

6-1995

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Recommended Citation

Genalo, Lawrence; Windom, Kimberly D.; and Semple, Alethea, "K-12 Linkage for Women Engineers- Students Creating Courseware for Other Students" (1995). *Materials Science and Engineering Conference Papers, Posters and Presentations*. 36.
http://lib.dr.iastate.edu/mse_conf/36

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Abstract

Engineering education techniques have been changing at a tremendous pace over the past several years; a significant portion of these changes have been to recruit and retain women in engineering programs. Iowa State University is committed to these changes in engineering education and is implementing new programs for high school and undergraduate women interested in science and engineering related fields. The Program for Women in Science and Engineering (PWSE) began offering paid internship programs for both high school and undergraduate female students in 1987, with the objective to provide research experiences for talented women and to build their confidence in science and engineering related fields [1]. The six week program gives outstanding female high school students the chance to work independently on a research project with an ISU faculty member. Starting with eleven high school interns in 1987, the program has since had 137 high school students complete the program.

Disciplines

Engineering Education | Other Materials Science and Engineering | Science and Mathematics Education

Comments

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K-12 Linkage for Women Engineers - Students Creating Courseware for Other Students

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Iowa State University / Ames High School / Roosevelt High School

Program for Women in Science and Engineering Summer Internship Program

Engineering education techniques have been changing at a tremendous pace over the past several years; a significant portion of these changes have been to recruit and retain women in engineering programs. Iowa State University is committed to these changes in engineering education and is implementing new programs for high school and undergraduate women interested in science and engineering related fields. The Program for Women in Science and Engineering (PWSE) began offering paid internship programs for both high school and undergraduate female students in 1987, with the objective to provide research experiences for talented women and to build their confidence in science and engineering related fields [1]. The six week program gives outstanding female high school students the chance to work independently on a research project with an ISU faculty member. Starting with eleven high school interns in 1987, the program has since had 137 high school students complete the program.

Chosen students are assigned to professors as their mentors and are expected to complete a hands-on research project and present a formal paper and poster at the completion of the session. This poster session gives the interns a chance to defend their work and the ISU community an opportunity to see the completed research. The interns are expected to work 30-40 hours a week on their research projects. Usually interns are supervised by their immediate professor, but in some instances undergraduate and graduate students are added sources of supervision in the laboratory. Being able to work independent of supervision is a key lesson learned by many of the interns, along with setting and attaining goals for the completion of their

projects. The internship also gives the students an introduction to Iowa State University and provides them with a support network of peers and professors already established in science and engineering fields. These networks prove useful not only for honor and scholarship references, but also to expose these talented students to role models and career mentors that will help recruit talented women into engineering and science.

The internship program enables the students to investigate career choices in science and engineering outside of the classroom setting, giving them a clearer sense of their interests and strengths. In a survey done by the PWSE office in 1993, it was reported that 68% of the respondents felt that the internship had furthered their interests in a career with science and engineering [2]. These findings are significant when one considers that most high school juniors have not decided on a college major, thus showing that the PWSE program is effectively promoting science and engineering to our brightest female students. The same study showed that 92% of the respondents were considering graduate school, indicating that the program is also successful at promoting higher degrees for women.

The Division of Engineering Fundamentals and Multidisciplinary Design (EFMD) has been involved with this outreach program for talented female high school students for many years. The original computer course used in the PWSE internship program was designed and taught voluntarily in the EFMD labs by Dr. Lawrence Genalo. Since then, the course has been modified to a computer orientation course, but is still taught using EFMD resources [1]. EFMD had two female high school interns during the summer of 1994, furthering the outreach through the K-12 educational structure. These interns were involved in creating interactive multimedia courseware for other high



school students, thus adding another level to EFMD's outreach effort: students creating courseware for other students. EFMD continues to improve its recruiting programs for K-12 students by direct involvement in these programs.

Engineering Courseware

An extensive program of courseware creation is an ongoing project in EFMD at Iowa State University. Many computer lessons, tutorials, and study questions have been created for the engineering problem solving and programming course and the engineering graphics and design course. Much of this courseware has been written using a commercially available package, MacroMedia's Authorware Professional for Windows 2.0.1 [3]. Courseware such as this has proved beneficial to the learning process [4]. One purpose of creating this courseware is to allow students to interact with it at their own pace. This frees some time that might normally be dedicated to the one-to-many lecture format and provide more time for active and collaborative learning. For example, using the courseware that will be described in this paper, one Iowa high school is able to devote more time to hands-on work with electronics while the students study the theory at their own pace.

Iowa State is also a member of the Synthesis Coalition, one of the first engineering education coalitions funded by the National Science Foundation. A major goal of the coalition has been to create a catalogued database of multimedia courseware for use in engineering education [5,6]. The engineering courseware developed for the two freshman year courses mentioned above was among the first entries in the National Engineering Education Delivery System (NEEDS) database. The coalition's NEEDS program has been very successful and is currently being "nationalized" to bring more developers and users into the system. The Synthesis Coalition has goals to provide linkage programs with K-12 schools and has, in fact, named official high school partners. Recruitment and retention of women students is also a goal for the coalition. The program outlined in this paper, therefore, represents an integration of several goals and programs to provide a linkage among women, K-12 programs, and Iowa State's Engineering College.

Summer 1994 Project

In June of 1994, two PWSE high school interns began developing courseware modules for the NEEDS K-12 database under the direction of Dr. Lawrence Genalo.

The interns began their work for EFMD with a general orientation of the computer facilities and a brief tutorial of the authoring package. Both interns received an account on the EFMD computer system so that they would have access to network resources. Although they had access to as much help as necessary, both worked independent of constant supervision. During the mornings they worked together and in the afternoons they had access to the help of their female undergraduate supervisor. Although they were expected to work outside of constant supervision, they did have to maintain specific deadlines.

After the initial introduction and tutorial with MacroMedia's Authorware Professional for Windows 2.0.1, the subject matter for the courseware had to be reviewed and divided between the interns. The courseware developed was for vocational education classes at Nevada High School in Iowa, thus the subject matter was predetermined by the educators in Nevada. The material to be covered was divided into five sections: ohm's law, voltage, current, resistance in series circuits, and resistance in parallel circuits. These sections were then divided between the two interns for development and were later put together into the final product. At this stage the interns were asked to experiment with various techniques in Authorware, such as different color schemes, animations, and varied response questioning. By allowing the interns a chance to develop their own skills, they learned how to use their ideas creatively and felt more confident in their abilities to take on jobs with limited supervision. Specific tips, such as trying to keep the screen simple for ease in comprehension and maintaining an element on the screen for continuity were given to the interns by their undergraduate supervisor. Advanced technical programming was performed by the undergraduate supervisor, but all front end graphics and questions were created by the interns. After the initial experimentation period, the sections began to unfold with each intern developing new and creative ideas on presenting potentially difficult material. One such idea was the use of a cartoon character, Adam the Atom, to explain how atoms lose potential due to the influence of voltage. This was a very effective authoring technique; not only does it explain a complicated subject effectively, it keeps the students interested in what is going on in the lessons, creating a more effective learning environment. Another innovative idea was the use of "hands on" sections; simulated lab experiences on the computer eliminated the danger of harm to the students and equipment while presenting the material in such a way that the students could learn it at their own pace. In one such section the students are asked to measure the resistance for a circuit. To accomplish this



they must first know how to connect the ohmmeter, and then click on the screen to connect the correct wires to the ohmmeter. The computer will then give the students immediate feedback as to whether they connected it correctly or not, and if not explain the correct procedure.

At the end of the summer session, both interns were required to write a research paper and present a poster at the Annual PWSE Poster Presentation on their activities for the summer. Due to the nature of this project, the interns also incorporated a notebook computer with the lessons available for use into their poster presentation. Once the papers were submitted and the presentation given, the courseware was delivered to Nevada High School for use in their vocational education classrooms.

The great advantage to using these tutorials in the classroom is the immediate feedback given to the students. They reinforce key concepts while providing an opportunity for the students to see what areas they personally need extra help on. The lessons are developed to give thorough explanations when the incorrect answer is given or the students guess incorrectly numerous times, as well as brief explanations of major concepts even when the correct answer is given. By developing the lessons in this manner it is less likely that the students will be able to randomly guess the answers and not learn the major concepts behind the questions. Also, by using an interactive one-on-one setting, the time normally spent reviewing with an entire class can be shortened, giving more time for laboratory work. The lessons also provide a safe environment for the student to work with potentially dangerous situations in the laboratory, enabling them to feel more confident when dealing with real-world applications.

Conclusions

The lessons created this summer are part of the National Science Foundation's goal to create computer modules for high schools as well as reach out to gifted female students. The lessons are already in use by students and educators at Nevada High School, showing that students can create beneficial interactive multimedia courseware for other students. These lessons will expose more students to high technology teaching methods, helping them to be more prepared for the technological nature of our present world. They should also benefit educators by allowing them to teach students with several different methods, increasing the opportunity for students to fully learn the material in

different ways. Opportunities such as the one given to the two high school interns to learn and program courseware for other students will also help bring talented women into science and engineering. These lessons are just the beginning of integrating new technologies into high school classrooms, and will be placed on the NEEDS database for access by other educational institutions.

Acknowledgements

The authors wish to thank the Program for Women in Science and Engineering, the National Science Foundation, the Synthesis Coalition, ISU's College of Engineering, the Division of Engineering Fundamentals, and Nevada High School for their support of this project.

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LAWRENCE J. GENALO

Lawrence J. Genalo obtained the B.A. degree from Hofstra University in 1971, and the M.S. and Ph.D. degrees from Iowa State University in 1974 and 1977, respectively. His Ph.D. is in Applied Mathematics with an emphasis in Systems Engineering. He has been at Iowa State University since 1971, and has been an Associate Professor since 1981. He has served ASEE as Program and Division Chair for Freshman Programs and DELOS. His current research interest is in bringing high-technology classroom delivery systems into greater use in engineering education through his work with the NSF-funded Synthesis Coalition.

KIMBERLY D. WINDOM

Kimberly Windom is an undergraduate student at Iowa State University pursuing a B.S. degree in Chemical Engineering. Ms. Windom is involved in courseware development programming, including maintaining, evaluating, and creating lesson modules for engineering courses at ISU. She was a participant in the Program for Women and Science and Engineering (PWSE) high school internship at ISU in 1992, and became a supervisor for two PWSE interns in 1994. Before her position with EFMD, Ms. Windom held a developmental position with the Scalable Computing Laboratory, DOE.

SHANNON JOLLY

Shannon Jolly is a senior at Ames High School in Ames, IA. She has been listed on the Honor Roll throughout high school and was named a commended scholar for her score on the PSAT exam. Ms. Jolly has been involved in the girls swim team all four years and has served as the co-captain. To recognize her excellence in both the classroom and in athletics, Ms. Jolly was named to the Academic All Team. Ms. Jolly also participated in the Program for Women in Science and Engineering High School internship program during 1994.

ALETHEA SEMPLE

Alethea Semple is a senior at Roosevelt High School in Des Moines, Iowa. Ms. Semple is valedictorian of her graduating class and has been named a commended scholar for her score on the PSAT exam. She has also been named an AP Scholar with Honors and is the co-president of her high school's physics club. She was also a participant in the Program for Women in Science and Engineering High School internship program in 1994. Ms. Semple plans on pursuing an advanced degree in a science related field after high school.

