineers is not enough. Engineering needs to be integrated into some whole, into a unifying vision, into systems of systems that will build individual nations and the nations of Native America.”²⁵

As Thomas points out, simply training Native Americans in science and engineering is not sufficient.²⁵ Integration of knowledge across disciplines as well as between indigenous knowledge and western knowledge is crucial. Gregory A. Cajete and others similarly advocate teaching activities and techniques which integrate scientific concepts and traditional knowledge.^{26, 27, 28}

In terms of Native American communities, there is an additional compelling reason to utilize pre-college outreach programs to increase the number of Native Americans in S & E fields. Indigenous nations continue to work towards self-determination for their peoples. As they do so, relying on engineering and scientific professionals from within their own tribes and their own communities who understand and can bring together unique cultural knowledge and practices is essential. Combining Indigenous scientific knowledge with western knowledge offers great promise for building capacity within tribes to resolve many of the issues in tribal communities described above, without introducing the conflict that can arise when those trained only in western science and engineering make decisions affecting native peoples. Building such capacity is a critical step for tribal communities in building true self-determination that is based on self-reliance, or as expressed by Gerald Alfred, “we help ourselves.”²⁹

Conclusion

In light of the state of women and minorities in S & E fields, and in particular, Native Americans the question arises, “Why should we care about women and minorities in S & E fields, when they clearly are making gains?” The most obvious answer to that question is we have to care about the entrance, exit and persistence of women and minorities in science and engineering disciplines because it simply is the “right thing to do” in a democratic society. Universities are a microcosm of society and when women and minorities benefit from gender equity in the S & E fields at the same rate or in excess of their male counterparts, society in general would be the beneficiary of a “just” democratic society.

And while some institutions remain stuck in the familiar rut of viewing minorities and women as tokens to represent diversity by numbers, such an approach to diversity does not embrace the true value of diversity but merely represents a superficial approach to the “problem” of under representation. In short, universities are missing the point. Diversity is no longer defined as simply physical attributes such as “skin color” or gender. This is where industry has taken the lead in embracing the true value of diversity, by moving the discussion to a broader scope that primarily focuses on “diversity of thought”.³⁰ “These forward-thinking industries are progressing far beyond basic recruiting, but are leveraging their diversity initiatives to achieve strategic advantages over the competition”.⁴ Industry then has begun not simply to accept diversity but to welcome it for the advantages it brings to their organizations- increasing creativity, generating better innovations and finding better solutions.^{4, 30} If the old adage that “two heads are better than one” is true, and companies seem to be saying that it is, then a diverse team of engineers and scientists bringing multiple knowledge contexts and approaches to solving problems can only result in a competitive advantage for their companies and benefits for society at large. “Celebrating diversity has evolved into an internal corporate campaign to improve workplace productivity by creating a culture of inclusion. Celebrating diversity means celebrating the difference among employees- and capitalizing on those differences to build a more productive corporation”.⁴ As illustrated, by numerous corporate organizations and their proactive development of internal diversity employee networks and other diversity initiatives, they are blazing a trail that universities have can follow.

Pre-college outreach programs particularly, residential S & E camps that focus on female and/or Native American students (or programs that see a high percentage of female or Native American

student participants) and which use non-traditional approaches to S & E education, can not only demystify S & E for young women--and in particular minority young women--but in turn can increase self-confidence in their abilities to succeed in those fields, nurtures their interest in applying engineering and science to solve important problems in the world. Consequently, such programs offer great promise not only for recruiting young women and minorities into S & E college programs but also for enhancing their possibilities for retention and their entrance into the S & E professions. However, these camps must utilize innovative pedagogical approaches such as those integrated in STEP UP by making the case for relevance of S & E in solving real world problems, and providing multiple opportunities for the participants to “see themselves” as the scientific and engineering professionals of tomorrow.

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