Summer Industry-Based Research Internships for Female High School Students

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Abstract:

Building on a successful high school internship program started by a National Science Foundation grant in 1997, an internship program has been offered the past two years that provides students opportunities to join university research teams and investigate industrial work environments. The interns develop complete lesson plans targeted at a 5th – 8th grade audience that are based on the university research and industrial sponsor's work. These lesson plans are placed on a web site for dissemination. The interns have visited the industrial sponsor to learn about their business and done final project presentations for them.

This program has a history of success in attracting women students into engineering and science majors. It also hopes to have a larger impact in the long term as the 5th – 8th grade audience targeted for the lesson plans becomes of college age and chooses science, technology, engineering, or mathematics (STEM) careers in (hopefully) larger numbers than before.

Introduction and History:

Female, high school summer research interns at Iowa State University work with engineering industries and Iowa State research groups to learn about connections between STEM coursework, research, and the work of the companies. They also are guided in K-12 pedagogy and create web documents based on their research that include complete lesson plans aimed at a target audience of 5th – 8th grade students.

Summer research internships for high school students began in the Program for Women in Science and Engineering (PWSE) at Iowa State University in 1986. In the summer of 1997 an auxiliary program, financed by the National Science Foundation in its initial year, began in the College of Engineering and was called "The Internet Explorers Program." It extended research internships to twenty high school girls who had completed their junior year with the primary goal of increasing middle school girls' participation in science, engineering, and mathematics (SEM).[1] The interns spent eight weeks during the summer of 1997 on the Iowa State University campus where they researched science and engineering topics, learned programming methods and developed SEM units for the Internet. The Internet Explorers Program has continued each year with the help of contributions from General Motors, Square D, Microsoft, Proctor and Gamble, Goodrich/Delavan, Lockheed, the College of Engineering, the Program for Women in Science and Engineering, and the Department of Materials Science and Engineering.

At first the corporate involvement was strictly through a financial donation, but in the past two years it has evolved into a more collaborative, active partnership. The interns have visited the companies to see first-hand what science and engineering was being employed in the companies' product development and production. They have also worked in ISU research facilities in related areas.

Program Description:

The purpose of the internship program, from the university and faculty mentor's point of view, is to increase female enrollment in STEM fields, especially engineering. For the high school interns the purposes are to see what research in a STEM lab is like, to gather information about possible majors, to live on a college campus to sample what college life is like, and to make a little money. For the companies the purposes of the program are recruitment of women into STEM fields in general and to establish contact with specific, talented females who may go on to major in STEM fields, co-op or intern at the company during college, or seek permanent employment with the company.

The PWSE Summer High School Internship Program receives hundreds of applications. The interns for the Internet Explorers Program are selected from this pool of applicants along with all the other summer research interns. While the other interns are placed "one at a time" in a research group, the Internet Explorers program has ranged from four to twenty interns during a single six-week summer period. After the application deadline (usually the end of January), interns are selected on merit and matched with potential mentors based on their expressed interests. The Internet Explorers Program gives special attention to underrepresented minorities and applicants from rurally disadvantaged school districts. The mentor faculty then contacts the selected interns and the summer research position is described and offered. Those applicants who accept are then sent contracts and information about stipends, housing, and other programmatic matters.

In the Internet Explorers Program for the past two years there have been two types of experiences. The interns have either worked directly with corporate mentors and ISU mentors to develop K-12 STEM lessons related to the company's work or they have worked in an ISU research lab in a related area and then developed K-12 lessons on those topics. In either case the interns have worked in pairs and had ISU students, including the co-author of this paper, as direct supervisors and mentors. The first-named author has been the ISU faculty mentor for all of these students. For those working directly with the companies, the students visited the company during the first week of their internship. They were hosted by the company and assigned a company mentor who maintained contact and provided assistance and advice (mostly via e-mail and phone calls) throughout the six-week experience. Interns who worked in ISU research groups had another ISU faculty member as a research lab mentor. The first-named author mentors the students while they create a web-based lesson plan relating to their research work. He also has overall responsibility for the program and lines up the research and industrial mentors.

The interns spent part of their time in research labs or visiting companies and the rest of their six-week experience at ISU learning the K-12 pedagogy, lesson plan development, and programming tools necessary to develop STEM lesson plans based on their research or the work of the

company. These lessons, along with all previous Internet Explorer work, are available at http://www.eng.iastate.edu/explorer.

Curriculum Development

In the summer of 2001 four companies worked collaboratively in this program to help the interns produce web sites with complete lesson plans related to science and engineering topics of interest to the companies. The companies and the lesson titles were Square D and "Electricity," Proctor and Gamble and "How does shampoo get to the store," Lockheed and "The Scientific Process," and Goodrich/Delavan and "Jet Engines." The Square D team, for example, created links to sections titled **CONSERVATION**, **ENERGY, GREEKS, AND LIGHTNING TOO...**, **HOW A CIRCUIT BREAKER WORKS!**, **FATAL CURRENTS!**, **ABOUT SQUARE D**, **SAFETY SQUARE-D**, **GLOSSARY**, **WORD SEARCH**, **QUIZ**, **SUGGESTED READING**, **LESSON PLAN**, **INTERNSHIP!!**, **and** **ACKNOWLEDGMENTS**.

The lesson plan includes the following objectives and hands-on experiences to achieve them. As a result of these activities students will be able to:

1. Provide a simple and concise explanation of renewable and non-renewable resources.
2. Define what energy is and how it is used.
3. Detail ways to conserve energy.
4. Define potential and kinetic energy.
5. Define electricity.
6. Explain how a circuit works.
7. Understand how lightning works.
8. Understand safety precautions.
9. Be able to construct a simple circuit.

The Lockheed team used the "egg drop problem" (create a protective device to keep an egg unbroken in a specified fall) to demonstrate the scientific process. Report writing is integrated into this lesson. Its objectives state that at the conclusion of this lesson, students will be able to:

1. use the internet as an effective research tool
2. name and explain the steps of the scientific process
3. explain applications of the scientific process and how companies use it
4. follow the procedure of the scientific process
5. design and construct an egg protection device
6. analyze and draw conclusions based on the results of the egg drop experiment

Besides the lesson plan that details the process for making and delivering the shampoo in the Proctor and Gamble example, a math enrichment activity in the form of a game asking questions like "Mike is in charge of shipping 270 boxes of Pert Plus Shampoo. It took him 30 minutes to ship 100 boxes. How long will it take to ship all 270 boxes?" The Goodrich/Delavan lesson on jet engines included numerous illustrations provided by the company that serve to stimulate the interest and understanding of the students' using this lesson.

In the summer of 2002 two companies sponsored intern teams who worked in research labs at ISU that are related to company topical interests. Square D sponsored interns who worked in photonics and Goodrich/Delavan sponsored interns in polymers. The photonics team created a series of five lessons that include building models of photonic crystals with popsicle sticks, a full motion video of a photonic crystal, and connections to a web-based scanning electron microscope for crystal visualization. An example of the Popsicle model (Figure 1) and an actual crystal are shown here (Figure 2).

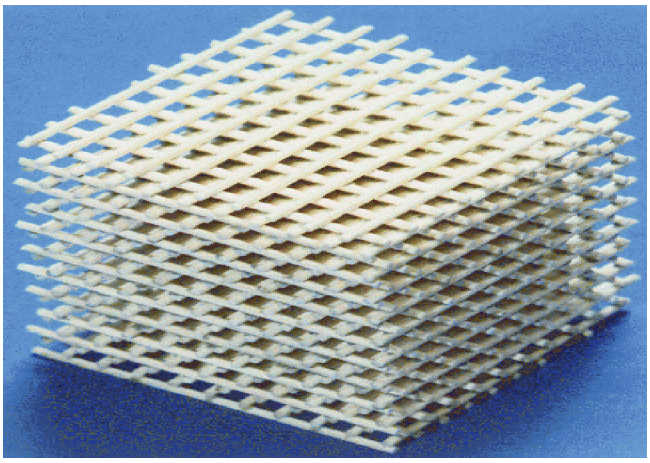

Figure 1: Popsicle model of a photonic crystal

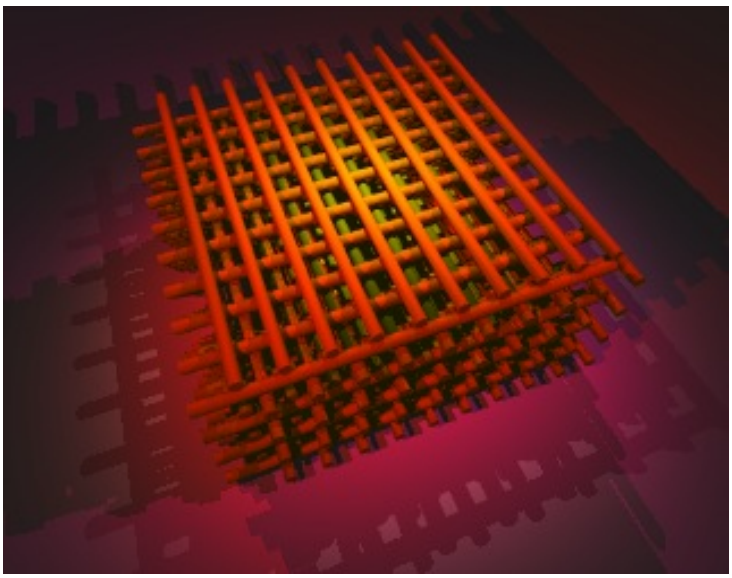

Figure 2: Actual photonic crystal, courtesy of the University of Freiburg

The polymer lessons (there are four of them) also include model building, this time with gumdrops and raw spaghetti. In lesson 1 the objectives are

1. Students will be able to understand the structure of monomers and their common functions.

2. Students will also be able to recognize and become familiar with common elements on the periodic table.

The students using this lesson begin by building simple models such as for water (Figure 3) and progress to more complicated models (Figure 4).

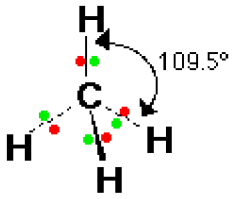

Figure 3: Water

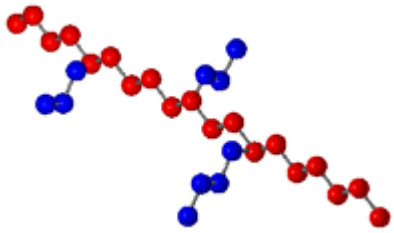

Figure 4: Polystyrene

Both the photonics and the polymers lessons make scientific research accessible to younger students.

Results of the Internet Explorers Program:

The program has been quite successful in attracting the high school interns into STEM majors in college. Figure 5 shows the interns, undergraduate mentors, and faculty from the first year of the program. Many of these interns have now graduated from college and a few are pursuing graduate degrees. From this first year of the program, 15 of the 20 interns began college the next fall in a STEM major, 12 have graduated in a STEM major or are about to, and all 20 are either graduated or still enrolled in a four-year college. In our recent survey of the Internet Explorers from all years (1997-2002), 75 of the 79 interns responded, and 57 of the 75 are currently in STEM majors (or recently graduated in one). Among the remaining 18 interns are accountants, political science majors, and future K-12 teachers. All of the interns will be more technologically literate citizens no matter what their career path becomes.

Internet Explorers gather to begin first summer of web page production.

Figure 5: The first year interns - Summer, 1997

Literature Cited

1. Genalo, L.J., Athreya, K.A., Dieterich, A.K., "Internet Explorers: An NSF Sponsored Internship," Proceedings of the ASEE Annual Conference, on CD - Session # 1692, June 1998.

LAWRENCE J. GENALO is Professor and Assistant Chair of the Department of Materials Science and Engineering at Iowa State University. He received a Ph. D. in Applied Mathematics with Systems Engineering emphasis in 1977, served as Chair for Freshman Programs and DELOS Divisions, and runs the Toying With Technology[SM] Program at Iowa State.

EMILY J. SMITH is a senior in psychology graduating in May, 2003. She served as supervisor and mentor for the high school interns during the summer of 2002 and continues follow-up work with the interns from that and previous years. She also serves as a volunteer/officer for the Dance Marathon fundraiser and during the summer at Heart Connection Camp.