2006-2039: INTRODUCING ENGINEERING AT THE MIDDLE SCHOOL AND HIGH SCHOOL LEVEL

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Linking Middle Schools and High Schools with Engineering Programs

Abstract

A problem facing the United States is the declining numbers of students expressing an interest, or majoring, in engineering. Recently the American College Testing organization reported that between 1992 and 2003 the percentage of high school students expressing an interest in majoring in engineering dropped from 9% to 6%[1]. In addition to the lack of numbers there is also the recurring problem of the lack of preparedness among US students in math and science[2]. While many programs address these problems there is a growing movement towards teaming college faculty with K-12 teachers as a means of addressing these issues. Among these programs is the recent "Research Experiences for Teachers (RET)" program initiated at the National Science Foundation. This paper will describe activities at Washington State University aimed at creating closer ties between the engineering faculty and K-12 teachers in an effort to address both student interest and teacher preparedness issues.

Background

A program focusing on addressing these issues was undertaken in the Chemical Engineering Department at Washington State University in 1993 with a National Science Foundation grant (Grant # ESI-9254358) from the Division of Elementary, Secondary, and Informal Education. The genesis of this concept was a conversation amongst chemical engineering faculty members on what influenced them to major in engineering. Almost uniformly the conclusion was that it was an influential teacher (usually in math or science) that got them started. While the influence of this teacher led to an interest in science, how this ultimately resulted in majoring in engineering was never as clear cut. To eliminate this uncertainty we submitted a proposal to bring math or science teachers to the WSU campus for a summer to work along side engineers in their research laboratories to get a clear idea of what engineers do. The teachers, in addition to strengthening their math and science backgrounds, then would serve as spokespersons for engineering in their respective classrooms. During the five years that this program was in operation, a total of 67 teachers from throughout the United States participated. Of the approximately 100 engineering faculty at WSU, 19 served as mentors (some multiple times) during the teacher's stay.

New Program

Our experiences with this prior grant led to the submission of an RET proposal granted in 2004 (Grant #EEC-0338868). The experiences gained in the prior NSF grant helped guide the development of the current RET activity. There are three primary goals for the program: 1) enhance the math/science skills of the teachers in the K-12 system, 2) increase the number of students interested in engineering as a major, and 3) provide a means by which faculty at all levels who are concerned about this problem can communicate. While the first item had clearly been addressed in our prior activity we did not feel that the latter two issues had been adequately resolved. The steps we took to improve on this situation will be outlined below.

Conduct of Program

One of the most important aspects of a successful activity is the recruitment of the teachers who will participate. We started our teacher recruitment activity in October, 2004 at the Washington Science Teacher's Association (WSTA) by hosting a booth at their annual meeting. This was followed up by an ad placed in the WSTA newsletter and letters sent to prior participants. Prospective participants were asked to complete an application form along with a reference form to be completed by their principal or supervisor.

Unlike our previous activity, this program also sought to include pre-service teachers. These were recruited by contacting science education programs at the University of Idaho, Washington State University and a number of other four-year institutions in the area. We also solicited applications from Heritage College, an institution in Toppenish, WA serving a mainly Hispanic population.

Applications from both pre-service and in-service teachers were due by February 1. The three authors met shortly after this deadline to select the teachers to participate for the following summer. While not selecting for either a math or science specialization, we did aim to have eight in-service and four pre-service teachers as participants. Teachers selected for participation were notified by March 1 and had to reconfirm their intention to participate no later than April 15. This latter action was found necessary in order to insure that we had our full compliment of 12 teachers during the summer.

At the same time that the teachers were being recruited, so too were the engineering faculty who would serve as the mentors for the teachers. Unlike our prior program for which no focus was planned, this program seeks to use biologically related engineering topics as its focus. This topic is both current as well as being of interest to the K-12 students. A number of faculty who had worked with the teachers in our prior program have research interests in this area and so were contacted to serve as mentors again. In addition, some of our newer faculty, with appropriate research interests, we also asked to join. In all six faculty are recruited for each summer session, with each faculty member being expected to mentor two teachers.

The first activity in the program is a one-day meeting that was held in May involving the teacher participants and the faculty mentors. The purpose of this meeting is to start forming relationships among all of the participants to address the desire to form a community (item #3 mentioned above), firm up housing arrangements for the summer, distribute information on the research projects that would be available for the summer, and tour the campus and laboratories. All of the teachers, whether they were able to visit the campus or not, then were asked to return a listing of the top three projects on which they would like to work. By the end of May all teachers had been assigned projects, with two teachers assigned to each project and each pre-service teacher paired with an in-service teacher. This allowed about two weeks for the teachers to communicate with each other, and with their mentor, prior to the start of the on-campus portion of the program. We found this two week period to be extremely important for the teacher's preparation as it allows them to start their preparation prior to arriving on campus. Furthermore, details such as housing arrangements, meals, parking, and continuing education or academic

credits can be cleared up before the start of the program. This allows the full duration of the program to be focused on the research activity.

The on-campus portion of the program starts in late June so as not to conflict with the calendar for the K-12 schools. The duration of the on-campus activity was six weeks, ending in late July or early August. The duration was largely set by the desire to have the research activity last as long as possible, so that the teachers could make a meaningful contribution, but not so long as to conflict with the school year for either the K-12 system or the university. During the six weeks there was a daily, one-hour lecture covering basic concepts of engineering. These concepts were introduced by examining current issues such as the hydrogen economy, biodiesel, and genetic engineering as well as taking a historical perspective of the development of the field of engineering.

This past summer there were six projects available for teacher participation: protein separations, sensors for water analysis, biomechanics, food processing, cancer treatments, and biocompatible materials. An example of how the teachers were involved can be found in the food processing project. Dr. Juming Tang of the Biological Systems Engineering Department at WSU has a large project examining alternative methods of food processing and preservation. Part of this involves treating food with microwaves to the point of destroying microorganisms but not cooking the food. Two teachers worked with his group on this project examining the effect of the level of exposure on the quality of the processed food. Since the equipment they used was beyond the scope of what would be available in a typical high school or middle school setting, they developed a module that needed only a conventional microwave oven, sheets of thermal printing paper, and sheets of polystyrene foam. The thermal paper and Styrofoam sheets were cut to fit the microwave oven opening. They were laid into the microwave cavity in an alternating fashion. The microwave then was turned on. Places where the microwaves passed through the thermal paper became hot, causing a color change in the paper. After removing the thermal paper from the microwave they could be reassembled in a clear plastic rack with the same spacing obtained by using the Styrofoam sheets. It then became possible to see the actual path taken by the microwaves through the oven cavity. Students could actually measure the wave length and amplitude of the microwaves.

Social events, to build esprit-de-corps, have also been found to be essential to build the desired sense of community. These start with a welcoming picnic prior to the first day of the program. This is followed by a one-day training session using the ropes course at the WSU Student Recreation Center. This is an excellent way of getting the teachers introduced to each other and starting to form lasting partnerships. Later events (whitewater rafting, mountain biking) are attended by a majority of the participants and often their families. All of this is intended to form lasting relationships between the teachers and their mentors.

In addition, the teachers were required to develop a teaching module, based upon their research experience that could be brought back to their classrooms. To aid in developing this module Don Orlich, from the Science, Mathematics, Engineering Education Center (SMEEC), conducted many of the classroom sessions during the latter portion of the program. During the final week of the program local middle school and high school students, selected by the participating teachers, came to campus to test the modules that had been developed.

Outcomes

There were three goals for this program that were mentioned earlier; improved skills for the teachers, increased interest in engineering by their students, and improved communications between the teachers and the faculty mentors. One of the major tools in achieving these goals is the teaching modules that are developed during the summer. Fifty-two teaching modules, available for use by any teacher, were developed during our prior program and are still available on line at www.che.wsu.edu/home/modules/index.html. The modules developed during the summers of 2004 and 2005 are being tested and will be added to this site once the teachers have had a chance to use them in their classrooms and make final alterations to the modules.

The interactions between the high school/middle school teacher and his/her university mentor have been valuable to both parties, as well as to the graduate students who inevitably get involved. The teachers do make valuable contributions to the research effort, albeit at a level roughly equivalent to an undergraduate engineering/science student. The graduate students gain a deeper understanding of their projects as they must guide a person with little experience in the laboratory through the six weeks spent in the lab. The faculty also gain valuable insights as well as a possible pipeline to highly qualified and motivated future students.

A shortcoming of our prior program was our inability to maintain communication with many of the teachers who had been participants in our program (our third goal). In part, this was due to the fact that the prior program had recruited teachers from throughout the US. Since the current program focuses on the Northwest, the distances involved in maintaining contact will be greatly reduced, but not eliminated. To overcome this impediment, an interactive meeting capacity using high-end, Internet based technology has been developed. Dr. Maring used this technology in a project (co-TEACH) where graduate students and faculty in the Department of Teaching and Learning were able to mentor teachers and students at a number of schools scattered around the Northwest. We currently have the equipment to do this and more. While Dr. Maring's equipment was largely stationary (everyone had to go to a fixed location to make use of the technology), our equipment is mobile. A typical usage consists of two units, one at WSU and one that is brought into the K-12 classroom. By linking the two via the Internet we can provide real-time audio and visual between the two sites. Thus a teacher and his/her class could have a virtual face-to-face interaction with the faculty member at WSU, similar to what was done in co-TEACH. A more exciting application of this technology will be to bring the K-12 students into the faculty member's research laboratory to let them see activities and equipment that would not be accessible to them at their school.

We also wish to obtain better follow-up on student attitudes concerning engineering after their teachers have been participants in our program. We are currently working with a faculty member in the Department of Educational Leadership and Counseling Psychology, whose specialty is assessment, on developing an instrument to measure the student's attitudes towards engineering. This instrument will be used in the classrooms of the participating teachers before and after they have used the modules they developed in their classroom. This, coupled with mandatory visits by the WSU faculty member to the teacher's classroom, will provide a stronger

link between the teacher's and the engineering program at WSU, hopefully leading to the attainment of goals 2 and 3.

Conclusions

As a result of past summer's activities we have reached certain conclusions concerning activities such as ours, where laboratory experiences are used to convey the essence of engineering to K-12 teachers. We found that six weeks was necessary for the conduct of the on-campus portion of the program. Although many teachers initially felt that this was too long, most felt that they were just starting to contribute to their projects by the time that six weeks was ending. Shorter periods of time would not allow the teachers to become contributing members of their research groups. In addition, without a substantial involvement in the project the teachers would feel less confident in presenting this material to their class, thus reducing the impact of the program at the K-12 level. A longer period of time (8 weeks) was viewed as too long by both the university mentors and the teachers, in addition to presenting significant scheduling barriers.

A preliminary meeting was essential in maximizing the usage of the six-week, on-campus period. This first meeting gave us the opportunity to take care of many important items prior to the teacher's arrival in the summer, including project/mentor selection, preliminary research, housing, academic or continuing education credit, and laboratory safety.

Having the teachers work in pairs on their research projects is a powerful tool. They have a compatriot with whom they can share experiences, and they develop a close relationship with another teacher with whom they could interact in the future. This helps in implementing the module they have developed into their classroom as they will have a person with intimate knowledge of the module with whom they could talk. The close contact with another teacher was an especially valuable experience for the pre-service teachers.

Follow-up between teachers and between teachers and mentors is probably the hardest issue to address. This is particularly true for our situation because of the distances involved between WSU and the various schools where the participating teachers work. The two-way, Internet conferencing capability will be monitored to see if this can provide a useful tool in addressing this issue.

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