

Reaching 6th through 8th Grade Students through the National Science Foundation Research Experiences for Teachers Program

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Abstract

The National Science Foundation instituted a novel program recently called Research Experiences for Teachers (RET) which allows principal investigators to request a funding supplement to existing grants to enable interaction with K-12 teachers. At Auburn University in Auburn, Alabama, the Department of Industrial and Systems Engineering received funding for two teachers for the summers of 2002 and 2003. A science teacher of 6th and 7th graders and a math teacher of 8th graders joined the research team on the project “Relating Field Data to Accelerated Life Testing”. The project aimed to correlate wear and degradation of solder connections on under the hood electronic components with that expected through accelerated testing using temperature cycling. Besides conducting research, the other primary goal of the RET was for the teachers to develop classroom modules based on their research experiences. This experience has been enriching, not just for the teachers and their young students, but for the Auburn University industrial engineering faculty and students. This paper will describe how the RET program works and the possibilities for benefits to both K-12 and higher education in math, science and engineering.

Overview

Through the National Science Foundation’s Research Experiences for Teachers (RET) program, at Auburn University in Auburn, Alabama, Alice Smith of the Department of Industrial and Systems Engineering received funding for two teachers for the summers of 2002 and 2003. Mark Jones, a science teacher at Drake Middle School (6th and 7th grades), and Cynda Fickert, a math teacher at Auburn Junior High School (8th grade), joined the research team on the project “Relating Field Data to Accelerated Life Testing (EEC-0002669)”. Both schools are part of the Auburn City Schools. This school system serves a diverse student body which includes approximately 30% low income students. This project was conducted jointly with the interdisciplinary NSF sponsored University / Industry Center for Advanced Vehicle Electronics (CAVE) and DaimlerChrysler Electronics in Huntsville, Alabama. The project aimed to correlate wear and degradation of solder connections on under the hood electronic components with that expected through accelerated testing using temperature cycling. The test subject was the transmission controller on Jeep light trucks.

Jones, with his background in the natural sciences, worked primarily on the examination of the solder joint material through mechanical testing and scanning electron microscope photos. Fickert concentrated on the data analysis and statistical modeling for the correlation between mileage of the field units and solder joint degradation as measured through joint shear strength.

Besides conducting research, the other primary goal of the RET was for the teachers to develop classroom modules based on their research experiences. These modules were to be used in their classes as both hands on learning experiences for their students, and as stimulators for students to consider career opportunities in engineering. During the RET time, Fickert and Jones designed two inquiry-based units to use in each of their classrooms.

Jones says of his RET experience, “I use a great deal of discussion in my classroom to promote inquiry in my classroom culture. One aspect of that culture is the students’ perception of the teacher as an expert on certain topics. The experience with CAVE allows me to put myself in a professional setting if I find the opportunity to use that

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experience within the context of the classroom. I expect that I will be able to use CAVE within my own testimony when my class begins a unit on properties of matter.” Fickert states, “The interaction with the entire CAVE project challenged me in many ways, and I enjoyed learning how the project relates industry to education, at both the graduate and junior high school levels. The interaction with professionals, the financial opportunity, working with graduate students, operating the machines in the lab, and helping with the CAVE project all helped to make this a very meaningful opportunity for me personally and professionally. I believe this summer’s work will help me in various ways throughout this school year and the years to come. I use many activities in my classroom to incorporate problem solving skills and number sense. In addition, the experience added to my knowledge of real-world applications for the skills in my pre-algebra curriculum. I will be able to help my students better understand the need for a solid understanding of statistics, graphs, ratios and proportions, and I will be able to help them connect this information with everyday electronics such as cell phones and video games... This was the one of the most dynamic summer experiences I have had, and my students will reap the benefits.”



Figure 1. Teachers Mark Jones (left) and Cynda Fickert (right) work in the CAVE labs.

Mathematics Students

The math-oriented unit involves the use of different cross-section sizes and different types of wood to test them for strength. This was inspired by the use of shear-strength testing of the solder joints from the project. The students’ objective is to test different woods for strength by placing samples of wood on a loading block and hanging a bucket in the middle of the wood by a force sensor. Part of the materials money supplied by the RET grant was used to buy digital interfaces that included force sensors, so that the experiment would integrate computers. The students pour sand into the bucket until they break the wood. The computers log the data automatically and allow for faster data gathering, enabling the students to complete this activity in one class period. The inquiry part involves the groups’ interpretation of the results on the next day. Eighth graders performed this module during fall term with the side result of a sand-laden computer lab.



Figure 2. Math students performing shear strength activity at Auburn Junior High School.

Science Students

The science-oriented unit is about soldering copper pipes. This is connected to the CAVE project since it is about solder, lead's effects on the environment, but also to the common student, since all of them have running water and some of them may have experience with soldering or one of their parents soldering. The RET grant funded soldering kits and propane blowtorches. The students first learned how to solder a joint using a soldering iron in order to introduce them to the technique and allow them to become more comfortable and mature when working with something that is extremely hot. After that, the students soldered four pieces of copper pipe (one for each person in the group) with a blowtorch. The competition was for the students to create solder joints by using the least amount of solder, while also keeping the joints watertight. This correlated with CAVE's work with industry in which research is done to make the cheapest product that is still safe and functionally dependable. The student groups were ranked according to their product. First, students' pipes were attached to a faucet and if they leaked, they were ranked behind all others that did not leak. All of the pipes that did not leak were then ranked according to the amount of solder used. Students had to integrate some math into this set of labs as well as getting a good understanding of how business and research work together by experiencing the challenge of production.



Figure 3. Science students solder on wood to get used to working with the soldering equipment.



Figure 4. Science student blowtorch copper pipes (left) and get used to working with heat (right).

Field Trips

As an extra activity, the University invited both schools on a field trip to the CAVE labs. Over 100 students from four math classes at Auburn Junior High and over 100 students from four science classes at Drake Middle School visited on two different days. The students were rotated through stations at the CAVE labs (clean room and screen printing room) and student designed and built race cars (mini Baja and formula racer). At each station, they were hosted by undergraduate and graduate engineering students who described what was going on. Each student took home a screen-printed coaster from the CAVE lab with the Auburn University logo on it.



Figure 5. Field trip to the CAVE labs to see how circuit cards are manufactured.

Training at NASA Goddard Flight Center

NSF, in conjunction with NASA, sponsored the teachers to attend a one-week intense training session at Goddard Flight Center in Maryland in June. The training was customized from five of the NASA courses on soldering, ESD, fiber optics, crimping, surface mount and polymeric coverings. The teachers learned many techniques and had a chance to tour the Flight Center. NASA also donated 120 soldering kits for their students, which are being used in this year's activities.

Concluding Remarks

This experience has been enriching, not just for the teachers and their young students, but for the Auburn University industrial engineering faculty and students. We have learned more about how 11 to 14 year olds learn and their views on engineering. It is been a joy to interact with these youngsters – their sense of wonder and enthusiasm are infectious.



Figure 6. Teachers Cynda Fickert and Mark Jones with their NASA instructor.

This year's activities are even more exciting. Cynda will be working with her students on soldering stained glass ornaments, then using the ornaments to measure angles, areas, etc. This combines science with geometry and art. Mark has added the subject of conductivity to his units and has started an Electronics Club for students especially interested in that area. This after school club will provide more in-depth activities that tie science and engineering together and create devices for the regular classroom to use like an ultrasonic translator. We also anticipate some more technical field trips to the CAVE labs for this group of students.

Reference

"Are you experienced?", *Industrial Engineer Magazine*, vol. 35, no. 9, September 2003, 36-39. Article on the RET (Research Experiences for Teachers) project.

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Alice E. Smith

Alice E. Smith is Philpott-WestPoint Stevens Professor and Chair of the Industrial and Systems Engineering Department at Auburn University. Previous to this position, she was on the faculty of the Department of Industrial Engineering at the University of Pittsburgh, which she joined in 1991 after ten years of industrial experience with Southwestern Bell Corporation. Dr. Smith has degrees in engineering and business from Rice University, Saint Louis University and University of Missouri - Rolla.

Her research in analysis, modeling and optimization of manufacturing processes and engineering design has been funded by NASA, the National Institute of Standards (NIST), Lockheed Martin, Adtranz (now Bombardier Transportation), the Ben Franklin Technology Center of Western Pennsylvania and the National Science Foundation (NSF), from which she was awarded a CAREER grant in 1995 and an ADVANCE Leadership grant in 2001. Her industrial partners on sponsored research projects have included DaimlerChrysler Electronics, Eljer Plumbingware, Extrude Hone, Ford Motor, PPG Industries and Crucible Compaction Metals. International research collaborations have been sponsored by the federal governments of Japan, Turkey, United Kingdom and the U.S. Dr. Smith has served as a principal investigator on over \$2.5 million of sponsored research. She was named a Philpott-WestPoint Stevens Distinguished Professor in 2001 by the Auburn University College of Engineering. For outstanding achievements in research and scholarly activity she received the annual Senior Research Award of the College of Engineering at Auburn University in 2001 and the University of Pittsburgh School of Engineering Board of Visitors annual Faculty Award in 1996.

Dr. Smith holds one patent pending and has authored over 50 publications in books and journals including articles in *IIE Transactions*, *IEEE Transactions on Reliability*, *INFORMS Journal on Computing*, *International Journal of Production Research*, *IEEE Transactions on Systems, Man, and Cybernetics*, *Journal of Manufacturing Systems*, *The Engineering Economist*, and *IEEE Transactions on Evolutionary Computation*. She won the E. L. Grant Best Paper Award in 1999 and the William A. J. Golomski Best Paper Award in 2002. Dr. Smith holds editorial positions on *INFORMS Journal on Computing*, *IEEE Transactions on Evolutionary Computation* and *IIE Transactions*.

Five of her doctoral students have obtained tenure track positions at U.S. universities and two of these are NSF CAREER awardees. Dr. Smith is a fellow of IIE, a senior member of IEEE and SWE, a member of Tau Beta Pi, INFORMS and ASEE, and a Registered Professional Engineer in Industrial Engineering in Alabama and Pennsylvania. She serves as Senior Vice President (Academic) and on the Board of Trustees and on the Educational Foundation Board of the Institute of Industrial Engineers.

Cynda Fickert

Cynda Fickert is an eighth grade pre-algebra teacher at Auburn Junior High School in Auburn, Alabama. She is in her twelfth year of teaching. Prior to her current position, she taught sixth and seventh grade mathematics at the same school, and she taught fifth grade in Rome, Georgia. She has degrees from Berry College and Columbus State University.

Ms. Fickert was awarded a Toyota Time Grant in 2003 and an Educational Data Systems Grant in 2002. She has also received several Foundation for Auburn's Continuing Enrichment in Schools (FACES) grants over the last six years. Ms. Fickert is currently serving as Auburn Junior High School's Teacher of the Year.

Professionally, Ms. Fickert has been involved with a Research Experience for Teachers (RET) program at Auburn University for over two years. Through this program, she has brought hands-on activities incorporating various aspects of engineering research to her students. She is also an active member of the National Council of Teachers of Mathematics, Alabama Education Association, and the National Education Association.

Mark Jones

Mark T. Jones is a Nationally Certified Teacher and Chair of the Science Department at Drake Middle School in Auburn, Alabama. Before coming to Drake, Mr. Jones was a teacher within the same system at Auburn Junior High

School for three years and taught at a military academy for two. Mr. Jones took a teaching job after getting a master's degree in zoological sciences from Auburn University. Within his teaching career, he has since received an M.Ed in science education and later a specialist's degree. He is currently pursuing his doctorate from the Science Education Department at Auburn University.

Over the past four years Mr. Jones has implemented hands-on inquiry based kits into the science classrooms at Drake and led the ongoing professional development needed to succeed with these kits. These kits provide students the chance to actively engage in science and problem solve at the same time. The results of this professional development have led to a professional development school partnership with Auburn University and their science education department. Mr. Jones' experience with this program has developed into a dissertation topic.

Mr. Jones has multiple other experiences in programs designed to bring real and engaging science into the classroom. He has used research experiences to provide connections in the classroom between the curriculum and real science. Mr. Jones has worked within the Industrial and Systems Engineering Department at Auburn University for the past two years. Within this program he assisted in multiple research projects and was allowed time to develop these experiences into units for all his classes as well as activities for focused groups of students who show advanced interest and are willing to participate in activities after school. These units are also being piloted among other science teachers at his school and at Auburn Junior High School. Another experience with University faculty included a "Soils Magic" book with the Geology Department at Auburn University which is to be made into classroom activities. Mr. Jones' first experience like these was in 1998, where he worked with the Auburn University Vet School in a project involving detector dogs.