Session 2550

Enrichment Experiences in Engineering (E^3) For Teachers Summer Research Program

Angie Hill Price, Karen Butler-Purry, Robin Autenrieth, Jan Rinehart, Naomi Gomez
Dwight Look College of Engineering, Texas A&M University

Abstract
With funding from NSF, faculty from Texas A&M University have developed an outreach program aimed at providing secondary school teachers with laboratory experiences with faculty researchers. The overall mission of the project is to excite, empower, and educate public school teachers about engineering so they in turn will excite, empower, and educate young people they come in contact with each day. After one year of the three year program, the feedback from participants has been overwhelming.

Eleven in-service teachers and one pre-service teacher from urban and rural areas of Texas were hosted for a 4 week summer research program on the Texas A&M campus. Combined, these teachers work with approximately 1400 secondary public school children every year, who are 80% Hispanic and/or African American. The teachers were placed in teams of two based on their school location so that they would be able to develop a supporting network. These teacher teams were matched with faculty research programs in power, water resources, smart materials, food engineering, space exploration, and mathematical modeling. They also engaged in discussions with researchers about the "reality" of research, not just the media version, in order to gain a thorough understanding of topics such as genetic research, the Columbia experience, and alternative energy sources. The teachers then developed lesson plans for their specific content area that utilized an engineering/technology application or example from the NSF sponsored program.

Educational discussions formed an important part of the on-campus experience as well. Venues for these interactions were facilitated peer discussions on the impact of culture on learning, and group work on how to incorporate their experience into the classroom. In addition, industry field trips were provided to develop further engineering and technology awareness. In the future, the participating teachers will be brought back together to discuss their classroom implementation experiences. The combination of the teaming format, the peer discussions, program development and classroom implementation of the research experiences appears to have been successful. Other faculty at the university, having heard of this initiative, volunteered to host next year's teachers. The participants and the sponsoring school districts have provided positive feedback and continued participation.

Introduction
The E^3 for Teachers Summer Research Program is a National Science Foundation (NSF) funded four week summer research experience offered by faculty in the Look College of Engineering at Texas A&M University (TAMU) in conjunction with the Texas Engineering Experiment Station

(TEES). The purpose is to match secondary, math and/or science public school teachers with engineering researchers. The objectives of the program are to: 1) offer teachers experiences with the latest in engineering research; 2) to enhance laboratory skills and techniques; 3) to reinforce educational research in inquiry, learning styles, and diversity; and 4) excite public school teachers about careers in engineering so more students study mathematics and science in pre-college coursework.

There are three major components of the E^3 for Teachers Program. The first is a discovery and learning about engineering research experience with a faculty/researcher in an engineering laboratory. The second component is educational and is designed to provide the teacher participants with educational theory and experiences to better prepare them to transfer the research experience into their classrooms. The third component is engineering career awareness through current issue discussions with top researchers and industry field trips.

Program Description

The College formed partnerships with schools from the NSF funded Urban Systemic Initiative in Houston, Texas and the NSF Rural Systemic Initiative in Corpus Christi, Texas. The NSF Systemic Initiatives provide professional development and training for public school teachers in math and the sciences. In 2003, eleven in-service teachers and one pre-service teacher were hosted for the 4 week summer research program on the Texas A&M campus. Combined, these teachers work with approximately 1400 secondary public school children every year, who are 80% Hispanic and/or African American.

Application

Applicants for the 2003 session were solicited through announcements issued in conjunction with the partner Systemic Initiatives. Applicants were requested to discuss previous continuing education involvement and any laboratory and research experiences. They were also asked to assess their knowledge of engineering through a comparative ranking, and through writing exercises. The applicants gave short definitions of engineering from their own current knowledge, described three types of engineers, and described at least three engineering solutions that made a difference in their lives. The intention was to identify a genuine interest in the research program and to assess their current level of knowledge of engineering. In addition, an essay was required that described the applicant's expected gain in participation and how each expected to implement this experience in the classroom.

Selection

The applicants were asked to select three of the research areas in which they were interested based on provided research project summaries. Sample projects were listed and are in Appendix A. The principal investigator (PI) and co-PIs reviewed each complete application and as a committee selected the participants. The faculty providing research projects participated in the assignment of participants to specific projects. The participants were assigned in teams of two based on their school district, so that they would be able to develop a synergistic relationship that would support their follow-on activities.

Logistics
The four week duration was selected at the recommendation of the directors of the Systemic Initiatives and through previous experience of faculty with summer teachers programs. The teachers lived on campus in residence halls throughout the program. Stipends covered weekly participation, travel, housing, and meals. There was also a small stipend to purchase materials and supplies to help facilitate taking the research experience back to the classroom. Continuing educational credits and Gifted and Talented Curriculum Development credit granted through the Texas Education Agency also was earned by the participants.

Table 1 shows the schedule for the four week program in 2003. The first day was dedicated to orientation to the research program the college and the University setting. The participants met all of the research sponsors and had a first opportunity to visit the research facility in which they would be working. The educational discovery session was the research experiences in the laboratory, termed as such to emphasize the outcome desired for the participant.

Week	Monday	Tuesday	Wednesday	Thursday	Friday
June 9-13	**8-9:30** Check In **10:00-11:45** Orientation **11:45-1:00** Lunch w/ faculty **1:00-5:00** Orientation	**8:00-3:00** Educational Discovery **3:30-4:00** COE Recruiter **4:00-5:00** Educational Discussion	**8:30-10:00** Discussion: Culture and Learning **10:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion	**8:00-3:00** Educational Discovery **3:30-4:00** Dr. Ding **4:00-5:00** Educational Discussion	**8:00-3:00** Educational Discovery
June 16-20	**8:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion	**8:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion **5:30-7:30** Speaker	**8:30-10:00** Discussion: Culture and Learning **10:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion	**7:00-6:00** Out of Town trip to Houston Schlumberger Houston Rail System	**8:00-3:00** Educational Discovery
June 22-27	**8:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion-	**8:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion- **5:30-7:30** Speaker	**8:30-10:00** Discussion: Culture and Learning **10:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion	**7:00-6:00** Out of Town trip to Houston Atofina Chemical Co.	**8:00-3:00** Educational Discovery
June 30-July 3	**8:00-12:00** Practice Run for Symposium w/Faculty **1:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion	**8:00-1:00** Symposium **2:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion **5:30-7:30** Speaker	**8:30-10:00** Discussion: Culture and Learning **10:00-3:00** Educational Discovery **3:30-5:00** Educational Discussion	**9:00-11:00** Program closure **11:00-1:00** Celebration lunch	

Table 1. Schedule for 2003 E^3 Program at Texas A&M University

Component two was the educational discussion sessions. These were used to make the connection between the work that the participants experienced in the laboratory and what they would bring back to their students. The discussion on culture and learning was designed to allow the participants to explore theories and principles including reflection, learning styles, inquiry and how culture influences learning styles. At the end of the program, participants presented their work, lesson plans, instructional materials, and learning activities they planned to incorporate into their classrooms. The participants met with their faculty sponsors on the day before the symposium for a practice run of their presentations. Faculty involvement in the reviewing the technical side of the work was critical and provided one more opportunity for the faculty to learn what the participants gained from the experience. The symposium was held in the last week of the research program, though not on the last day. The participants thus had the ability to make adjustments in their lesson plans based on the feed back received from audience members. Attending were the participants, their sponsoring faculty members, as well as representatives from the Urban and Rural Systemic Initiative partners. Lesson plans and other presented materials have been posted at http://eapoweb.tamu.edu/e3/ , the E^3 website.

As part of Component three of the program, teachers participated in industry field trips to Schlumberger, Houston Light Rail System, Atofina and Texas Instruments. The purpose of the field trips where, to further develop their awareness of careers in engineering and technology. The four industries were selected to provide the teachers with as broad a range of engineering as possible. Schlumberger Oilfield Services is the world's premier oilfield services company, supplying a wide range of technology services and solutions to the international oil and gas industry. The teachers visited the Research and Development Center. The Houston Light Rail System is expected to provide a higher level of transit in the city of Houston, Texas. The light rail will link downtown with other major venues, but it is also believed to have the potential to become the cornerstone of a regional rail system. Atofina is one of the major chemical companies in the world. The teachers visited the research and development center, and then visited an actual chemical plant. Texas Instruments is the world's leader in digital signal processing and analog technologies, the semiconductor engines of the internet age. The teachers visited a fabrication and design facility.

Also part of Component three, a weekly discussion was provided to enhance the teachers understanding of the reality of research versus what was reported by the media. These sessions were developed to broaden the teacher's understanding of the tension between the media and the actual research, so they could take current technological information back to the classroom. Dr. Mark Holtzapple, Professor of Chemical Engineering, presented alternative energy sources. He has developed a process that converts biological materials into useful fuels and chemicals. There is a lot of debate in the media as to America's dependence on fossil fuel and if U.S. will become dependant to other countries. Dr. Bonnie Dunbar, a NASA astronaut, spoke about the Challenger tragedy. She was responsible for operating Spacelab and its subsystems which performed a variety of experiments, while participating in the 61-A Challenger (October 30-November 6, 1985). This was the first shuttle to carry eight crew members, the largest to fly in space, and was also the first in which payload activities were controlled from outside the United States. Dr. Jim Wild, Professor of Biochemistry and Biophysics, provided a thought-provoking look into the ethics accompanying the rapidly evolving business and science of biotechnology. He specifically led a discussion on cloning.

Conclusions

The response from the participants and the faculty sponsors was overwhelmingly enthusiastic. The most valuable aspects of the program, as perceived by the participants, were the opportunities to participate in the research and to see the engineers at work. They felt that the industry tours and the speakers were mentally stimulating. The participants again were asked to define engineering from their current knowledge. Their answers reflected a new and real understanding of the field, as well as a greater appreciation. Several expressed surprise at the range of engineering evidenced in everyday life. When asked if the E^3 experience would impact their teaching, all responded positively. Several felt that they could better explain to the students why they were learning certain skills, while others planned to integrate engineering into their teaching methodologies. The teachers were supported by the community of peers that was built during their experience. Cross-curriculum development and diversity were mentioned as benefits. Many felt that the community could be sustained after the end of the summer program.

Follow up plans include visits to the schools of the participating teachers. One participant has been invited back to work on a NSF funded Career grant with a faculty member. Another has been asked to facilitate the educational discussion sessions. The investigators anticipate widespread interest in program participation for this year as well.

Biographical Information

ANGIE HILL PRICE, Ph. D. is an Associate Professor in the Manufacturing and Mechanical Engineering Technology program at Texas A&M University. She serves as Co-PI on the NSF Research Experiences for Teachers. Her research interests are quality of weldments and thermal grinding damage of gear steels.

KAREN BUTLER-PURRY, Ph.D. is an Associate Professor of Electrical Engineering and Assistant Dean of Engineering at Texas A&M University. She is PI on the NSF Research Experiences for Teachers. Her interests are in the areas of fault diagnosis, equipment prognosis, and reconfiguration of terrestrial and navy electric power systems.

ROBIN AUTENRIETH, Ph.D. is a Professor of Civil Engineering and serves as a Co-PI on the NSF Research Experiences for Teachers and the contact person for the Women Engineering Faculty Interest Group. Her research interests include biological processes: water treatment, biodegradation and bioremediation of selected xenobiotic compounds; bioavailability of contaminants in aqueous and soil environments; and environmental risk assessment.

JAN RINEHART, M.S. is the Director of Engineering Student Programs at Texas A&M University and Immediate Past President of WEPAN (Women in Engineering Program and Advocates Network). She earned a B.S. in secondary education from Abilene Christian University and a M.S. in Higher Education Administration from Texas A&M University. Her interests include equity, leadership, and engineering education.

NAOMI GOMEZ is an Administrative Assistant in the Dwight Look College of Engineering at Texas A&M University and coordinates the NSF Research Experiences for Teachers Program. Her interests include equity, diversity and engineering education.

Appendix A

Faculty Research Descriptions – Research Component

Faculty-participant interaction is a vital element of the proposed research component. E^3 participants will be paired with faculty researchers from Aerospace Engineering, Agricultural Engineering, Biomedical Engineering, Civil Engineering, Computer Science, Electrical Engineering, Engineering Technology, Industrial Engineering and Nuclear Engineering. The faculty researcher will mentor and help a participant understand the current status of emerging technologies and current research findings as well as provide informal instruction in research methodology and science theory appropriate to the research problem. The E^3 participants will be provided the opportunity to examine the outcomes of research performed in a variety of engineering disciplines. **Please rank and select three areas you are most interested in participating from the examples below:**

1. **Maintenance on Utility Power Distribution Systems (Butler-Purry)**

One of Butler-Purry's research projects has been development of techniques for performing predictive maintenance on utility power distribution systems. Their research investigates how various types of distribution system equipment fail. Understanding their failure models requires a fundamental knowledge of the physics of insulating materials and their degradation processes. Performing the research requires experiments, mathematical modeling, and simulation activities to represent the failure characteristics, and signal processing analysis to characterize failure processes. A physics or chemistry teacher might work with a graduate student who is conducting research to observe what has been done experimentally, the models that have been constructed, and how simulations are performed and the results that have been obtained. In conjunction with a more thorough understanding of the failure modes of distribution equipment, the teacher would think about how this could be integrated into their curriculum. Then, the teacher, the science education specialists, Dr. Butler-Purry, and the graduate student would discuss how what the teacher has learned might be incorporated into their curriculum and what might be interesting for the students to do and/or see. Finally, the teacher would prepare lesson plans that they might use during the upcoming school year.
Web site: http://psalserver.tamu.edu/

2. **Environmental Risk Assessment (Autenrieth)**

Risk assessment is a process that can be applied to issues as diverse as business decisions, personal safety, and environmental concerns. Risk assessments provide a systematic framework to understand and manage diverse risks whose basic components include: hazard identification, toxicity assessment, exposure assessment, and risk characterization. Risk analysis, the tool used to evaluate risk assessments, is based on probability of an adverse effect of an agent (chemical, physical, or other), industrial process, technology or natural process. The proposed project would address environmental applications of risk assessment in two realms: human health and ecology. The faculty researchers will provide access to databases on two locations: a wetland on the San Jacinto River, and two cities in Azerbaijan (of the former Soviet Union). The San Jacinto wetland has been studied for the effects of oil inundation in an area that suffers chronic exposure to a range of contaminants. The Azerbaijan cities are linked to an on-going study that

will generate samples from the environment and the human population, which provides a link between environmental concentrations, and human exposures that, can lead to health effects. This project can provide opportunities for mathematics teachers through the statistical foundation of risk assessment and the engineering aspects of environmental management. For science teachers, the mobility of chemicals through the environment encompasses biology, chemistry and physics as processes controlling their fate, transport and exposure to target species, human, plant or animal.
Web site: http://www.civil.tamu.edu/Ugrad/Environmental/faculty.asp

3. Grinding Thermal Damage to Helicopter Gear Steels (Price)

Helicopter gear steels are susceptible to thermal damage during grinding of the gear teeth. This thermal damage manifests itself in the form of untempered martensite that then leads to crack propagation and failure of the gear. This research is critical to preventing failures of helicopter gears that are used in the engines of the helicopters. The grinding process is being studied to determine the amount of energy introduced to the gear surface, which leads to the phase changes. The amount of energy is dependent upon several variables including the grinding wheel, material, and coolant. A science teacher can participate in the data analysis and metallurgical sample preparation for this study.

4. Intelligent Systems Change Lives (Lagoudas)

Teachers would have the opportunity to work with researchers on projects related to Intelligent Systems. The field of Intelligent Systems covers a broad array of systems that can respond to new conditions or requirements on their own in an intelligent way. Much of the work in this area at Texas A&M centers on Intelligent Systems for advanced vehicles (advanced airplanes, space vehicles, submarines, etc.) and is part of a new $15M research institute funded by NASA.

Examples of work currently ongoing at Texas A&M are:

- Aircraft that can sense flight conditions and change the shape of their wings to optimize performance
- Development of special materials such as shape memory alloys and piezoelectric that can be made to move and change shape by changing their temperature, applying a magnetic field or an electric field.
- Intelligent autonomous vehicles that can fly without and perform special missions without a pilot
- Biomimetic vehicles that mimic living organisms, such as submarines that swim like fish
- Nanotechnology for intelligent systems, such as carbon nanotubes to be used as sensors.

All of these technologies have the capacity to greatly enhance the capabilities of advanced vehicles for space, military and other applications.
Web site: http://aeromaster.tamu.edu/Faculty/lagoudas/

5. Using Engineering to Improve Food Safety with Electron Beam Irradiation Technology (Moreira and Castell-Perez)

Foods contaminated with pathogenic microorganisms (Salmonella, Campylobacter, and E. Coli, for example) have caused serious foodborne illness. Foodborne pathogens have been linked to several fruits, vegetables, and juices. In many cases, it is difficult, if not impossible, to either wash these pathogens off the produce or inactivate them by chemical treatments. With almost

25% of food production after harvest in the United States lost due to damage caused by bacteria, mold, and insects and contamination with spoilage microorganisms, it is imperative to investigate the applicability of promising alternative technologies that can be used to improve the safety of ready-to-eat and fresh agricultural products. Recent progress in the development of electron beam accelerators together with the increased number of illness associated with produce-associated foodborn disease outbreaks in the last years provide the incentive for development of an efficient technique to ensure hygienic quality of food products, especially those to be consumed raw or undercooked, to protect consumer health.

This project focuses on understanding, simulating, and predicting irradiation dose distribution for food safety applications. To this end, we will (1) obtain detailed, high resolution dose maps in various irradiated foods using radiation therapy technologies to simulate dose distribution in a product; (2) compare simulated and measured dose distributions for a variety of common food items that are likely candidates for irradiation processing; (3) develop a protocol for irradiation treatment to insure uniform dose distribution in non-homogenous food products; and (4) establish a training program. Our main goal is to design, test, educate, and disseminate developments toward novel technology for a safe and efficient way to enhance microbiological safety in ready-to-eat fruits and vegetables.
Web site: http://baen.tamu.edu/users/castell/ and http://baen.tamu.edu/users/rmoreira/

6. Project: Engineering Design: The Mathematics behind Good Decisions (Klutke)
The process of designing engineered systems (parts, products, or processes) involves allocating scarce resources among risky alternatives. While the performance or use of an engineered system is unpredictable, good designs protect against undesirable outcomes and take advantage of favorable outcomes. This project will lead toward a mathematical framework for assessing risk and will utilize this framework to improve the resource allocation decisions in engineering design. The design paradigm developed will be investigated through several case studies of product and process design, and will used to distinguish between "good" and "bad" designs.
Web site: http://ie.tamu.edu/