Women in Engineering Programs in the United States and Korea: Making Best Practices Even Better

Amy L. Freeman
The Pennsylvania State University

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Abstract

Women in Engineering Programs (WEPs) have assisted in increasing the numbers of women in technological fields in the United States (US) over the past 20 years. The most successful programs include several well recognized best practices. The author of this report was invited to The Republic of Korea to speak at this country's first *International Workshop for Women in Science and Engineering* to discuss the importance of continuing current proven program strategies as well as new strategies needed to ensure future success. Interestingly, "best practices" and how they are carried out are relative and subject to the norms of a given culture. It is difficult to compare successful practices across cultures. In this session, she will present the results of an assessment contrasting the cultural barriers and accomplishments involved in creating a national Women Into Engineering (WIE) Program in Korea. Some of these barriers include family acceptance of this occupation for daughters, how women engineering students are viewed, challenges with employers, and recruitment and retention remedies developed by WEP program there. The report will also review anticipated long term strategies and national policies required to sustain success both in Korea and in the United States.

Introduction

Current diversity issues in the U.S. regarding the technological inclusion of women (and other underrepresented groups) are based on world market competition. Globally, the need for engineers in the future exceeds the numbers produced by the U.S. currently. China and India produce five times more engineers at a higher education level and a lower wage than that demanded by U.S. engineers. Any other country aspiring to remain or become a primary holder of technological intellectual property in the world has two options: create more engineers from domestic means or import the more well educated and economically sensible international engineering workers and services. The push to become a primary player in the global economy has driven several countries to deliberately seek those previously left out of the domestic engineering equation. Among those typically left out are women who compose over half of the

global population. One country which is beginning to take extraordinary measures to increase its female engineering population is The Republic of Korea.

In September of 2007, The Penn State Women in Engineering program was visited by the Director of the Women Into Engineering (WIE) Program of Pukyong National University in Busan Korea, seeking to collect information about the best Women in Engineering Programs (WEP) programs in the U.S. When asked, the director stated that the Penn State WEP was targeted because it was honored by President George W. Bush with the 2003 Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring, and therefore was clearly a national model. Within a month of providing information about the process and the strategies used to increase the numbers of women in engineering in the U.S., Penn State was invited to share these strategies at Korea's first *International Workshop for Women in Science and Engineering* in Busan, Korea in November 2007. The purpose for this visit was to join other countries in providing Korea with information that would assist them in continued development of a national system women's engineering programs that would be effective in increasing the numbers of women in research, faculty positions and industry.

In Korea, the percentage of women receiving technical degrees are as follows: In science, women receive 48.8% of bachelors degrees, 38.8% of masters degrees and 23.3 % of doctorate degrees. In engineering, the numbers are lower with 19% receiving bachelors, 13.3% masters and 5.4% with doctorate degrees. Korea is looking for similar numbers in faculty, research and industry. To jump start this process, Korea enacted several laws with the aim of increasing the numbers of women in technical fields. Two are listed below:

1. 2001- "Framework Act on Science and Technology," legislated by the Ministry of Science and Technology. Outcomes resulted in the creation of a national Women in Science and Engineering (WISE) Program targeting girls and college students. Also, the Korea Science and Engineering Foundation was established and funded.
2. 2002- "Act on Fostering and Supporting Women Scientists, Engineers and Technologists," legislated through he Ministry of Science and Technology. This resulted in the "Recruitment Target System (RTS) for Female Faculty." RTS also applies to women in research at government supported research institutions.

The goals for increasing the numbers of women in faculty, and research is set for 25% over a 10 year time period from 2000 to 2010. In 2004, the figures for women in science and engineering government supported research institutions was at 14.0%, public and private academic institutions were at 16.8% while industry was at 9.6%. Current 2006 figures show the most change in government supported research institutions where figures climbed much faster than expected and some research institutes are already past the 30% mark. Overall, it is expected that the 25% goal should be achieved in the research area. Faculty figures are increasing more slowly, while industry remains relatively unchanged. Also, the figures for women in Science far exceed those for women in engineering. In the time that as passed, officials have benchmarked other countries that have been successful. One of the best practices utilized is the creation of engineering programming targeting women. These organizations have many names and venues under which they operate, but the underlying goal is to design programs that encourage women

to enter the field of engineering through outreach, recruitment and retention programming that targets girls and women from grade school through graduate school.

Terminology

For this report, the national system designed to begin outreach for women in technical fields in Korea is divided into three sectors: the Women in Science and Engineering Program (WISE) which targets pre-college girls; the Women Into Engineering (WIE) program which targets undergraduate women; the Women In Science and Technology (WIST) program which targets professional degree-holding women. For this report, the entire national system will be alluded to as the WIE system. In the U.S., this same system will be alluded to as WEP. Any allusions to "Korea" in this report always imply the Republic of Korea or South Korea, as it is commonly referred to in the U.S.

Limitations of Cultural Comparisons

This assessment is written to assume a readership from both eastern and western cultures. Consequently, broad descriptions of the US and Korean systems (in the sections that follow) are generalized allowing both reading audiences to see general differences between the working relationships that exist between government, universities and industry. In truth, both countries have very complex political structures that connect these entities internally. Since the author is from the US, comparisons between the two systems, are admittedly translated through a western lens.

The term "best practices" is commonly used in western professional settings to define a universal, generalized model that serves as a guide to others regarding how to proceed as a practitioner. In truth, actual best practices are relative and culture-specific. This document could also serve to demonstrate the difficulty and perhaps even the unintended inaccuracies in the interpretation of events that occur when making direct cross-cultural comparisons.

It is not the intention of this report to compare WEP systems of the US with the Korean WIE system in the sense that one or the other can be recognized as a perfect model. The purpose of this report is to assist all program practitioners in understanding that although most research on this topic is based on western models, it is not safe to assume that western models are universal solutions to fit all cultures. Instead, this author suggests that as non-western nations continue to diversify their technical workforces and share research in this area, the western model will be come one of many culture-specific models in the future, allowing all to benefit from new strategies in a broader forum.

U.S. Relationships: Government, University, Industry

In the U.S., government, industry and universities are separate systems. There is extensive funding of some universities by the government, such that public universities are defined as those which receive primary funding from the government. Private universities are those which are funded by private donors. Officials who are employed by a university are rarely simultaneously employed by the government for the same job. Universities are seen as autonomous entities. Industry does partner separately with universities providing funding for the research in that universities lend to the discovery process in product development. Aside from

universities, there are government research institutions also such as National Institutes of Health (NIH), the National Aeronautical and Space Agency (NASA) and others. Government research entities are not associated with producing products for profit. They serve the public need and address problems of national interest. However, national research institutions will utilize private goods and services from industry to fulfill its mission (such as NASA's contract with Boeing for the creation of rocket parts). Private corporations tend to be more creative in their solutions and problems they choose to address. Funding is less of an issue and there are few limitations on projects embarked upon.

Women in Engineering Programs (WEP) exist throughout the university system and are represented through a national organization, the Women in Engineering Program Advocates Network (WEPAN). The mission statement of a typical WEP in the U.S. would include the following:

- To ***provide access*** to the occupation of engineering for talented women
- To ***increase the percentage*** of women in Engineering universities
- To ***increase the numbers*** of professionals in the pipeline and in industry.

Industry recognizes the importance of including women and other underrepresented groups in engineering, and has associated diversity with higher profit margins. This is a result of the diversity of ideas and solutions that emerge when many viewpoints are involved in solving a problem. Consequently U.S. technical companies actively seek a diverse workforce and also incorporate diversity retention programming within the company to nurture this. Industry does provide some of the funding for many WEPs in an effort to have direct access to women engineers early in the employment recruitment process.

Korean Relationships: Government, University, Industry

In Korea, the national universities are funded by the government, and have more resources than private institutions. They also hold more prestige and are viewed as the model that private universities aspire to. Officials at national universities are often employed by the government, hence government officials are always available to carry out the national agenda regarding education. The Korean government sponsors national research institutes just as the US does. Private corporations provide little funding to the national university, and have expressed no desire to diversify its employment pool which is consists of primarily Korean males. This presents problems for degree-holding women engineers who are seeking employment with privately held companies. In Korea the numbers of women in science is higher than the numbers of women in engineering. Therefore, more effort is being put into the engineering sector.

Research Questions

From an assessment perspective, the primary research questions are:

1. When identifying best practices defined by the WEP programs of the US, how many are currently implemented through the emerging WIE system of Korea?

2. Which of these practices are not culturally transferable- or require modification for transfer?

The objective of this assessment is to identify strategic factors which will assist Korean WIE Programs in being effective in increasing the numbers of women in government and university research positions, in University faculty positions and in industry positions.

Literature Review

The primary literature regarding women in engineering is based on research and experiences in the US and other western countries. It is questionable whether this information is directly applicable to the cultural situation in Korea or other Asian countries. There are common problems although the solutions may not be the same in each country. At the *International Workshop for Women in Science and Engineering* in Korea, there were perspectives from other Asian countries regarding women in engineering in Japan, Indonesia and Korea (Hermawati 2007; E.K. Lee 2007; H. Lee 2007; Tsugawa 2007). These included funding issues, community and cultural barriers and program development. In a review of international achievement of women in science and engineering, van Langen, Boskers and Dekker (2006) ranked countries based on the gender empowerment index composed of three components: economic participation and decision making, political participation and decision making and power over economic resources. The index range is from 0 to 1 with the U.S. scoring a 0.78. Korea ranked lowest in this area with a 0.38, indicating cultural factors that may be attributed to cultural beliefs that ultimately prevent women from excelling in math and science.

Again, most of the literature regarding the typical WEP framework is based on the findings of western countries. Best practices for excellent WEPs and other retention programs are listed in the methodology. These include good funding, strong university support, inter active programming, good relationship building, continuing professional development for counselors, pipeline programming, networking with employers and the community, and long term planning. All of these elements assist dramatically in the successful retention programming for women in engineering (Cavanagh 2007; Holladay, Knight, Paige and Quinones 2003; Kahveci, Southerland and Gilmer 2006; Kezar 2000; Kleupfel 2000; Vogt, Hocevar and Haqedorn 2007). In addition to programming, the climate of the academic environment must be favorable to women. The classroom climate must also be favorable once students leave programming and structured environments (Persaud, Freeman, Salter and Yoder 2006).

While there is a wide rang of information supporting the best practices in the US, it is difficult to say if these are directly applicable to non-western countries.

Methodology

The population inferred by this assessment would be the Korean public and private university system, the National research system and the engineering employment industry of Korea. The sample would be those universities and research centers affected by the designated WIE programs initiated by the government. Several of these were represented at the International Conference.

Of the several assessment data collection instruments available, (interview, focus groups, surveys, questionnaires, observations and extant data) in this case, unstructured observation was the most appropriate in that the assessment took place during a formal visit to Korea. During this time, informal interaction was available through meetings with graduate and undergraduate students, professors, WIE directors, the Dean of Engineering at the Pukyong National University, and other women's program directors from Japan, Indonesia, Korea and the U.S. Though the term "interview" would be less appropriate, a wide range of information was garnered through these conversations.

The type of data analysis for this study would be more closely aligned to a strategic needs assessment in that internal and external factors are being evaluated in the success of achieving the goals (Gupta, 2007). Additional factors that categorize this analysis as a strategic needs assessment are as follows:

- Gaps are identified between the current situation and the targeted position sought.
- Performance needs are linked to the national strategy.
- There are performance improvement targets for the national, process and job levels.
- There are long term performance measures.
- Processes that do not add value are being identified.

Identified gaps are based on the best practices of the U.S. WEPs through this assessment. (Other countries represented at the conference provided best practices based on their experiences as well.) Performance goals are defined on the national strategy which begins by increasing the national numbers of women in university faculty and engineering research to 25% by 2010. The process for this is the newly established WIE system, the jobs or individualized work entailed the design of numerous programs for girls, college women, and professionals, that provide access to the industry. The long term measures include increase of women in research (where progress is being made), but also ultimately, increase of women in industry. Those processes that do not add value were identified in the conference and in several meetings.

There are several best practices that define successful WEP programs in the US. These have been consolidated in to five categories:

- **Strong institutional support**
- **A positive academic and professional climate for men and women<B>**
- **Pipeline programming from primary school through graduate school**
- **Continuous retention programming**
- **Community building and networking**

Each of these is described below and formatted into an assessment checklist. These are the US benchmarks that the Korean system will be measured by in this report. (Keep in mind that other countries provided similar information, making the overall assessment information received by the Korean hosts of the conference very broad.)

1. **Strong institutional support**
    - Resources to operate programs
        - Funding
        - Equipment
        - Talented people and time
        - Space
    - Institutional leadership members are vocal advocates of the Program
    - Institution lends credibility to those associated with the program or equity issues (volunteering faculty and staff)
2. **A positive academic and professional climate for men and women.**
    - Teaching and Learning
        - Context
        - Gendered language
        - Pedagogy (understanding how women learn)
    - Policies and Practices
        - Admissions, merit awards, placement
    - Methods of addressing complaints
    - Culture
3. **Pipeline programming from primary school through graduate school**
    - Outreach programming for students in transition
        - Grade school to high school
        - High school to college
        - Undergraduate to employment or graduate school
        - Graduate school to employment or faculty
    - Everyone learns, everyone teaches
4. **Continuous retention programming**
    - Academic collaborative learning (tutoring)
    - Professional development
    - Access to academic learning tools
    - Networking opportunities
    - Early warning systems for those having momentary problems
5. **Community building and networking**
    - Alleviation of isolation issues
    - Access to new areas of growth
    - Forums that provide resource information in a politically safe environment.
    - Provision of professional opportunities that might not typically be available without specific information.
    - Local, National, International Partnering with Industry
    - Membership/Sponsorship with National Organizations

Figure1. Listing of assessment measures based on best practices of WEPs in western countries

Assessment Results

Strong institutional support

It was clear that institutional support was strong and growing, in that the university and the government were directly tied together and working to fulfill this government mandate. At the international conference, the government was represented and reviewed the goals of the WIE programs, and the government's goal of increasing the number of women in engineering in government agencies to 25% by the 10 year milestone. National funding for this effort was increased from tens of millions to over one billion dollars. It was also clear that each of these programs were at various stages of development, some having completed more programs than others, and some with differing local challenges than others. Interestingly, the host of this author was the only male head of a WIE program. He alluded to this and said he was proud to be a supportive male to such a government initiative. He hoped to be a model for other men to follow, as they moved forward in building a better Korea. His institution is one of the most prominent of the national universities.

A positive academic and professional climate for men and women.

This was questionable. There were many women in the audience who expressed problems in this area. As one put it, "*Nice* girls don't do engineering." This comment was met with agreement across the room. While speaking to a group of students, I received a comment from a male professor, "Engineering has no gender: Therefore, it is impossible to make teaching allowances for women." Of course this was countered with a variety of techniques that make women (and all students) feel welcome and more likely to participate in classroom course proceedings, ultimately leading to higher retention rates for women in engineering (Persaud, Freeman, Saltar and Yoder 2006). Although this author was not in a position to get actual hard data for every college, there was extensive discussion at the conference regarding the chilly climate in the university as well as industry. (Some would venture that this was the primary reason for the conference.)

Pipeline programming from primary school through graduate school

The WIE system is divided as explained earlier to assist girls and women from grade school to professionals. At the conference, several programs were reviewed that seemed to address this. Although programs have begun, the challenge is very large. Some challenges may be indicative of Asian culture, while others are common globally. The presenter from Japan pointed out that surprisingly, her study showed that when asked, young students' parents did not have high expectations of their abilities in math and science. But even lower still were the expectations of their teachers. If the teachers are not encouraging girls to be engineers, there is an additional challenge (Tsugawa 2007).

Continuous retention programming

Retention programming is evolving. The climate is difficult, however, the presence of the WIE programming is helping. The international conference was a retention tool to which several women and men students were invited. Culturally, students were not invited to speak among elders, and were silent unless asked for input. This author did take the time to pose a public

question to the young male college students in the audience: Having attended the first conference of its kind, and having heard the issues that women face would they, as the next generation of men in power think differently regarding hiring women should they assume a position of power in industry in the next 10 to 20 years? The answer was a resounding YES! and was met with applause from the mostly female audience.

Community building and networking

This area seemed to present difficulty. Although the government and its entities were on board with the plan to increase the numbers of women in engineering, there seemed to be a problem getting private entities to concur. At the community level, the government struggles to get families to encourage their daughters to pursue engineering or technical fields. Several times it was said that once women received degrees, employers simply would not employ them. While at the conference, no partnerships with employers were reported. Industry was noticeably absent from the conference that focused on producing more employees for a growing field. There were a number of questions regarding the industry sponsored model programs at Penn State that featured employer support of internships and work experiences that target women. Most of these programs in the U.S. come through long term relationship building and the corporations understanding that diversity brings profits. It is difficult to say that the same relationship building techniques and corporate motivations apply in Korea.

Challenges and Limitations

Though the U.S. and Korea are both aiming for higher numbers of women in engineering, the methods for going about his are very different in many instances. Some of the best practices in the US will need to be altered for the use of another culture. In fact, there may be other completely different best practices that are effective for a non-western country. It is difficult to say what the politics are between government and industry in Korea, consequently, the suggestion that "they should talk more" or do more "relationship building" may have detrimental implications for the private company. While visiting, this author witnessed situations that might suggest that not only is it difficult to share information across gender lines, but also across generational lines. This poses a challenge when attempting to groom the next generation of both genders for the future.

Summary and Recommendations

The five best practices of successful WEPs in the US and detailed explanations of each were provided in a public forum as requested at the *International Workshop for Women in Science and Engineering* along with insights from around Korea and other countries. By western standards, the goal of increasing the number of women at universities, and in government research forums to 25% over a 10 year time period is ambitious to say the least. In the US, it has taken 50 years to get to the current levels which are still less than 25%. However, it was pointed out during a visit to the Busan Memorial Museum that in the last 60 years, the modern Korea that currently exists, supporting millions of people has only emerged from the dust of a war zone in just the last 60 years. The sense of patriotism is very high. This is a cultural difference in that the general

population appears more likely than westerners to do challenging things for the good of the nation, rather than the comfort of the self.

In the interest of cultural harmony, this author, as a guest of the Korean Government and Pukyong National University, was reluctant to be so presumptuous as to give recommendations to the government as to how to resolve this problem. Rather, she chose to present the US model, allowing the host to chose portions that might apply to given situations. All information in this report is based on a brief three day observation of a well orchestrated public forum. It is understood that in every venue, there is the underlying everyday truth that only those within the system can unravel. The conference took place because those within wanted external input to assist them in the implementation of new ideas to achieve their goals. This is to be commended. The long term goal is clearly to get women into industry. The government chose to begin by holding itself up as a model perhaps in hopes that industry will follow in the future. Only time will tell us if this strategy was the correct one.

Since this visit, another Korean delegation scheduled a visit to Penn State for February of 2008. Penn State WEP has suggested that additional visits that follow be coordinated with actual WEP events allowing the group to see programming in action, and to talk to US Penn State industry partners regarding their strategies for diversifying the workforce. Should Korea succeed in accomplishing this goal, it will be a model for other countries, especially those with similar cultural practices.

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Author Contact Information
afreeman@engr.psu.edu