

MAKING THE CONNECTION TO ENGINEERING: INDUSTRY INTERNSHIPS FOR PRE-COLLEGE

Marcela Castro¹, Bettie A. Smiley², Patricia M. Secola³, and Mary R. Anderson-Rowland⁴

Abstract—The collaborative effort between universities and industry to produce engineers from diverse backgrounds has led to industry's role in systemic change in public education. The Women in Applied Science and Engineering (WISE) Investments program has established a collaboration with industry to support WISE Investment's framework to increase the representation of women in engineering. A partnership with industry has enhanced the engineering learning experience and has contributed to the successful integration of engineering into math and science classroom curriculum and outreach activities at school campuses.

One of the major learning experiences that are offered by industry to pre-college educators is a one-week job shadowing internship. The internships facilitate a greater understanding of engineering concepts and allow educators to become familiar with the daily responsibilities and challenges engineers face in the workplace..

An overview of the internship component will be discussed. Examples of the internship experiences will be shared. More importantly, the significance of industry's contribution to K-12 education will be discussed, as well as, the need for continued collaboration.

Index Terms---industry, internship, K-12 education, professional development

INTRODUCTION

The responsibility for creating diversity in engineering belongs to key stakeholders: K-12 educators, administrators, parents and students; university administrators, faculty and students; and industry partners [1]. Arizona State University's College of Engineering and Applied Sciences' (CEAS) Women in Applied Sciences and Engineering (WISE) Investments Program has used this comprehensive team to build a model of inclusion for the next generation of engineers.

Industry partners are valuable educational resources [2]. They can foster relationships to upgrade skills; relieve employees to volunteer in schools; and contribute funds and equipment to improve educational opportunities, as well as

support the interest and preparation of students for the engineering workforce.

To understand business-education partnerships, the Morrison Institute for Public Policy analyzed 122 written descriptions of existing partnership programs (Vandegrift et al., 1993). There were two distinct models: a cooperative model and a collaborative model. The cooperative model was defined as an "autonomous agency" with programs working to make other programs successful. The collaborative model included agencies and programs working together on a shared vision, mission, and goals. The collaborative model is valued more in a modern society.

Partners in collaboration usually make long-term commitments in the form of time, personnel, and money; share decision-making; reciprocate; share risks; and maintain the impact of services provided. According to Vandegrift et al. (1993) collaboration appears to be the best kind of partnership. Explicit and implicit concepts of collaboration have been used as the standards to judge all industry partners.

"Business entered into strategic partnerships with universities" in the 1980's [3]. The federal government decidedly encouraged these partnerships. The most important and significant role of the university is to train and to educate engineers [3]. One of the significant roles of industry is to provide internships to fully prepare students for industry by including management skills, quality assurance, communication skills, and a team approach to solving problems. Recognizing industry's contribution to K-12 education, the WISE Investments program has entered into strategic partnerships with industry to broaden the engineering knowledge of pre-college educators through industry tours, mentors, and most significantly, internships.

PROGRAM DESCRIPTION

The WISE Investments (WI) program was established to encourage more female students in middle school and high school to pursue engineering and related careers. During the summer of 1998 and the 1998-99 academic year, a pilot WISE Investments program was conducted [4]. As a result

¹ Marcela Castro, Arizona State University, Dean's Office, College of Engineering & Applied Sciences, P.O. Box 875506, Tempe, AZ 85287-5506, marcela.castro@asu.edu

² Bettie A. Smiley, Arizona State University, Dean's Office, College of Engineering & Applied Sciences, P.O. Box 875506, Tempe, AZ 85287-5506 bas0817@mainex1.asu.edu

³ Patricia M. Secola, Arizona State University, College of Education, P.O. Box 870611, Tempe, AZ 85287-0611, patricia.secola@asu.edu

⁴ Mary R. Anderson-Rowland, Arizona State University, Dean's Office, College of Engineering & Applied Sciences, P.O. Box 875506, Tempe, AZ 85287-5506, mary.anderson@asu.edu.

of the success of the pilot program, WISE Investments secured a three-year National Science Foundation grant beginning in 1999. Middle school and high school math and science teachers and counselors are integral to the success of WI [5]. These pre-college educators participate in a two-week summer professional development workshop and an optional one-week industry internship. The objective of the workshop is to increase the educators' awareness and knowledge of engineering, thereby, allowing the teachers to integrate engineering into their existing math and science curricula and to allow the counselors to include engineering information in their career counseling. During the first-week of the workshop the educators are exposed to eight disciplines of engineering through a series of hands-on labs conducted by CEAS faculty [6]. The second week of the workshop the teachers are responsible for creating engineering modules for classroom integration and the counselors are responsible for developing engineering outreach fairs for their campuses. The CEAS faculty serves as consultants during this development process providing advice and assistance as the participants create their modules and outreach plans. The teachers and counselors also practice their modules in Saturday Academies held for middle school and high school young women during the following academic year [7].

Throughout the workshop industry participates by offering tours of their companies. The tours allow all the participants the opportunity to talk to engineers and provide a view of the engineering environment. However, it is the industry internships that provide a greater impact of the field of engineering to those pre-college educators who opt to job shadow an engineer.

INDUSTRY K-12 INITIATIVES

The WISE Investments program has maintained its relationship with industry partners since the project began in 1999. Collaboration with industry partners such as Intel, Boeing, Motorola, Honeywell, Medtronic Microrel, Salt River Project, and Lockheed Martin have provided participants with direct exposure to the engineering work environment. Industries have scheduled tours of their facilities during the summer professional development workshop with pre-college educators and throughout the school year with pre-college female students and their parents. Guest speakers for program activities and recruitment of engineers to serve as guest teachers or mentors in the classroom have been ongoing commitments. All of the WI's industry partners have demonstrated strong educational partnerships with universities, school districts, and students. Two industry partners that demonstrate strong K-12 initiatives are Motorola and the Boeing Company .

Motorola

Motorola's strategic plan includes a proactive workforce development to sustain a talented pool of employees. The workforce and education framework provides professional development for teachers, classroom enrichment, and other special services for the school-community partnership. Motorola maintains its visibility and credibility in the community specifically by:

- providing opportunities for school personnel to learn more about the labor market;
- provide business volunteers an opportunity to improve the learning environment by bringing their expertise to the classroom or the classroom to the business; and
- by providing short-term activities and resources to assist with other school-related issues [8].

The summer program, for shadowing engineers with the WI internship program, offers teachers a professional perspective on the realities in the workplace as well as the benefits and challenges of the level of technology used in the industry. Precollege educators that participate in the internship use their experience to provide students with the necessary information to guide their interest in engineering careers.

The Boeing Company

The Boeing Company is the world's largest aerospace company. It manufactures commercial jetliners, military aircraft, and space satellites. "Boeing's capabilities include rotorcraft, electronic and defense systems, missiles, rocket engines, launch vehicles and advanced information and communication systems [9]." Boeing's commitment to precollege educators and students is demonstrated by its partnership with local communities in more than twenty-six states.

Boeing plays a major role in systemic reform for public school education. Its partnership with K12 school districts provides assistance to develop and to implement strategies for improving academic achievement for all students. Boeing exposes students and educators to opportunities in their business operations by demonstrating the use of applied math, science, and language arts in the workplace. A few of their community programs for students include Junior Achievement, Tech Prep, Career Day and Discover Engineering [9].

- Junior Achievement offers activity-based lessons in the classroom on the business enterprise.
- Tech Prep is a school-to-work program for high school students. The students learn manufacturing skills through paid internships while they earn college credit.
- Boeing's parents sign up to bring their children to work for Career Day. The students learn real-world applications as they make the connection between school and work. This opportunity creates a true sense

of the skill requirements for careers in engineering and related occupations.

- Discover Engineering is designed for hands-on participation. Employees donate hours each year for workshops that make exploring science interesting and exciting. Inexpensive, everyday materials are used for the project.

Other programs offered at Boeing include: Precollege Educator Engineering Internships, Educator Enrichment Day, and the Summer Science Camp.

- The Precollege Educator Engineering Internships are used in conjunction with the WI summer professional development sessions. After educators are exposed to the eight engineering disciplines, they have an opportunity to shadow engineers during their weekly employment responsibilities. The industry's Division Coordinator tailors the internship to meet the professional interests and needs of the educators.
- Educator Enrichment Day is held annually for elementary and middle school teachers. The teachers practice ideas for making math and science lessons exciting for their students. The teachers develop how-to kits and experiments that are used to enrich the curriculum.
- The Summer Science Camp is designed for students enrolled in grades three through twelve. Students spend three weekends taking fun and creative classes in biology, chemistry, physics, astronomy, machinery, computers and robotics [9]. Parents get involved in the open house with the hands-on science events. Ideas from the Summer Science Camp are refined for use in the Educator Enrichment Day.

WISE INVESTMENTS INTERNSHIPS

Since the pilot project in 1998, WISE Investments has collaborated with industry to provide pre-college educators with a first-hand experience of the engineering field by offering a one-week job shadowing internships. The job shadowing internships have proven to add insight to the educators' experience with engineering. For their participation the pre-college educators receive a \$350 stipend from WISE Investments and can opt to receive graduate credit and district credit.

The two-week professional workshop occurs during the month of June. After the conclusion of the workshop the internships take place during the first three weeks in July. The internship consists of job shadowing one engineer for one week. However, some industry partners such as Salt River Project, The Boeing Company, and Motorola have provided internships where participants job shadow several engineers throughout the week to give a more comprehensive understanding of different engineering roles. The structure of the internship will depend on the industry partner's organization, processes, and procedure.

Objectives

The main objective of the internships is to provide a vital link between K-12 education and industry. WISE Investments has provided its industry partners with a list of objectives that should be met in order to give the pre-college educators a comprehensive experience of engineering. The objectives are listed below:

- Educate participants on specific mission and goals of the companies involved.
- Educate participants on industry's processes, procedures, and challenges.
- Allow the educators an opportunity to understand the role of an engineer in various settings on a daily basis.
- Expose the educators to engineering-related activities in a real-world setting.
- Assist the educators in understanding how engineers use problem-solving skills in their jobs everyday.

Results

Between 1998 and 2001 school years, 98 teachers and counselors have participated in the WISE Investments program. Of these educators 52% have participated in a job shadowing internship. The internships have become increasingly popular with each WI cohort. Each year more teachers and counselors are interested in participating in the industry internship component. This is a result of educators who have completed the WI program sharing their experiences with colleagues who will be new participants in the program.

ASSESSMENT

In order to determine if the objectives of the internships were met, the educators who are job-shadowing engineers are instructed to observe certain aspects of the company that they can share with their students and WISE Investments. Points that the educators should be observing are: (1) new skills and tasks performed by engineers that can be incorporated into the curriculum, (2) the "real world" application of math and science in the engineering profession, (3) the level of education and courses required to become an engineer, and (4) job opportunities for students and starting salaries for college graduates. Each internship participant is required to write a brief summary of his or her experience. The summaries are the main assessment instrument of this component of WISE Investments. The summaries reflect the value of the internships and the importance of industry partnerships.

The collection of summaries from the educators who participated in the WISE Investments industry internship were analyzed to identify patterns, which could provide evidence of the value of their participation in the engineering shadowing experience through content analysis. WI

determined that there were three different styles of summaries: journal entries, informal, and formal academic papers. Below is an example of journal entries:

"July 10th.

Morning- Electrical and Computer Software Engineer working on Aspira program. Afternoon-Electrical Engineer and Configurations Manage on the High Availability Platform. "

"Monday: This day was spent with a Structural Engineer, who gave us an overview of engineering and the types of problems that they face on a daily basis.

Tuesday: This day was spent with the Structural Analysis group...First, I look at the process through which flight data is analyzed and put into a pilots manual."

The majority of the summaries were informal essays: *"My experience at Motorola was awesome! I met with two engineers or more everyday, one in the morning and one in the afternoon. I pretty much just followed them around all day. Some took time out of their busy schedules to sit, talk and answer questions on the field of engineering and how math ties into their jobs."*

"Talk about a great experiences: five days, five different contact persons, numerous departments, and manifold experiences with practicing professionals- everything except for a ride in the helicopter! If I could have designed it myself, I couldn't have planned a better week."

There were two formal and academic papers that were identified amongst the summaries. An excerpt from one of the papers is below:

"During my internship, I formulated from interviewing six male and six female engineers from Intel. I was most interested in finding a common denominator or a pattern of characteristics that define engineers. In my findings, the majority of engineers I interviewed had a role model, which influenced their decision in becoming an engineer."

The Experience

Although the formats varied, WI was able to find constant elements among the summaries. The basic patterns found as evidence of the value of the experience were the following:

- Open descriptions on the value of the experience.
- Evidence of individual knowledge acquisition as a result of participation in the job shadowing program.
- Reflections on the applicability of the industry internship experience and the connection to students.

The first found pattern, statements related to the value of their experiences, were evident in the majority of the summaries. Educators repeated phrases of excitement, consideration, and gratitude towards the participating industry companies and WISE Investments as expressed in the following:

"The Job Shadowing Internship I was fortunate enough to take part in was scheduled for the week of July 17 at Salt River Project. It was a fantastic experience that I will

encourage my fellow teachers to take advantage of, if they have the opportunity."

Secondly, WI found examples of new knowledge and concepts acquired by the participating educators. They mention details of manufacturing processes, first hand exposure to technical equipment or parts, reactions about technology use, and overall everyday activities of engineering professionals as evident by the three statements below:

"The third day required running shoes. I was on the Apache helicopter assembly line troubleshooting problems with the engineers and production people. The engineers are right there close so if a question arises, they can be found quickly. I had the chance to be under...above...on...around...near...touching...etc...the Apache [Helicopter] and it was fabulous. I felt respected. I was proud to be a teacher."

"I can't even describe this day! I was to shadow GR who had a Board of Directors meeting at the Traper Coal Mine in Craig, Colorado. I didn't have to go to the meeting, but I had a tour of the mine and a round trip flight in a corporate airplane. The pilot also showed me a video from Channel 3 about how he revolutionized the work of the linemen by delivering them to the top of the tower by helicopter (instead of climbing all the way up). The linemen can service twice as many towers per day."

"How can I possibly put into words how amazing my participation in the flight simulator was? I was shown the computers, the demo room, and finally allowed to fly in the actual pilot's flight simulator inside a huge dome. This experience was the highlight of my summer. Wow, thank you WISE Investments and thank you Boeing!"

The Engineering/Education Connection

The third and most relevant pattern identified in the content analysis of the summaries was the applicability connections between their engineering internship experience and their students. Finding these engineering/educational connections reinforced our hypothesis that educators share any new exciting content with their students.

We found two different types of concepts that the educators wanted to bring into their classrooms. One series of concepts were ideas and abilities necessary in the real world-working environment: team work, collaboration, communication and problem solving skills:

"The week I spent at Motorola was helpful because I can share with students what key skills are needed in the work place. We all talk about how important it is for students to develop skills in mathematics and science. The engineers at Motorola said students should have those skills as well as good communication skills, both verbal and written."

"Different teams and team leaders all touch base with each other to make sure that everything is being coordinated and all the bases are covered for their project. This was my

first insight into how to bring some of the work place back to school for my kids. Many of them think that group work is 'stupid' and that they shouldn't have to participate if they don't want to."

Another cluster of concepts that educators wanted to share with their students were the descriptions of the field of engineering, specific activities conducted by engineers, and examples of contributions of engineering in our daily lives:

"What will I take back to my students? The engineers were working on state of the art projects in telecommunication – projects that my students can relate to directly if they've ever seen or used a computer, television, cell phone, or pager. Science and engineering can offer careers that are both exciting and rewarding."

"I came away from this week excited and energized. I can't wait to get back to my classroom. For seventh graders, career opportunities seem a long way off, but if I can spark an interest in continuing math and science and looking ahead to a possible career in engineering, then I feel I've done my job. By integrating engineering ideas and problem solving into my classroom I hope to make the connection easier for students to see."

The content analysis of industry internship summaries revealed that educators considered their participation as an educational, interesting, and fun activity of the WISE Investment program. Seventy percent of the participants openly recommended future program participants to take advantage of the industry internships. Sixty-three percent of participants found connections between their internship experience and their classroom. In addition, the experience created a relationship between the educators and the engineering professionals that has allowed the engineers to visit the classrooms and provide real world applications of math and science to the curriculum.

CONCLUSION

Industry internships cap off an enlightening and exciting WISE Investments program for middle school and high school teachers and counselors. After learning about engineering for two weeks, the opportunity to shadow real engineers doing real engineering work is invaluable to the participants. After the industry internship, the teachers and counselors can talk from actual experience about the work done by engineers and can give actual examples of the application of mathematics and science in their classroom or counseling session. At the same time, the internships provide an opportunity for WI's industry partners to share resources with the pre-college educators that can enrich math and science curriculum and counseling information. Some of the engineers follow the internship with a visit to the classroom of the teacher that they hosted. The internships then are a true collaboration between industry and the university to help enrich the K-12 mathematics and science curriculum with the integration of engineering ideas and problem solving. The educators considered their

internship participation as highly educational and beneficial to their course curriculum and career counseling. The WI stipend and graduate/district credit were an additional incentive that the teachers and counselors appreciated. More importantly, the internship experience inspired the educators to want to get back into the classroom or counseling centers to share their experience with their students. In this way, the internships more than met the original objectives.

REFERENCES

- [1] Intel (1995). Bridging the Gender Gap in Engineering and Sciences: The Challenge of Institutional Transformation. *Conference Proceedings*, October 14, 1996
- [2] Vandergrift, J.A. & Sandler, L. (1993). "Evaluating Business Partnership Programs in Education: What Defines a Successful Venture? *Briefing Paper. Morrison Institute of Public Policy. School of Public Affairs.* Arizona State University, Tempe, AZ 85287
- [3] Bowie, N.E. (1994) University-Business Partnerships: An Assessment. Maryland: Rowman & Littlefield Publishers, Inc.
- [4] Mowzoon, May; White, Mary; Blaisdell, Stephanie; Anderson-Rowland, Mary, "WISE Investments: A Yearlong Pilot Program Introducing Engineering to Teachers and Counselors," *ASEE Annual Proceedings*, June 1999, CDROM, 6 pages
- [5] Anderson-Rowland, Mary; Secola, Patricia; Smiley, Bettie, WISE (Women in Applied Sciences and Engineering) INVESTMENTS," *GASAT 10 Conference Contributions*, July 2001, pp. 61-65
- [6] Castro, Marcela; Blaisdell, Stephanie; Moore, Mona; Anderson-Rowland, Mary, "University Faculty Commitment and Involvement in an Outreach Program: Instrumental in Program Success," *ASEE Annual Proceedings*, June 2000, CDROM, 9 pages
- [7] Secola, Patricia; Smiley, Bettie; Anderson-Rowland, Mary; Castro, Marcela, "Assessing the Effectiveness of Saturday Academies in an Engineering Outreach Program," *ASEE/IEEE Frontiers in Education Conference Proceedings*, October 2001, CDROM, S1F-16 – S1F-21
- [8] Motorola (2000). Southwest Region Workforce & Education Team Strategic Approach. Version No. 1.8: Motorola, Inc.
- [9] Boeing (2001). Education Relations. <http://www.boeing.com>