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Bringing Engineering Concepts to the Middle School and High School

Donald C. Orlich[1], William J. Thomson[2], Richard L. Zollars[2]
[1]Science, Mathematics, Engineering Education Center
[2]Department of Chemical engineering
Washington State University

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 have been started to 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.

A program was undertaken in the Chemical Engineering Department at Washington State University in 1993 with a National Science Foundation grant 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.

After gaining some experience with this activity we settled upon the following procedure for conducting the program. Advertisements for the program were disseminated in various publications from state and national science teacher's organizations. The deadline for the

submission of the application, along with a supporting letter from a principal, was February 1. At the same time a solicitation for mentors at WSU was also started. By March 1 both participants and mentors were selected and notified of their selection. Both needed to respond by March 15 to verify that they would participate in the following summer's activity. Invitations to participate continued to be extended until we had commitments from as many teachers as we could adequately handle (20 teachers and 10 mentors).

During April information on available research projects was obtained from the mentors and distributed to the teachers. In early May a meeting was held on the WSU campus where the teachers met all of the WSU faculty who were involved with the project, as well as being able to 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. This allowed time for the teachers to communicate with their mentor, and with each other, prior to the start of the on-campus portion of the program.

The on-campus portion of the program started in mid-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 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, trips to various industrial locations, social events (picnics, whitewater rafting) to build esprit-de-corps, and the research. 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 a faculty member 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 came to campus to test the modules that had been developed. Finally, the faculty mentors tried to go to the teacher's classroom at some time during the subsequent academic year to provide further support.

The feedback from the teachers and their students was overwhelmingly positive. In fact we had many of the teachers ask if they could come back for a second experience (something we elected not to do). Attitudinal surveys about students' interest in engineering were requested of the teachers after their participation in this program but the return on these was very sparse. However, anecdotal evidence from the teachers did show an increased interest in science and engineering amongst their students when the modules that the teachers had developed were used in the classroom. Another method to measure the impact of this program would be to monitor increased enrollments in engineering from the high schools and middle schools of the participating teachers. However, because this program drew teachers from throughout the United States it is unlikely that we would see any discernable change in enrollments in the engineering programs at WSU. Likewise the number of high schools and middle schools impacted by this

program was too small for there to have been any significant impact on national enrollments in engineering.

While statistics on the impact of this prior program are not available two important outcomes have been observed. First, some lasting connections, both personal and professional, were made between the teachers and the engineering faculty member that last to this day. Second, fifty-two teaching modules, available for use by any teacher, were developed. These are still available on line at www.che.wsu.edu/home/modules/index.html.

As a result of our experiences we submitted an RET proposal in 2003 and received an RET site award from the National Science Foundation to start the program anew in 2004. Based upon these past experiences there are a number of key points that we feel lead to a successful prior experience, and which will be incorporated into the current RET program.

1) 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 the 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.
2) A preliminary meeting was essential in maximizing the usage of the six-week, on-campus period. This first meeting, conducted 4 – 6 weeks prior to the start of the on-campus activity, gave us the opportunity to take care of many important items prior to the teacher's arrival in the summer. Project selections were largely settled during this visit. By knowing the project to which they had been assigned, the other teacher with whom they would be working, and the mentor with whom they would be working, teachers could start preparing for the summer experience before they arrived. In many cases the mentors were able to send the teachers background information on the project so that they could come to the campus with a good idea of what they would be doing once they arrived. It also allowed us to cover other important items such as laboratory conduct and safety, paperwork so that the teacher could receive the stipend for the program, housing, and how to receive credit for their participation.
3) The teachers found that they could get more accomplished if they worked as pairs on their research projects. In addition they developed a close relationship with another teacher with whom they could interact in the future. This helped in implementing the module they had developed into their classroom as they had a person with intimate knowledge of the module with whom they could talk.
4) The first couple of summers we conducted this program the module development portion was conducted in a two-day intensive workshop on the Monday and Tuesday following the conclusion of the research experience. This did not work well. The teachers were anxious to head home and spending an additional weekend on the campus was not viewed

favorably. In addition, this separated the module preparation from the research activity. Thus we integrated the module development into the six week on-campus period. This worked extremely well. This also gave us the opportunity to use local middle school and high school students to test the modules prior to their final submission. This testing uncovered many valuable changes.

While this prior program was very successful there were some areas where improvements could be made. Among these areas are:

1) The amount of follow-up between the teachers and the university faculty members was less than desired. This is a significant concern since a good deal of benefit to be derived from the program is the relationships that are developed between the K-12 teachers and the university faculty members. In our original program the follow-up visits by the faculty to the teacher's classroom were largely on an ad hoc basis – the faculty would do so if it could be arranged. Since the prior program was conducted on a national scale (with 27 of the 67 teachers who participated coming from outside the State of Washington) this did not work well. Even within the state visits were sporadic. Other forms of communication, e-mail mainly, did carry on but in many cases it also dropped off in time. Thus, while the impact of the program continued to be felt in the classroom, through the use of the modules, it was not as great as would have occurred had the university faculty member been more involved in the classroom and if there had been consistent contact between the university faculty, the teacher and the teacher's students.
2) The effectiveness of this program in altering student's interest in engineering was also not adequately measured. This arose from a number of difficulties. Each teacher was asked to conduct attitudinal surveys in their classes after using the modules they had developed. This often did not happen. The fact that the program was conducted on a national scale also prevented numerical data from being collected on enrollments into engineering programs, since the effect would have been too small to observe.

We are now in the recruitment process for the 2004 RET activity to be conducted on this campus. In view of the past success of this program, much of it will be conducted as in the past. To address the prior shortcomings a number of new activities are being introduced. Foremost among the changes are a greatly increased emphasis on developing and maintaining faculty-teacher relationships. This will be partially addressed by the fact that the current RET program will be a regional activity (Washington, Oregon, Idaho and Montana). This still does not guarantee the type of long term relationships we desire between the teachers and between the teachers and the university faculty. To overcome the difficulties of communication over the distances in the Northwest we will be utilizing a cybermentoring network developed by another WSU faculty member, Dr. Gerald Maring. This system uses high-end video conferencing over the Internet to allow interaction between people at WSU and a teacher or a group of teachers (and their classes) at any time. The use of the cybermentoring network, and required in person visits, will help develop the type of long term relationships desired to maximize the impact of this program.

We will also be adding pre-service teachers to the group of teachers involved in the program. The pre-service teachers will always be paired with in-service teachers on any research project. In this way we can build long lasting relationships between science and mathematics teachers throughout the region.

Finally a more complete assessment of the impact of the program will be conducted. The closer relationships between the university faculty and the K-12 teachers will help insure that this activity will be improved. The cybermentoring network will also aid in completing the surveys required for tracking student attitudes. Finally, since there are only five major engineering colleges in the region a numerical evaluation of the impact on engineering enrollments may also be possible.

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DONALD C. ORLICH

Don Orlich graduated from the University of Montana in 1953 with a B.A. in Education. He received a Masters of Science Education in 1959 from the University of Utah and an Ed.D. in 1963 from the University of Montana. He taught five years as an elementary and junior high science teacher in Butte, MT before taking a faculty position at Idaho State University. From 1967 to 1994 he was a faculty member in the Department of Education at Washington State University. He currently works at the Science, Mathematics, Engineering Education Center at Washington State University.

WILLIAM J. THOMSON

Bill Thomson graduated from the Pratt Institute in 1960 with a Bachelor's degree in Chemical Engineering. After receiving an M.S. in Chemical Engineering from Stanford University in 1962 he received his Ph.D. from the University of Idaho in 1969. He was on the Chemical Engineering faculty at the University of Idaho from 1969 to 1981 rising to the rank of full professor. In 1981 he became the Department Chair in Chemical Engineering at Washington State University, a position he held until 1993. In addition he has worked with Esso Research, AVCO Research, the Union Oil Research Company and the Stanford Research Institute. He currently is a full professor at Washington State University.

RICHARD L. ZOLLARS

Dick Zollars graduated from the University of Minnesota in 1968 with a Bachelor's degree in Chemical Engineering. He attended the University of Colorado where he received an M.S. in Chemical Engineering in 1972 and a Ph.D. in 1974. After working for three years with the Union Carbide Corporation he returned to the University of Colorado in 1977 as a faculty member in Chemical Engineering. Since 1978 he has been on the Chemical Engineering faculty at Washington State University. He has also worked at the Laramie Energy Research Center (DOE) for a summer and at the National Science Foundation for a year as a Program Director.