EVALUATING THE BROADER IMPACT OF THE WISE INVESTMENTS SUMMER INSTITUTE FOR K-12 EDUCATORS

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Abstract - The Women in Applied Sciences and Engineering (WISE) Investments program is a comprehensive program that introduces middle school and high school teachers, counselors, and students to the exciting and challenging field of engineering and technology. The goal of the WISE Investments (WI) program is to encourage women to pursue a career in engineering and computer science. The WI program begins with a two-week summer institute to educate the teachers on how to integrate engineering and technology into K-12 math and science curriculum. Counselors attend the summer institute to learn about engineering and computer science to counsel students in these areas. After attending the WI training, teacher and counselor teams are formed to present a particular engineering discipline to middle school and high school girls at the WI Saturday Academies held during the school year. The paper reports on the broader impact of teachers who attended the WI summer institute. An external program evaluator has evaluated the WI project for all four years of the program.

Index Terms – Professional Development, Engineering in K-12, Middle School and High School Teachers, Assessment

INTRODUCTION

The Women in Applied Sciences and Engineering (WISE) Investments program is a comprehensive program that introduces middle school and high school teachers, counselors, and students to the exciting and challenging field of engineering and technology. During the first two years of the program, community college teachers were also included in the project. A pilot program was run the first year. Then the program was funded by National Science Foundation grant HRD 98 72818 for three years, but was offered for a fourth year on a no-cost extension. A total of 109 teachers and counselors have gone through the WI summer institute.

WI was the product of many collaborators. [1] It would have not been successful if it had not had strong support from many areas. Although the WI staff has changed considerably over the four years, the staff has always been passionate and committed to the program. Both the College of Engineering and the College of Education were involved. Engineering professors were key in giving hands-on workshops in their engineering area. The professors were also available as a consultant during the next academic year as the teachers and counselors prepared for the Saturday Academies. A professor in Education with an expertise in gender equity has strengthened the program directly and through education doctoral students who have taken her courses. Another education professor provided insights to the counselors for encouraging girls in math and science. Through an Erudicio Project, in the pilot year of the project, each teacher (10) without Internet hook-up at their school received a computer equipped with a modem and Internet access, on-line support, and in-person and on-line instruction. Unfortunately we were not able to continue this partnership after the pilot year. School district administrators have been an integral part of the program, especially the development in the pilot year, and in encouraging and supporting their teachers and counselors to attend as the program continued. Collaborating industries provided internships, guest speakers, financial support for participant lunches and the end-of-the-year banquets. [1]

The goal of the WISE Investments (WI) program is to encourage women to pursue a career in engineering and computer science. The WI program begins with a two-week summer institute to educate middle school and high school teachers on how to integrate engineering and technology into K-12 math and science curriculum. Counselors attend the summer institute to learn about engineering and computer science to counsel students in these areas. Gender equity training is included in the institute to help the teachers make their classrooms supportive and encouraging of the girls in their classes. [3]

After attending the WI training, teacher and counselor teams are formed to present a particular engineering discipline to middle school and high school girls at the WI Saturday Academies held during the school year. There are eight Saturday Academies that provide information and hands-on experiences in the following fields of engineering: aerospace, biomedical, chemical, civil, computer science, electrical, industrial, and material science. The sessions are held from 9 am to noon and are sometimes followed with pizza mentoring parties with engineering college women. There are two follow-up sessions to provide assistance and

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support to the teachers in developing lesson modules with engineering applications. [4] An optional summer internship opportunity was available for the teachers and counselors after the institute, [5] as well as two follow-up sessions held in the following academic year.

Program success can be measured in a number of ways. One method that we have used is to compare the general information and attitudes that the teachers and counselors had about engineering before the program to after the program. We have reported on attitudinal changes that we tested and observed. [6], [7]

This paper reports on the broader impact of teachers who attended the WI summer institute. Much of the evaluation reported in this paper has been done in a qualitative fashion through an external program evaluator.

**The Theory-Driven Qualitative Evaluation**

An evaluator, external to the program, has evaluated the WI program since its inception. The evaluator used a research-based inquiry process that aims to provide assistance to decision-makers. External evaluators are brought in to decrease bias and subjectivity. The evaluator performed a Theory-Driven Qualitative Evaluation for each year of the four years of the program. A Theory-Driven Qualitative Evaluation (TDE) uses the program theory as its starting point. Program theory is defined as the way the program plans to address a “problem,” the activities it uses to “treat” the problem, and the outcomes it hopes to obtain. [8]

In this case, the “problem” is the small percentage of women who choose engineering as a career. Based on research and experience, WISE Investments theorizes that this is in part because pre-college women may encounter less information about engineering than do young males. This is especially true in Arizona where engineering courses do not count as a science credit and pre-college girls have little or no exposure to engineering information in middle or high school. Additionally, middle and high school girls are less likely to see engineering as a helping profession – another instance of information lack.

Program activities, therefore, “treat” this problem by attempting to increase the amount of information available to students in the classroom. Holding engineering workshops for middle and high school math and science teachers, who then are required to pass on the information to their classes, increases information. The workshops are part of a comprehensive program that demonstrates engineering as a helping profession, provides gender equity training, and draws connections between engineering and the State of Arizona science and mathematics teaching standards. [9]

The expected program outcomes that relate to teachers include:

- Infusing engineering information and activities into pre-college math and science classrooms;
- A hands-on introduction to engineering;
- Providing relevance to classroom math and science;
- Providing teachers and counselors with better understanding of the issues facing women in math and science contexts;
- Assisting teachers to create a gender-inclusive classroom/teaching environment; and
- Improving pre-college advising for pre-college women about engineering.

The theory of the program and its expected outcomes are then compared to the actual results of the activities as shown by the evaluation. To make the comparison, an evaluator looks at the way the program is implemented, at its activities, and at its outcomes, strengths, and weaknesses.

The results reported in the evaluation section of this paper concentrate on the evaluation of the middle school and high school teacher participants. The results of the evaluation are formative, summative, and cumulative. That is, evaluations helped provide information to improve an ongoing program (formative), helped determine some outcomes of the program each year (summative), and accumulated information across the four years of the program (cumulative). This type of evaluation can provide decision-makers with information about how well the program is performing, the strongest elements of the program, how the process could improve, how changes in personnel and activities affect the program, unnecessary program components, and unanticipated benefits. [10]

The data collection instruments in this particular evaluation are qualitative. The two primary instruments are ethnographic observations and focus group interviews. Focus groups can be particularly important in developing a picture of the program from the participant’s perspective. In addition to the qualitative data collection measures discussed below, the evaluation incorporated two quantitative instruments: 1) a Likert scale question that asked participants to rate the extent to which the program met its goals; and 2) an Absorptive Capacity Index which measures the extent to which a participant understands, has absorbed, and can utilize new knowledge. [11], [12]

In each instrument, the goals of the program and its intended outcomes form hypotheses to be tested. Having multiple data collection methods permits an evaluator to “triangulate” data. That is, each data source provides a check on the biases of other instruments. Together the sources form a more complete picture of the program being evaluated. In qualitative terminology, this is called “authenticity” and is a parallel form of reliability and validity checks. [13], [14]
Ethnographic Observations

Observations of elements in a program are one in a series of measures used in qualitative research. The observations take place in a natural setting. Observers are usually not associated with the program and are there to learn more about the program operations, relationships among stakeholders, and the ways the program sets about meeting its objectives. [15]

Observations of the teacher portion of the program have included summer engineering workshops, gender equity sessions, orientation and information sessions, and both the Fall and Spring Follow-Up Sessions each year for the past four years. Observations are structured and focused according to a systematic guide to elements associated with WI program objectives. [12]. An Observation Checklist includes the behavior of participants, faculty, and program staff as well as organizational elements such as registration, timing of activities, and interest of activities to students.

Each of the observations contributes to the knowledge base about outcomes of the program and each may provide additional material for focus groups or other aspects of the evaluation.

Focus Group Interviewing

Focus groups are a major data collection instrument. The purpose of a focus group is to elicit feelings, perceptions, and ways of thinking in a relatively natural environment. The permissive and nonjudgmental environment tends to encourage self-disclosure and increase participant candor. Questions are usually open-ended and the moderator has an opportunity to probe participant responses.

Information is elicited about the extent to which the program is meeting its stated goals, the strongest elements of the program, and suggestions for improvement. Participants also are asked whether there is any change in their behavior or interests since starting the program. These might include an increased interest in science or engineering programs on television or more awareness of engineering connections to everyday events.

For the past four years, participants have given their candid opinions about the success of the program and about elements that have not impacted them positively.

In addition to the focus groups that are held at the end of the two-week summer workshops, an end-of-year focus group is held at the WI Spring Follow-Up Session. This final focus group is held to determine whether and how participants have incorporated engineering materials and activities into their math and science classrooms.

RESULTS OF THE EVALUATION

Results from all data collection sources for the past four years indicate that the summer workshops are the strongest element in the program. The workshops were fully implemented the first year and adapted and improved each year thereafter. The value of the workshops is magnified because only three of the 109 middle school or high school teachers had any engineering education prior to WI. Because of their lack of information about engineering, the teachers had not been including any engineering information in their science or mathematics classrooms.

As the evaluation progressed, it began to appear that WI was becoming like a pebble in a pool that sends out ripples beyond its immediate impact. Participants saw connections to engineering that they hadn’t seen before and used these connections in their classroom. The following are some comments that have been made by participants over the years:

- I see it as a problem of visibility and competition. Engineering is completing with other science and non-science majors for students. But [because engineering is not taught in the classroom] engineering has been pretty much invisible to these students over the years.
- We have eight science teachers on campus and I have photocopied everything I’ve gotten for them. Half of them are women and it has encouraged these women, some of whom have Master’s degrees … to improve their level of teaching. They could see that students could grasp more – it isn’t just those few straight A boys.
- I had always thought of engineering as like this honors science. This year I have incorporated it into all my science classes and I can’t believe the positive response I’m getting from students.
- It gave me a real clear idea of what engineering was. The old stereotype of the “geek” was definitely there in my mind and this helped dispel a lot of that stereotype.
- Now I have a sense and a definition for each engineering field. I can actually see how it’s used in the real world.
- It’s almost weird now, how conscious you are of these things [engineering issues in the real world]. I’m coming to work in that traffic and I’m thinking of all these things we learned here.
- This is a strength of the program. After all, how many engineering shows do you see on television versus how many medical shows. People are well acquainted with the medical field but you don’t see very much about engineering and we have to expose these kids more to engineering and its applications.

The interest in engineering continued throughout the year. In addition, participants implemented activities and made connections to engineering that they would not have made before the WI program. For example, participants began to
bring in newspaper and magazine articles related to engineering. Some teachers assigned computer searches related to different engineering fields and gave extra credit to encourage attendance at a science center.

There also was a different relationship between some teachers and their students. For example, teachers consciously encouraged female students, used girls in leadership roles, and encouraged advanced math and science classes in high school. Also, some teachers have matched gifted students with specific mentors to improve their information about engineering careers. Teachers have acquired career path information for seventh and eighth grade students so they know the courses they will need in high school and beyond. Finally, teachers and counselors have teamed with one another to identify and to provide information to promising pre-college women.

This year, a science teacher reported that he has changed the way he teaches. At the beginning of each new section the students have a hands-on application so that they have a practical application on which to base the theory that follows. He learned this technique as part of his participation in the WI program.

Teachers develop projects related to engineering that they would not have developed before. In addition to integrating engineering into science classes, one teacher had students build a city and colonize a planet including placing the buildings as a civil engineer would.

**INDUSTRY INTERNSHIPS**

The WI program is interested in the long-term impact of the training in the Summer Institute on the educators who participated in the program. To reinforce the information gained during the two-week Summer Institute, the option to shadow engineers in private industry was given to the educators. This internship occurred during the summer in which they attended the institute. During the week the teachers and counselors had the opportunity to shadow many different engineers and to better understand what an engineer might do all day.

The internships were popular among teachers, most of whom had never seen an engineering firm in operation. Particularly important was seeing women engineers at work. Some of the industry engineers later came to participant classrooms and talked about engineering. These comments illustrate the general attitude toward the weeklong internships:

- I never thought of women as engineers. I didn’t even know the different disciplines so this really helped me. Seeing the different women helped me too. You can relay that information to students. It’s not like you’re saying that “oh it’d be great if we could get more,” but that you’re really seeing them …"

- The industry internship was excellent [general agreement from other participants]. I have been better able to see kids who are gifted in science and math and to encourage them and I never would have thought of that.

- It was extremely interesting to see how engineers go about solving problems. You bring that back to the classroom.

- Well, you see female engineers working every day. I walked with a female engineer for a whole week and I couldn’t believe what this one person had to do.

Teachers and counselors who did the internship reported that they were able to see how engineers use problem-solving skills to solve day-to-day tasks and were given a glimpse into understanding the world of engineering and its complexities. In general, the educators shared that their experience was informative and impressive.

Equally as enthusiastic, were most companies who hosted the teachers and counselors. They enjoyed sharing their world with them, especially knowing that the teachers and counselors would in turn share their experiences with young people.

**VARIETY OF WAY ENGINEERING IS BEING APPLIED IN THE CLASSROOM**

Ultimate success for this program has generally been thought to be that teachers, after their engineering training, would now introduce engineering modules into their classrooms. Instead, our teachers have taken their new information and experience and have applied it in very creative and diverse ways. We have seen engineering introduced into the classroom with the simple exercise of having students read a copy of Newsweek each week. In this assignment, the student is to find an article on engineering or technology, read it, and report on it, either written or oral. Some teachers now use engineering as an example of the application of some mathematics or science that they are teaching. Some teachers have been able to convert entire science classes to engineering classes.

One mathematics teacher, with his self-confidence raised by the WI program, is in the process of starting a special pre-engineering program at his community college. He is now in a position to encourage and to support students who are interested in engineering. Recently he brought eight students from his community college (a four hour drive) to the CEAS to talk to people about engineering, to see some of the classrooms and labs, and in general to encourage them to enroll in the CEAS as an engineering or computer science major.

Some of the WI teachers have started Engineering Clubs for young women after school. After the WI experience, a counselor planned and held an engineering day. The day
and the events were well publicized, including a newspaper article with picture, and young women were surprised that there were so many kinds of engineering!

UNIVERSITY FACULTY

Each year of WI, engineering faculty were involved in teaching the Summer Institute. Many of the professors were paid, but those on year-round contracts actually volunteered their time. Some of the teachers leaned quite heavily on the professors early in the program and requested their help during the Saturday Academies. The result in some of these cases was that the teachers and counselors depended on the engineering faculty member and their laboratory for their presentation. While some of the labs were very exciting to the students, these labs were not part of what the teachers and counselors could take back to their classrooms and counseling. During the past two years, most of the Saturday Academy presentations by the participants have been good preparation for presentations in their own classrooms or school events.

The teachers, however, have not continued to call upon the professors for help and as a resource after the WI year. The teachers and counselors have expressed their reluctance to ask for additional help of “busy” professors. We have urged the teachers to contact their professor contacts for help or ideas. We felt that the faculty that had worked with them in the project (and were paid to do so) would be more than willing to assist them and give advice if they were asked to do so or refer them to someone who could. [5]

EVALUATOR SUMMARY AND CONCLUSION

Many of the teachers comments above and the results of the evaluation overall, indicate that WI has achieved its intended outcomes. Workshops expose participants to eight engineering fields and provide them with information that is relevant to science and mathematics classrooms. The industry internships and the university faculty show the human face of engineering. Program staff work with teachers to find ways to include engineering in their regular classroom curriculum.

The result is that students in some middle and high school classrooms are receiving engineering information as part of their regular curriculum. This information was not included in these classrooms before the teachers attended the WI program.

REFERENCES


