

Partnering with K-12 Institutions to Prepare School Teachers for Engineering Education

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Abstract— The Texas Tech University College of Engineering has been working for five years to develop and implement our Pre-college Engineering/Architecture Academy Program for K-12 institutions, but it was only when we began a teacher training program did the Academy begin to solidify into a program that empowers teachers to integrate engineering concepts and principles into the K-12 classroom.

The Glenn Commission Report [1], the 2004 ASEE K-12 Workshop [2], NSF funding trends, and a growing number of other sources indicate wide consensus that the quality of K-12 teacher preparation needs to be improved—especially in the areas of math and science—and that the number of teachers teaching out of their disciplines is alarmingly high. In addition, very few public school teachers have a clear concept of the knowledge, skills, and disciplinary areas that define engineering, so teachers are typically ill-equipped to advise students about engineering careers and almost certainly lack the skills to develop hands-on activities that demonstrate engineering concepts. As an engineering college we found our expertise in developing engineering course content that worked within the myriad of constraints of K-12 environments is limited, at best. Hiring K-12 teachers to work with us in developing engineering resources within the core K-12 disciplines—math, science, language arts, and social sciences—has allowed us to train teachers to incorporate engineering content that aligns with state standards, so teachers are not required to create new courses, but to incorporate engineering into what they are already teaching. By partnering with K-12 institutions in Texas, we have been able to form a cadre of teachers to develop and teach the workshops as well as develop resource guides that align engineering content to state standards.

This paper will discuss forming this cadre of teachers and developing the resources that support teacher training.

Index terms - K-12 education, teacher training, education partnerships

INTRODUCTION

Two years ago when we conducted our first teacher training workshop in order to inform and educate K-12 teachers about engineering, we had no idea that teacher training would be the

catalyst to launch our five-year old Pre-college Engineering/Architecture Academy Program (PEAP).

Because of the TTU College of Engineering Early Admissions Program (EAP) [3] we had developed in 2000, we had established an initial partnership with Lubbock Independent School District (LISD). Because the EAP required high school teachers from five area schools to act as facilitators for the Introduction to Electrical Engineering course, while COE faculty remained the instructors of record, we set a precedent of paying teachers a \$1000 stipend to participate in the EAP, working with their students who were taking the EE course while still attending high school. We piloted the PEAP at Estacado High School, populated with predominately African Americans and Hispanics students, located in an area of Lubbock that is considered mostly low income with a Title 1 designation.

When we initiated the pilot of the Pre-college Engineering/Architecture Academy program at Estacado High School [4], we continued the model of paying five teachers (math, science, language arts, social studies, and instructional technology) a stipend each semester. Our expectations were that the teachers would develop engineering curriculum for us that we would be able to disseminate to other schools.

However, because we had no experience with K-12, we had no idea what to ask for in the way of curriculum deliverables. Our presumption was that with our help, teachers would be able to work with and integrate engineering concepts into what they were teaching. At the same time, the high school teachers had little to no knowledge of engineering and had no idea how to begin developing a curriculum for us.

Pre-college Engineering/Architecture Academy Program

Although pre-college programs have been around since 1966 when Elizabeth Blodgett Hall established one at a private girls school in Concord, Massachusetts [5], the TTU Pre-college Engineering/Architecture Academy Program focuses on inspiring students to become engineers and teaching teachers about engineering so that they can encourage students to seek engineering careers.

Often students say that they chose engineering not just because they like and excelled in math and science but that they know an engineer or there is an engineer in the family. A few students will say that a junior high or high school teacher has encouraged them to seek engineering degrees. This is

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certainly not the fault of the teachers because very few teachers have the opportunity or a reason to take an engineering course. From our observation, teachers seem much more comfortable advising students to seek law or medical degrees than engineering. This is primarily because they lack knowledge of exactly what engineers do. We feel that the Teacher Training Institute and the PEAP will help to inform teachers about engineering so that they are as comfortable talking to their students about engineering careers as they are other professional careers.

In addition, we want to address the diversity issue in engineering by targeting students from underrepresented populations. Ronald Ferguson, a Harvard Kennedy School of Government professor, spent four years observing junior high and high schools to determine that “without interest and support from teachers—which matter more to minorities—floundering black students eventually become resigned to their low position on the academic totem pole, fail to develop essential skills and slip even further behind” [6]. By training teachers how to engage students in hands-on projects, we feel that more minority students will not only become engaged in learning but also interested in engineering.

But through our partnerships with Lubbock Independent School District (LISD), Roosevelt Independent School District (RISD), and Frenship Independent School District (FISD), we have discovered that we can do more. We can help teachers prepare students to seek higher education and to be successful once they get out of high school. Although, because the program is relatively new and there is little hard data to support this premise, K-12 teachers assure us that students are much more engaged in learning because they see how math applies to what they are designing or developing. As one Jr. High teacher indicated when talking about teaching variables in algebra, “Students see that the x’s and y’s have meaning because they are being applied to something real.”

ASEE president and Olin College Vice President for Innovation and Research, Sherra Kerns, “has become convinced that immersing children in the world of engineering should begin at an early age. ‘I think young children are natural engineers—if you’ve ever seen a 2 year-old figure out how to reach a countertop to get a cookie. They will move things into place, create structures and piles, test them for stability—it really is an engineering kind of a problem’” [7].

Through our PEAP, we want to nurture those “natural engineers” and ensure that they do not lose the sense of achievement when they discover ways to solve problems on their own, with direction and guidance from their teachers. We feel we are developing a K-12 pipeline of students who are excited about learning because they have engaged in project-based learning, have the ability to apply math and science to engineering problems, and have an understanding of differences among engineering disciplines.

External funds were used to continue a number of science and engineering-oriented learning activities from last year during summer 2004, and to develop two new training opportunities for K12 teachers that provided exciting hands-on learning experiences for their students in the upcoming school year. Each of the activities described in the following sections included a teacher training/support component.

In all of the tracks, teachers are trained to integrate engineering with the K-12 core subject areas Language Arts, Social Sciences, Mathematics, and Science—with a special emphasis on the latter two. For example, teachers are encouraged to have students research the history of a content area such as rocketry, or to develop writing assignments that correlate to the engineering project deliverables, or to include other communication assignments like progress reports in the form of oral presentations. One of the most exciting things to see is how students talk about their project, the problems they encountered and the processes they used to solve their problems—it does not matter if it is LEGO robotics or rockets, students have challenges to overcome in any project-based assignment because there is never a single solution to the kinds of problems they encounter.

RoboRaiders Summer Institute

In 2001, with the help of COE staff members, the LEGO RoboRaider program was initiated in a fourth grade class at one of the elementary schools in LISD Quadrant IV. Quadrant IV schools include Dunbar Junior High School and Estacado High School where we have established engineering magnet programs—all are Title 1 schools with majority populations of children from low-income African American and Hispanic families. Based on the success of this program, we offered our first LEGO workshop in 2003.

Because this training was so well received and impacted such a large number of students, we increased the number of offerings to two workshops in the summer of 2004. Again, we paid instructor fees, covered stipends to K-12 teacher participating in the training, and purchased site licenses and LEGO kits to seed programs in schools that sent teachers to the training.

In addition, TTU student mentors participated in the week long training as facilitators, and to receive training to inform their activities in providing classroom support for K-12 teachers in the upcoming year.

This training contributes to the Pre-college Engineering Academy’s project-based curriculum by giving the K-12 teacher/participants hands-on experience in developing classroom exercises using programmable LEGO equipment. The teachers applied this training in a Summer LEGO Camp for elementary school students in the summer and developed some activities during the school year that engaged students in

learning about science, technology, engineering, and mathematics.

These teachers also participate in follow-up meetings to share experience and receive additional training in short workshops during the school year.

Developing our own content for the RoboRaider training has resulted in several school districts from across the State sending teachers for robotics training. Several of these districts have initiated various activities such as after-school programs with engineering content as result, and Abilene and Bastrop have requested our help in establishing complete TTU Pre-College Engineering Academy programs.

Because of the increased demand for the LEGO workshops, this summer (2005) we plan to offer three sections of the original workshop, and one new advanced workshop that focuses on using LEGO probes and sensors for teachers that have taken the introductory workshop. This workshop is being developed in partnership with LEGO Education and Pitsco [8].

Lego Summer Camp

Some K-12 teachers trained in the RoboRaider Summer Institute worked with TTU College of Engineering staff, student mentors, and with their colleagues to expand the number of students and schools participating in our two-week summer program for fifth and sixth grade students. In the Lego Summer camp, students learned about and constructed various mechanisms and robotic devices, learned basic programming skills to control their devices, and visited the TTU campus to see research applications in various engineering departments for many of the skills and concepts they had learned. TTU student mentors and engineering staff participated in the program as classroom facilitators and as tour guides for the campus visit. As with the teacher workshops, the demand for this program has increased the scope of the program. In 2003 we supported a summer camp at one elementary school. In 2004 an additional school participated. Plans for this summer are for five elementary schools in Lubbock Quadrant IV to participate in the LEGO Summer Camp.

Rocketry Workshop: Physics of Stable Flight

Because the aerospace and defense industries have a higher need for engineers today that they have in the recent past, they are reaching out to K-12 students. "By the time you get to junior and senior year in high school, it's almost too late," Northrup Grumman's Haynes says in the November 2004 *Prism* article "Answering the Call" which talks about the need for more engineers in aerospace and defense. [10]

The Center is exploring every opportunity to develop curriculum and content that is useful in teaching engineering concepts and skills, so we were thrilled when Brett Williams, a teacher at Fredericksburg High School, approached us to

help develop and disseminate the exceptional rocketry program that he created. In developing this program, we formed the Texas Partnership for Areoscience Education (TPAE), a consortium that includes Fredericksburg ISD, Texas Tech, Midland College, and Pecos County Spaceport Development, Inc. With contributions from all the partners, a number of exciting educational opportunities have already emerged, and we are developing a rocketry thread that includes three levels of teacher training that will be developed for the Academy program. In the summer of 2003, we hired Mr. Williams to deliver the first level of training to teachers in the West Texas region. The content provides an exciting hands-on approach for teaching physics and mathematics using rockets to illustrate the concepts being taught. Texas Education Agency (TEA) funding was used to cover much of the cost of the one-week workshop, to provide the materials to build the rockets, and to provide materials and site licenses for a rocket simulation software program to help the teachers implement the content of the workshop in their own schools. TTU mentors helped facilitate the workshop and participated in the training to help further develop this thread in as part of the Academy program. As with the LEGO program, in 2004 we offered two sections of this workshop to meet the demand from Lubbock schools and school districts across the State for teacher training.

Tripoli Level I & II Rocketry Certification Workshop

Because of the demand for more advanced training in rocketry, in 2004 we developed a new workshop that would allow teachers to go beyond the training offered in the first rocketry workshop and receive certification by the Tripoli Rocketry Association. This certification allows them to launch larger rockets capable of carrying payloads that can give their students a wider range of engaging learning experiences. All seven participants in this workshop successfully earned Tripoli Level I & II certification, which was the largest group in Tripoli history to achieve both certifications at one time. We will offer this workshop again in 2005, and also provide assistance to 2004 participants who wish to earn their Tripoli Rocketry Association Level III certification in the workshop.

PongSat Program

The PongSat program is sponsored by J.P. Aerospace [9], an aerospace company that is affiliated with one of our partners in TPAE, Pecos County Spaceport Development, Inc. As part of their contribution to the TPAE, the Spaceport Development group and Midland College sponsored a training session in which teachers from Lubbock schools participated in during the summer 2002-2003. During the 2003-2004 school year, students sent their experiments on balloon platforms to altitudes approaching 100,000ft. The experiments were returned to the students to study the results with video footage

of the flight and all the flight data from the trip. The teachers who attended the PongSat training developed research problems for the students prior to placing their experiments in the ping pong ball, and on return of the balls to the classroom, students made scientific observations and measurements of the results of their experiments.

TEKS Workshop

While all of this training for teachers is exciting and gives them resources to get students engaged in hands-on learning and engineering, without curriculum materials that align with state standards—in Texas these are the Texas Essential Knowledge and Skills (TEKS)—it is almost impossible for teachers to find the time to add something new to their teaching schedule, much less have to justify the new content based on the TEKS. To help validate our program and develop useable content for teachers attending our training, in 2004 we paid stipends to a group of teachers who has participated in previous workshops to work with an educational consultant to align our workshops and other K-12 activities with the Texas Essential Knowledge and Skills standards for each grade level. The outcome of this workshop was an eight volume Teachers Resource Guide, which we are in the process of editing and obtaining all permissions necessary to disseminate to K-12 schools.

We now request that teachers taking any of our teacher training workshops, and those participating in the Pre-college Engineering/Architecture Academy program to provide us with lesson plans with engineering content for the resource guide.

Earth Engineering

The Aero-Science and the Robotics content threads are becoming fairly well established, so in 2005-2006 we plan to begin development of an Earth Engineering content thread. As with the AeroScience and Robotics threads, Earth Engineering will be multidisciplinary, but the focus will be on environmental and petroleum engineering. Halliburton funding is being used to help to establish this track.

This track will provide earth science content in the form of engineering projects that address such issues as water resources and water recovery. And because Lubbock is centered in an area of West Texas that is rich in oil, we want to take advantages of resources available to us by introducing teachers and K-12 students to petroleum engineering. The thread will also include architecture component to address environmental friendly housing and other issues that compliment the engineering focus on reusable resources.

Petroleum Engineering faculty as well as Halliburton engineers have expressed a keen interest in taking part in developing a teacher training program for the petroleum engineering component of this thread. In addition,

environmental engineering faculty members are looking at ways to get involved with K-12 students, so by participating in the teacher training workshops, faculty and K-12 teachers will have an opportunity to work together.

CONCLUSION

With funding from the Texas Education Agency (TEA) through the Texas Alliance for Minorities in Engineering (TAME) and Halliburton, we were able to pay teachers stipends and room and board for attending the workshops the first two summers (2003 & 2004); however, because the demand has outstripped our limited funding, this summer (2005) we will have to charge a nominal fee to attend the workshops.

While we are concerned that charging for the workshops—as opposed to paying stipends as in years past—will result in decreased attendance, we are only covering the cost of room and board for the workshops with the fees. We are still absorbing all of the instructor fees, materials, facilities, and other associated costs. After much discussion with school administrators and among ourselves, we realized that they have as much buy-in as we do to providing teachers with professional development, especially in math and science, but in Language Arts and social sciences, as well. They see the TTU Teacher Training Institute as supplement for the teachers with strong backgrounds in their disciplines and as a major support for teachers who are teaching out of their discipline. One of the areas that ISD administrators are most concerned is with scores on the Texas Assessment of the Knowledge and Skills (TAKS) test.

An additional benefit of working with K-12 teachers is that they will get a better sense of what higher education expectations are for students entering college. The Association of American Colleges and Universities National Panel Report points out that “most colleges do not share with secondary schools what they expect incoming first-year students to know and be able to do to succeed in college” [11]. K-12 teachers who take the Teacher Training Summer Workshops will have a better understanding about the demands an engineering curriculum has on students, and why the students need to have the advanced levels of science and math before they graduate from high school.

Additional information about the Texas Tech University Center for Engineering Outreach, the Pre-college Engineering/Architecture Academy Program and the Teacher Training Workshops can be found on the Center for Engineering Outreach website <http://outreach.coe.ttu.edu/>.

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