Teaching Teachers to Teach Engineering: the 19th Annual SECME Summer Institute

Matthew Ohland, Marc Hoit, Mary Kantowski
University of Florida, Civil Engineering/Civil Engineering/Mathematics Education

Abstract

The University of Florida hosted the 19th annual Summer Institute for the SouthEastern Consortium for Minorities in Engineering (SECME) from June 16th-29th, 1995. K-12 Teachers, counselors, and administrators from the southeast participated in engineering laboratory activities. These activities were designed as part of a freshman Introduction to Engineering laboratory class, and were explicitly designed to be portable to the pre-college level. Two hour “hands-on” laboratories in building bridges using popsicle sticks, exploring manufacturing technology using Legos, simulating aerospace composites subjected to impact loading using string and cement, and removing simulated hazardous pollutants using activated charcoal were the four activities. Education faculty provided teachers with an additional 10 hours of instruction in pedagogical technique in areas compatible with the engineering labs and objectives.

Engineering and education faculty efforts were coordinated in early planning using the engineering activities as the focus and through the use of "master teachers" provided by SECME. The master teachers are experienced teachers who were involved in planning and served as facilitators during engineering and education curriculum activities.

The teachers participated in the same hands-on laboratories which are part of the Introduction to Engineering class. Through this active learning experience, teachers were able to envision ways in which these laboratories could be exported to their individual classrooms to suit their teaching style. This technique is expected to be more effective than producing a published curriculum, because it provides the flexibility for teachers to customize the activity to their needs. The participants were required to submit lesson plans on how they were going to implement these activities into there courses in order to receive graduate course credit. The implementation of some of these laboratories K-12 classroom is described.

The institute was evaluated through an engineering perception and knowledge survey administered before and after the institute, as well as through daily feedback forms. Results of these evaluations are also given and discussed.

Introduction

The SouthEastern Consortium for Minorities in Engineering (SECME) was founded in 1975 to increase minority appearance in engineering by improving the science and mathematics curriculum for pre-college students. The

consortium includes and impacts K-12 teachers, students, parents of students, colleges and universities, and industry representatives.

This year, the University of Florida hosted the 19th annual SECME Summer Institute. The purpose of the Summer Institute is to empower SECME teachers (K-12) to return to their schools and effect a positive change in the educational system. Engineering and education faculty collaborated to develop appropriate objectives and supplementary teaching techniques for four engineering laboratory activities so that K-12 school teachers could return to their schools equipped to conduct the laboratories as a unit in their curriculum. All institute activities were facilitated by experienced SECME teachers, called master teachers. The master teachers provide insight by drawing on their teaching experience in K-12, where most university faculty are inexperienced.

There were 187 teachers and counselors in attendance. The group was divided into 5 groups and attended the labs accompanied by program administrators and various visitors. The four featured engineering laboratories, Aerospace, Civil, Environmental, and Industrial Engineering, therefore handled approximately 40 participants for 5 sessions. The lab instructors benefited from the assistance of master teachers assigned to remain with each group. The need to demonstrate the benefits of the institute to school administrators and corporate sponsors required that the Civil Engineering laboratory be conducted for a group as large as 150. With appropriate adaptation, the lab was still administered within the two-hour time frame.

The same groups attended 5 of the following educational training sessions: Cooperative Learning, Using Technology to Explore Data, Interdisciplinary Teaching, Presentation Skills, Creative Thinking and Inquiry, Science Processes and Technology, Higher Order Thinking, Augmenting Teaching with Technology, and Writing Across the Curriculum. Counselors attended separate sessions during this part of the program.

Logistics

The cornerstone of the UF Summer Institute was the joint and integrated effort of the Engineering and Education faculty. Leaders from both groups met with SECME staff on December 7, 1994. This initial meeting established the vision for the Summer Institute and the commitment of the various contributors to that vision. UF's team expanded the vision of the Summer Institute in two major ways. The first was that Engineering and Education faculty would collaborate to put forth an integrated institute. The second was that we would follow through on SECME's objective of including participants from the elementary school system.

One of the concerns addressed early on was the issue of assigning graduate credit for the work completed in the institute. The short duration of the institute complicates this option. Graduate credit was made possible by establishing guidelines for work to be done in preparation for the institute and follow-up work to be done after the completion of the institute. Grades for the graduate coursework were assigned on the basis of an implementation plan which detailed the way in which the teachers would bring what they gained during the institute into the school system.

SECME staff, University faculty and administration, and master teachers met February 24th, 1995 to develop and schedule the specific content of the summer institute. A great deal of time in this meeting was spent on honing what specific objectives were appropriate and feasible. The result of this meeting was a detailed schedule which accounted for the entire two-week summer institute. Following this meeting, arrangements for all facilities and meals were made by UF staff.

Since the institute is a summer event, the disruption of the schedule of the faculty involved did not pose an insurmountable problem. This disruption was mitigated through the use of student assistants who served SECME staff and the faculty for the duration of the institute.

The Institute Curriculum

The four engineering laboratory activities used within the institute were among those developed for an Introduction to Engineering class recently adopted as a permanent course in the engineering curriculum at the University of Florida. This class is one of the projects developed under the Southeastern University and College Coalition for Engineering Education (SUCCEED). This class replaced a one hour per week lecture. Each laboratory is intended to expose participants to hands-on experiments representing concepts related to the discipline's specialty.

In addition to their hands-on focus, the laboratory activities were to be designed to use simple equipment so that they could be exported to programs such as the summer institute discussed here. The four laboratory activities included in the SECME summer institute were those which best accomplished this objective, to maximize the opportunity for teachers to implement these activities in their home schools with little capital cost and startup time.

In the Aerospace Engineering laboratory, participants designed a composite slab using hydraulic cement, string, two cotton balls, and a sheet of notebook paper. The slabs are then tested for impact resistance by dropping a steel ball from successively higher altitudes. In the Civil Engineering laboratory, students watched a strength test of steel and concrete and built 2-dimensional trusses from popsicle stick erector sets. The limited number of parts and a cost penalty constrain the problem to encourage creativity. The complete trusses are tested within a plexiglass frame by hanging a bucket from the truss and filling it with gravel. In the Environmental Engineering laboratory, a colorant is used to simulate a hazardous waste in water. The process of removing this colorant is used to illustrate the process the process of removing chemical pollutants using activated charcoal. In the Industrial Engineering laboratory, the construction of Lego toys and origami birds are fashioned into assembly line processes. Through this exercise, participants analyze and attempt to optimize the manufacturing process.

Two of the labs are now accessible on the World Wide Web, and the others are under construction. Set any web browser to look at http://www.ce.ufl.edu/projects/labs.html to find the Aerospace Engineering and the Civil Engineering laboratories.

At the core of the integrated nature of the institute was that the educational components of the institute were also activity-centered. In addition to the benefit of such active learning methods, such a focus helped expose the teachers and counselors to a wide range of applications, enhancing the opportunity to strike a chord within each individual.

Evaluation Results

Each morning, participants filled out feedback forms evaluating the previous day's events. The ratings of all the engineering and educational actitivies were unilaterally positive. All such events received either a 4 or 5 on a 5-point scale. This outcome makes it impossible to assess which of the areas might most benefit from

improvement. However, when evaluating the demonstrations given by the engineering departments which did not lead a hands-on activity, the participants gave ratings which were a full point lower on average than those of the hands-on activities. This is an indication of the success of the hands-on activities.

A survey administered at the beginning and end of the institute was used to measure the effectiveness of the institute at meeting two stated objectives: increasing the teachers' knowledge of engineering and increasing the teachers' enthusiasm about guiding students into engineering careers. The survey primarily measures interest and background knowledge, with a few questions which specifically evaluate the program as a whole which are included in the survey administered at the completion of the institute. Many survey questions were taken directly from an instrument previously used at the University of Pittsburgh[1] and the University of Florida[2] in order to provide the opportunity for cross-comparison. Additional questions were added to suit the particular circumstances of those in the teaching profession. A five point (Likert) scale was used to assess student agreement with survey statements. The scale is shown in Table 1.

Table 1: Definition of survey evaluation scale

Opinion	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Point Score	1	2	3	4	5

A review of the survey results yields a number of interesting conclusions, which are illustrated below. For each conclusion, the most significant supporting data are included in a table. The entry survey was returned by 171 participants (out of 187). The exit survey, however, was only returned by 134 participants.

The summer institute educates its participants about engineering. Table 2 shows that the institute yields improvement in teachers' understanding of engineering in a variety of ways. Especially important to note is that teachers have been better educated about the diverse applicability of an engineering education.

Table 2. Responses indicating an increase in understanding about engineering

	Entry Average	Exit Average
Based on the information presented in this institute, I have a good idea of what engineers do and the difference between the disciplines.		4.6
Engineers need to use common sense as well as what they learned in college.	4.3	4.8
Writing and communication are important skills for engineers.	4.5	4.8
Engineers play a major role in solving environmental problems.	4.2	4.9
An engineering education can be a good pre-med or pre-law program.	3.4	4.5
An engineering degree is an advantage if you want to become a manager.	3.1	4.1

The institute increases enthusiasm about engineering. This conclusion is supported by the results shown in Table 3. For teachers to encourage students to pursue careers in engineering, teachers must perceive that an engineering career is respectable and financially beneficial. The first two statements measure the degree to which the institute have generated this appeal. The last statement is a direct evaluation of the program they have just completed.

Table 3. Responses Showing Enthusiasm and Attractiveness of Engineering

	Entry Average	Exit Average
Engineering is a respected profession.	4.4	4.8
Engineers are very well paid.	4.0	4.7
I enjoyed the labs and thought they were quite informative.		4.7

SECME teachers know about engineering before the institute begins. When SECME teachers arrive at the institute, we are presuming to teach them about the nature of engineering. However, when we compare the entry level of SECME teachers to the entry level of freshman engineering students, we discover that SECME teachers have already received some education about the study and profession of engineering. Results supporting this conclusion are shown in Table 4. SECME administrators agree with this finding, since even teachers from schools just initiating a SECME program have usually attended workshops and established contact with experienced SECME teachers. The average displayed for college freshmen includes results from 150 students surveyed over three semesters.

Table 4. Comparison of the Entry Level of College Freshmen and SECME Teachers

	College Student Entry Average	SECME Teacher Entry Average
Engineers use a calculator more than they write.	3.6	2.9
Writing and communication are important skills for engineers.	3.8	4.5
Engineers generally deal with machinery.	3.2	2.9
Engineers are generally well paid.	3.7	4.0

There is no significant difference between responses from each gender group. In each group, approximately 20% of the respondents were male. For no question was there any significant difference between the response of the female and male participants. We attribute this uniformity of response to the well-defined and taught goals and objectives of the SECME program. Although the teachers are certainly very diverse in their approaches to achieving the objectives of the program, they all strongly share the same objectives.

The institute can still be improved. All the previous results indicate the positive influence of the SECME organization and the summer institute. There were, of course, some less positive results, which are shown in Table 5. It does not imply failure that these shortcomings exist, but to fail to correct them would be negligent.

Table 5. Results Indicating Possibilities for Improvement of the Institute

	Entry Average	Exit Average
Engineers spend a lot of time doing drafting.	3.2	3.3
Most engineers do a lot of skillful work with their hands.	3.5	3.9
Engineering involves precise answers to problems.	3.7	4.0
Engineering is an exact science.	3.4	3.7
Engineers and architects basically do the same thing.	2.7	3.1

The first two statements assess the degree to which engineers are perceived to be technicians. In both circumstances, the summer institute has increased the degree of this misconception. This is probably caused by the hands-on approach at the heart of each of the laboratory activities. In order to improve this perception, future efforts should more clearly demonstrate the creative design process also central to the laboratory activities.

The second pair of statements measure the perception that engineering demands precision; this carries with it the rigidity of closed-end problems to which there is only one correct answer. Again, in both cases we have lost ground with respect to the desired result. To rectify this, more discussion of the open-ended nature of the laboratory activities would be helpful.

The last statement indicates that we have failed to clarify the differing roles of engineers and architects. This is an objective which will likely not be met unless this is directly addressed during some component of the education of SECME teachers.

Conclusions

Special programs such as the SECME summer institute provide an excellent opportunity for allowing K-12 teachers and counselors to benefit from institutions of higher education. Such events are among the few channels through which educational research will transfer into the mainstream on a timely basis. It is also noted that activities designed to be exportable (inexpensive and simple) will facilitate this transfer. Variants of the activities from the 1995 SECME summer institute are being used in schools in the consortium. At Wiles Elementary School (Gainesville, FL), for example, students compete in egg drops and other design competitions. In after school programs, a filtration experiment and an assembly line activity have been introduced. A bridge making exercise is also planned for introduction.

The SECME summer institute also provided opportunities for K-12 teachers and counselors and University faculty to network and share ideas. This synergy of such different perspectives can give direction to University research and teaching as well as keep K-12 teachers abreast of advances in educational methods and the engineering profession.

References

[1] Besterfield-Sacre, Mary E., Atman, Cynthia J., and Shuman, Larry J., "How Freshman Attitudes Change in the First Year," Proceedings 1995 Conference ASEE, Anaheim, California, June 1995.

[2] Hoit, M.I., Syfrett, Elizabeth, "Freshman Interdisciplinary Laboratory," Proceedings 1994 Annual Conference ASEE, Edmonton, Canada, June, 1994.

Biographical Information

MARC HOIT

Dr. Hoit recent contribution is a text book entitled "Computer Assisted Structural Analysis and Modeling," Prentice Hall, that integrates the use of the computer for teaching structural analysis. Dr. Hoit's research involves the analysis and design of traffic signal systems, a computer program which analyzes bridge piers, and engineering education with the SUCCEED coalition. Dr. Hoit's most recent award is the Teaching Improvement Program award in 1995.

MATTHEW OHLAND

Matthew is a doctoral student in Civil Engineering pursuing a minor in Education. His doctoral research is to create a methodology for designing engineering activities. Matthew has been recognized for his contributions to the University of Florida and its community. He plans to continue his work after graduating in August 1996. He is an active member of Tau Beta Pi and was recently nominated for Tau Beta Pi's Laureate Award.