Session 1692

Evaluating the Effectiveness of Gender Equity Training in Engineering Summer Workshops With Pre-College Teachers and Counselors

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Abstract

The WISE Investments (WI) Program is a three-year NSF project designed to encourage young women to pursue engineering and related careers. A major component of this grant is to provide two two-week summer professional development workshops that introduce middle school, high school, and community college teachers and guidance counselors to engineering. These educators are responsible for integrating what they have learned in the engineering workshops by using related activities in their mathematics and science curricula. The counselors include applied math and science in their career counseling and implement an outreach program to encourage students to consider a major in engineering.

The engineering workshops have provided instruction to 90 pre-college educators from the local community colleges, middle schools**,** and high schools. To evaluate the short-term effectiveness of the professional development workshops, assessment instruments were used to provide feedback and strengthen instruction. One part of this formative process included an objective measure related to gender equity.

The educators were asked to complete a questionnaire prior to the workshop to assess their understanding of gender issues in engineering, science, mathematics, and technology. The same instrument was administered after completing eight engineering labs. The paper will present a comparison of the summer 1999 and summer 2000 data to illustrate the need for gender equity programs in the middle schools, high schools, and community colleges.

I. Introduction

The term *gender equity* refers to eliminating sex-role stereotyping and sex bias from the classroom setting and instructional practices. It is used to signal efforts to broaden equal opportunities in an environment that empowers all students to follow through on their personal careers and life choices.[1] Despite the efforts to pass Title IX in 1972, there is evidence that society continues to hold different expectations for women and men.[2] Only 44% of the students majoring in engineering their freshman year remain in engineering their senior year and only

18.7% of the 1997 bachelor degrees in engineering were awarded to women. Only 2.4% of the women with bachelor degrees in engineering were minority women. [3]

The historical and social context of key problems associated with equal educational achievement in pre-college education was discussed in a three-year study conducted in elementary and secondary classrooms in four states on teacher interaction patterns with their students.[4] Some of the findings indicated that teachers interacted more with male students; boys were more likely to call out answers; minority females were asked the fewest number of questions; and the same patterns of interaction were observed among teachers regardless of the teachers' gender and ethnicity. Several ideas for organizing the classroom and questioning strategies to eliminate bias associated with academic achievement involve providing opportunities that allow all students to participate in the learning process; providing adequate wait time before and after students respond; implementing integrated seat patterns; monitoring group learning for equitable patterns of interaction; and checking displays and curriculum materials for an equitable classroom environment.[5]

Research suggested that middle school is a crucial intervention point for encouraging students to pursue math and science related fields. Between sixth to twelfth grade, there is an overall decline in both male and female students who show interest in math.[6] Students reported that math became more difficult and produced anxiety over time. They reported receiving less support to study math from parents, teachers, and peers. Even though math achievement was approximately equal for female and male students, female students reported that math was more difficult. Female students rated themselves as more anxious in situations related to the measurement. As early as the seventh grade, girls showed less interest in math while boys planned to study math more. High school girls viewed math as less valuable than boys do.[7] Research also indicated the factors that keep minorities from entering SMET are the same as those responsible for the under representation of women.[8]

Studies of science and math classrooms have found that teachers interact differently with gender, which resulted in more contact and more critical feedback for male students.[9]
Another study found that teachers were concerned about gender inequity, but they did not understand the possible causes. These teachers had no prior knowledge of an equity conscious curriculum.[10] Some of them felt that attempts to solve the problems of gender inequity were another form of reverse discrimination.[11]

The National Science Foundation (NSF) has funded over 100 projects since 1993 to increase access for girls and women in science, mathematics, engineering and technology (SMET). The 1999 Summary Report on the Impact Study of the NSF Program for Women and Girls cited "knowledge capital" as one of the primary contributions to developing and using engineering, science, mathematics and technology. [12]

The Women in Applied Sciences and Engineering (WISE) Program was established at Arizona State University (ASU) in 1993 under the College of Engineering and Applied Sciences (CEAS).[13] The mission of the WISE program is to recruit, retain and graduate female students in engineering and the applied sciences through several outreach programs. The CEAS Associate Dean of Student Affairs administers these services. To leverage the recruitment of young women, WISE determined that partnerships with the local industries, school districts, science teachers, math teachers, and counselors were necessary. With these ideas, the WISE Investments (WI) program was created with funding from the National Science Foundation. It offers pre-college teachers an introduction to eight engineering disciplines. WI provides staff development for problem solving techniques used in engineering; assists educators in creating socially inclusive engineering applications for their math and science classrooms; and provides the teachers and counselors with experience and knowledge of what engineers do. It helps teachers and counselors to develop an understanding of the skills and academic support needed for students to consider a college degree and a career in engineering and other related occupations.

The Accreditation Board for Engineering and Technology defined engineering as *the profession in which knowledge of the mathematical and natural sciences, gained by study, experience, and practice, is applied with judgment to develop ways to use, economically, the materials and forces of nature for the benefit of mankind.*[14] WI was designed to attract women and underrepresented populations by integrating engineering concepts into math and science curricula by demonstrating applications to solve real problems. One study found that young women are particularly drawn to careers that promote well being for society.[15]

Generally middle school and high school math and science teachers do not include engineering and its benefits in their classroom activities, because few of them have had engineering education. WI is committed to the professional development of pre-college math and science teachers by offering summer workshops and internships in engineering. Since 1998 WI has had a total of seventy-one middle school and high school teachers and counselors participate in its engineering staff development**.** In 1999 and 2000 a total of 19 community college faculty were included. On the average, each teacher has an annual load of five classes with an enrollment of twenty students. Student surveys have documented their improved interest in engineering by the content offered in their math and science classrooms. As the number of participants increases, the knowledge and application of engineering should increase exponentially.

This paper describes the WI program and its goals. The gender equity instruments used with the teachers and counselors will be presented with the raw scores and a data analysis. In addition, examples of feedback from surveys and focus groups will be given.

This paper is divided into six parts. Part II gives a description of the program. Part III provides a comprehensive description of the special sessions on gender equity. The instruments used to assess the participants' understanding of gender equity are the focus of Part IV. The outcomes from the pre- and post-tests are described in Part V and Part VI is a discussion on the data analysis. Part VII gives the conclusion of the paper and future plans.

II. Program Description

The WI program is the result of collaboration between the ASU CEAS, ASU College of Education, six school districts, three community colleges, and eight industry partners. At the heart of this collaboration are the engineering faculty members who educate a different group of participants each year. ASU's engineering faculty provide labs on basic information and applied activities from eight engineering disciplines: aerospace, bioengineering, chemical, civil/environmental, electrical, industrial, materials and computer science/engineering. The Departments of Counseling Education and Curriculum/Instruction offer lectures and support for academic and career advisement as well as instructional strategies for integrating engineering applications into math and science curricula. The workshop participants included middle school and high school teachers and counselors and community college faculty. Following the summer workshops, a special nine-month program was included for middle school and high school female students. The industry partners offered tours, internships, and a mentoring program with professional engineers. The WI program held different activities for each of the participating groups.

The component for teachers and counselors included a summer workshop, a Saturday Academy, follow-up sessions, and industry tours, internships, and mentoring. A two-week engineering workshop was provided for the teachers and a one-week workshop was implemented for counselors. The CEAS faculty were responsible for developing a four-hour lab that was tailored for pre-college instruction and promoting gender equity. The goals for the teachers were to familiarize them with the concepts and applications of engineering; to inform them about issues facing women interested in math, science and engineering; to help them create a gender inclusive classroom; and to provide relevance to classroom math and science. The goals for the counselors were to provide an introduction to engineering; to provide information about obstacles facing young women interested in math, science, and engineering; and to prepare them to encourage young women to enroll in advanced math and science courses to explore careers in engineering and related occupations. Math and science teachers formed teams for special presentations to middle school and high school girls in Saturday Academies held during the next academic year. Two follow-up sessions included a network of support for teachers and counselors. Industry tours were scheduled during the two-week workshops. An optional one-week internship was also offered.

Another WI program component is for middle and high school girls. The girls attend eight Saturday Academies, three industry tours, and five mentoring sessions. During the Saturday Academies, the girls benefited from teacher training in engineering and gender equity strategies.

An assessment was administered to evaluate the effectiveness of the staff development workshops for the pre-college teachers and counselors. Part one of the assessments was a pre-program questionnaire used to measure the program effect on perceptions of engineering. The participants were asked open-ended questions before and after the workshops related to their understanding of engineering and the content of the eight engineering disciplines. Part two of the assessment was a true/false questionnaire related to gender equity. The same instrument was used before and after the workshop. The questionnaires and the outcomes related to gender are the primary focus of this paper.

III. Gender Equity Session

Gender equity is a major focus of WI. The sessions were designed to support the need for change in education as well as the academic and professional climate to increase the involvement of women in science, math, and engineering. The intent was to develop the educator's awareness of the interests, needs, and potential of girls and women; and to promote instructional materials and teaching methods for advancing the interest, retention, and achievement of girls and women in science, math, and engineering.[16] An ASU faculty member from the College of Education (COE), whose primary research focuses on issues of gender, science, and science teaching, conducted this session. The engineering faculty also included information on gender equity in each of their workshops.

The professor from the COE focused primarily on appropriate pedagogy and curriculum materials for the gender-inclusive classroom. Participants explored and critiqued websites for equity resources. Middle school educators were given additional information on the differential treatment of girls and boys in mathematics. Discussions offered more on the current literature on the causes and correlation of girls learning to dislike mathematics and as a result, choose careers that are not math intensive. Another approach to this session included a presentation on the biographies of women and minority scientists, as well as information on their inventions and discoveries. Examples of units and lessons that promote equity in the classroom were made available.

The first gender equity session during the summer 2000 was held for two hours in the late afternoon on the first day of the workshops. Two other sessions were held later in the week to include a total of nine hours. The sessions included cooperative learning groups that involved learning the difference between *equity and equality*. A part of the session was devoted to reviewing a true/false questionnaire on issues of gender in the classroom and the workplace. The instructor explained the questions as part of the published literature. The final session gave the participants an opportunity to select published materials on gender equity and diversity in the classroom. The educators worked in teams to evaluate the materials.

IV. Instruments Used to Assess The Understanding of Gender Equity

The first questionnaire on gender communication patterns included a total of eighteen true or false responses focusing on school issues. This questionnaire was used during the initial workshops under this proposal in 1999. A total of twenty-eight pre-college educators participated in this thirty-minute assessment before the orientation. The same instrument was given after the gender equity training.

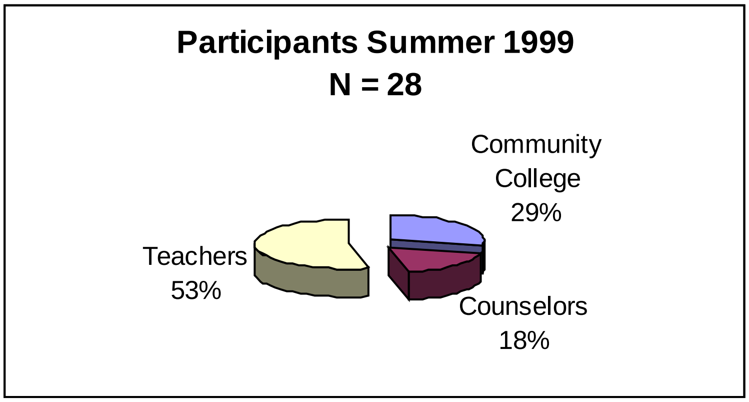

Figure 1. Distribution of Participants in Summer 1999

The instructions required the participants to consider a *generally accurate description* as a true statement. The answer key identified *generally accurate descriptions* in items 1, 3, 4, 7, 8, 10, 15, 17, and 18. The questionnaire is given below.

True/False (18)

True/False

		1.	Men are more likely to interrupt women than they are to interrupt other men.
		2.	When people hear generic words such as “mankind” and “he,” they respond inclusively, indicating that the terms apply to both sexes.
		3.	When a male speaks, he is listened to more carefully than a female speaker is, even when she makes the identical presentation.
		4.	In general, women speak in a more tentative style than do men.
		5.	Women are more likely to answer questions that are not addressed to them.
		6.	Teachers are more likely to give verbal praise to females than to male students.
		7.	Providing “wait time” after asking a question before having students raise their hands is a strategy that increases the participation of female students.
		8.	Using cooperative learning techniques helps girls to become engaged in math and science classes.
		9.	Boys, more so than girls, tend to learn better when what they are learning is put into a real-world context.
		10.	Girls learn better when they understand the people-side of what they are learning (E.g., who developed it, who uses it, how does it help people).
		11.	Nationally, girls do about as well or better in ***math*** as boys do during ***middle school***.
		12.	Nationally, girls do about as well or better in ***math*** as boys do during ***high school***.
		13.	Nationally, girls do about as well or better in ***science*** as boys do during ***middle school***.
		14.	Nationally, girls do about as well or better in ***science*** as boys do during ***high school.***
		15.	Women who enter fields such as engineering tend to be mentored by a family member, teacher or counselor.
		16.	Students who enter fields such as engineering must possess superb math and science skills.

		17.	Women tend to enter science careers in order to help people, animals or the environment.
		18.	Less than 10% of the United States engineering workforce are women.

Table 1. Pre-Post Gender Equity Questionnaire used in summer 1999

A second questionnaire was developed for the workshop held in the summer 2000. The assessment was changed to include more information on *gender equity* in the workplace. Twenty-five true or false questions were used. Participants were given thirty minutes to complete the assessment. A total of forty-four pre-college educators participated in the assessment before the orientation and after the treatment.

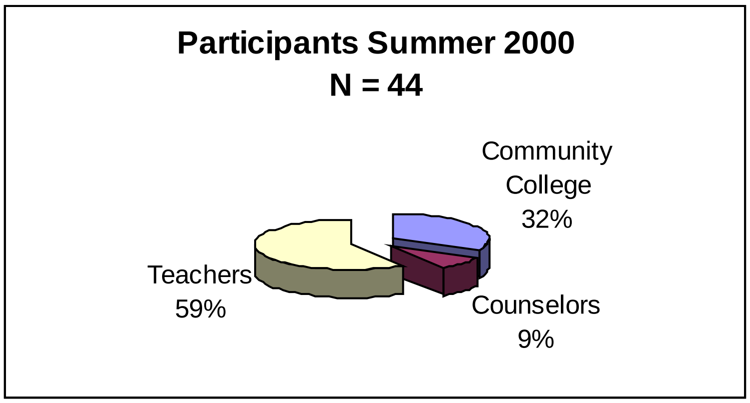

Figure 2. Distribution of Participants in Summer 2000

The instructions required the participants to answer true or false to the *gender equity information*. The answer key identified items 1, 2, 5, 6, 9, 10, 12, 15, 16, 17, and 19 as true.

True/False (25)

True/False

		1.	African American girls have more positive attitudes toward science than Anglo and Hispanic girls and boys and African American boys.
		2.	Girls have negative attitudes towards school science but like science in general.
		3.	Once women obtain a degree in science they remain in science at higher rates than men do.
		4.	Single-sex classes for math and science lead to higher achievement for girls.
		5.	Minority girls are the only group that benefits from single-sex classes in math and science.
		6.	Males take more mathematics than females regardless of ethnicity.

		7.	When females take the same number of math and science courses in high school as males and do as well, they are just as likely to choose a science career as males.
		8.	Teachers say that their favorite students in math or science class are bright African American females.
		9.	According to the National Assessment of Educational Progress (NAEP) Hispanic students performed better in science than African American students ages 9, 13 and 17.
		10.	Girls choose a career in science if they can see themselves helping people, animals or the environment.
		11.	A poor self-concept contributes to the low number of African Americans in science and math.
		12.	Minority students (African American, Hispanic, Native American) who attend affluent schools are as uninterested in math and science as minority students who attend poor schools.
		13.	Racial or ethnic prejudice has a greater effect on a minority female's success in math and science than gender.
		14.	Interventions are as successful in changing girls' negative perceptions of women in science as they are in changing boys' negative perceptions of women in science.
		15.	Hispanic Americans earn more bachelors degrees in computer science, engineering, math and physics than African Americans and Native Americans combined.
		16.	The leadership and communication style of women is different from men and seen as less effective in the world of business and industry.
		17.	Male and female students drop out of engineering majors as the same rate (42%).
		18.	Women who reach the upper level of science and engineering careers drop out at a lower rate than men do.
		19.	Children and family obligations interfere with career advancement for women in the workplace.
		20.	Women scientists and engineers with a Ph.D. have low rates of unemployment.
		21.	There are large differences in male and female mathematics and spatial ability.
		22.	Differences in male and female mathematics and spatial ability, favoring male students, explain why there are fewer women in science and engineering.
		23.	Computer games are getting girls interested in technology.
		24.	Women who delay or interrupt careers in science and engineering are likely to be unemployed or employed part-time in the future.

		25.	In general, female and male scientists and engineers employed in similar positions in business, industry and academia receive the same pay.

Table 2. Pre/Post Gender Equity Questionnaire Used in Summer 2000.

V. Outcomes

StatGraphics was the software program used for the statistical analysis to measure the significant differences between the paired data. The test used in 1999 was administered to the first cohort of educators. It contained eighteen items. The test used in 2000 was given to a different cohort. It contained twenty-five items. An analysis of raw scores was used for the participants that completed both the pre- and post- tests. There were three sample populations for each test**.**

The statistical analysis included a hypothesis testing procedure used to examine significant differences between two data samples where the data were collected in pairs. A paired t-test of the null hypothesis determined whether the mean of the pre-test and the post-test was equal to 0.0 versus the alternative hypothesis that the mean of the pre-test and the post-test was not equal to 0.0. If the P-Value for the group test was less than 0.05, the null hypothesis was rejected at the 95% confidence level.

Below are the charts of the raw scores from the instruments used in 1999 and 2000. The scores were listed by categories in the three groups: community college faculty, middle/high school counselors, and middle/high school teachers. A sample mean, a P-value, and a statement on the validity of the hypothesis statement are included for each of the three groups.

Table 3 shows that in most cases the number of correct answers given by the participants on the gender equity questionnaire increased after the two-week training. However, the P-value of .15798 in the case of the community college teachers says that there is a 15% chance that there really was no increae in their gender equity knowledge as measured by the questionnaire. The improvement was greatest for the counselors where there is less than a 5% change that there was no change in their gender equity knowledge. The sample mean of -2.75 for the counselors means that on average each participant increased their score by nearly three more correct answers.

Table 4 shows that in only one case of a community college teacher and in only one case of a middle school or high school teacher did the participant not show an increase in the number of correct answers on the gender equity questionnaire given in summer 2000. On average, the middle school and high school teachers scored over eight (8) more correct answers at the end of the two-week workshop than at the beginning on the pre-test. Statistically, each group showed an improvement in their gender equity knowledge at the 0%, 2%, and 0% levels of confidence for the three groups of participants. This means, for example, that there is only a 2% chance that the counselors did not really improve their gender equity knowledge as shown on the post-test, and just by chance happened to score better on the post-test with no real improvement in knowledge.

Participants	Community College		Counselors		Teachers	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
	10	13	12	14	13	15
	10	12	13	14	15	16
	12	12	9	14	6	11
	11	11	10	13	10	14
	9	8			16	13
	12	15			11	16
					12	16
					7	12
					15	11
					11	13
					17	14
					15	16
					13	12
					14	17
					15	16
Sample Mean Difference	**-1.16667**		**-2.75**		**-1.46667**	
P-Value	**0.15798**		**0.0485668**		**0.0831282**	
Hypothesis	**Cannot reject the null.**		**Reject the null.**		**Cannot reject the null.**	

Table 3. Pre/Post Results of Gender Equity Questionnaire Summer 1999
(Number of correct answers on 18-point questionnaire.)

Part VI. Discussion

The 2000 cohort of educators performed significantly better than the 1999 cohort. Their percentage of correct answers on the post-test was significantly higher. Their improvement in scores from pre to post was also noticeably larger. One explanation for their performance is given in the Summer 2000 Evaluation Report.[17] A survey of the 2000 cohort of educators was used to determine exposure to gender equity training prior to the workshop. The participants were asked to respond to their level of exposure from novice (0-4 hours), intermediate (5-10 hours), or advanced (11-100 hours) training. Thirty-eight of the participants responded. Thirteen were community college faculty and twenty-five were teachers. The community college faculty had the following response: ten novice, one intermediate and two advanced trainees. The teachers had fourteen novice, seven intermediate, and four advanced trainees. Unfortunately, since this survey of prior gender equity training was not given to the 1999 cohort of educators, WI can not determine their levels of prior exposure to gender equity training to compare against the 2000 cohort of educators.

Participants	Community College		Counselors		Teachers	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
	17	21	16	21	16	23
	18	21	11	19	12	21
	17	20	17	24	15	22
	10	18			13	20
	13	19			12	24
	15	13			19	24
	15	20			13	9
	16	21			14	24
	12	14			12	17
	11	14			13	20
	14	19			10	24
	14	20			13	22
					10	21
					14	24
					15	24
					11	22
					11	19
					13	19
					13	22
					13	17
					11	23
					13	16
					11	24
					10	22
Sample Mean Difference	**-4**		**-6.66667**		**-8.16667**	
P-Value	**0.000188253**		**0.0170536**		**.0000000**	
Hypothesis	**Reject the null.**		**Reject the null.**		**Reject the null.**	

Table 4. Pre/Post Results of Summer 2000 Gender Equity Questionnaire (Number of correct answers on a 25-point questionnaire.)

Another explanation gives consideration for the time allotted to the gender equity sessions. These special sessions were held throughout the two-week workshop in 2000. In 1999 there was only a one-day session. The distribution of information throughout the workshops in 2000 allowed for reflection and integration. In addition, the 2000 cohort reviewed and discussed each of the questions after their initial orientation.

Since the 2000 survey was an expanded version of the 1999 survey, a direct comparison of the effects of the gender equity training cannot be done. It is possible that the survey results reflect an improvement in the delivery of the gender equity material by the instructor as well as increased time exposure.

There were no perfect scores in any of the six testing sessions. It was assumed that the participants did not study for the test. They relied on their memory from the special sessions and interaction during the eight engineering labs.

The survey of the workshop participants questioned whether several items related to gender should be included in the workshop presentation. The groups responded overwhelmingly to including *procedures that create gender equality in the classroom*. The community college faculty was also interested in research, data, and examples. The teachers were interested in resources that highlighted the contributions of women in science and math.

The following statements were selected comments from a focus group on the gender equity sessions:[18]

- What was your perception of the sessions on gender equity?
  I really enjoyed it. I had looked forward to the workshop. I learned a lot of new information that I had not been exposed to. I went through it as an exercise personally and professionally. I thought it was very good.

- What would you change about the gender equity training?
  I think balance is the key. You can go over board with statistics. The statistics may not apply to my classroom.

- What would you recommend for the gender equity session?
  It is application that is lacking. I think having women engineers come into the classroom is best. I was looking for more ways to get women and minorities into engineering or into math.

VII. Conclusion and Future Plans

The WI program is committed to continuous improvement. As part of WI's assessment and evaluation, the Office of University Evaluation (OUE) has been utilized to conduct focus groups and observations of workshop labs and gender equity sessions. Through evaluation reports, OUE has been very supportive in providing feedback and recommendations for adjustments to the WI program. These recommendations have been accepted and several aspects of the program changed. As is the case with middle school high and high school programs, the effects of the efforts of this program will not be known until the students involved are at college age. Even then the tracking of the reasons for career decisions is very difficult to determine.

As we expand our recruitment efforts to the elementary schools, it is expected that we will also expand WISE Investments to include elementary school teachers, as funding allows. Research and our experience tell us that programs such as the one described in this paper are necessary if the interest in engineering and related fields is to be increased among entering college freshmen. Through our collaboration with OUE, WI continues to enhance its efforts in training pre-college educators in engineering and gender equity.

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