TTU College of Engineering Pre-College Engineering Academy© Teacher Training Program

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Abstract
This paper reports on progress to-date in the planning, design, and initial implementations of a K-12 engineering program being developed collaboratively by Texas Tech University, Lubbock Independent School District, and a growing number of other entities. The paper discusses various issues endemic in K-12 and post-secondary education that have driven the evolution of the program, especially focusing on our experience in working with K-12 teachers to introduce engineering content into public school curriculum.

The TTU College of Engineering Center for Partnerships in Science and Technology is actively engaged in developing curriculum, teacher training and support, academic competitions, after school programs, and other educational activities to increase awareness about engineering practice in the different engineering disciplines, and to provide engaging learning experiences for K-12 students and teachers. The Academy began with a pilot engineering magnet program at Estacado High School in Lubbock. The magnet program has grown to include feeder programs with several elementary schools and junior high schools in Lubbock. Additionally, teacher training programs and workshops with engineering content that have been developed as components of the program are increasing the scope of the program to schools across the West Texas Region.

Ultimately, the goal of the Pre-College Engineering Academy is to significantly increase the number of K-12 students, especially those from underrepresented populations, entering higher education tracks in science, technology, engineering, and mathematics (STEM) disciplines. To help ensure that these students are equipped to successfully earn their degrees, the Academy program is developing components not only to provide rigorous academic preparation, but also to establish support mechanisms to ease the social transition into the university environment. For example, a mentoring component provides resources for underrepresented TTU engineering students and organizations (e.g., National Society of Black Engineers, Society of Hispanic Professional Engineers, Society of Women Engineers, etc.) to work with K-12 students and teachers to facilitate project-based curriculum in K-12 classrooms while serving as role models.

This paper also discusses the structure and content of various K-12 teacher training workshops and professional development opportunities the Center has developed, which support vertical alignment of curriculum, provide engaging approaches to teaching mathematics and science, and educate teachers about engineering practice and education.

Overview of Our Current Progress

As reported at the 2003 American Society of Engineering Education conference [1], we were in the third year of a five year development plan based upon Michael Fullan's design for accomplishing

systemic improvement in education, which argues that the culture of communities and organizations must be changed before changes in their structure will be successful [2,3]:

> Our five-year plan aims at initiating cultural change in stages: first, within our partnering entities; then, through dissemination of our experience and best practices developed at the local level, expanding change to the educational culture of the West Texas / Eastern New Mexico region; and finally, by informing and actively participating in education reform at the state and national levels. We have identified four core areas of development that also will be addressed in stages, with results of pilot programs and initial activities informing increasingly larger scale implementations [1].

The four core areas of development we were pursuing, and are continuing to pursue, are excerpted from the 2003 article as follows:

> *Standards-based Curriculum Enrichment and Development* – …there are only a few courses at the high school level in the Texas Education Agency's (TEA) inventory that can be viewed as having any substantive engineering emphasis or content. This lack of approved engineering curriculum discourages schools from …programs with an engineering orientation because they are largely restricted to awarding local credit for these offerings——which may not always be transferable[1].
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> *Teacher Training and Professional Development* – The Glenn commission report raises disturbing questions about the level of teacher preparation in science and mathematics [4], moreover, teacher certification tracks in higher education almost never provide pre-service teachers with any exposure to engineering disciplines or practice. Teachers play a significant role in counseling and encouraging students toward specific educational and career paths, but their lack of experience with the requisites for engineering careers inadequately prepares them to help students make informed educational and career choices regarding engineering[1].
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> *Mentoring and Recruitment* – We view mentoring as a crucial activity for creating educational reform and cultural change because it promotes sharing of ideas, techniques, and resources, and provides advanced role models to encourage students, teachers, and practitioners alike to pursue higher-levels of achievement[1].
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> *Informal Education and Community Engagement Activities* – Texas Tech has a strong track record in K-12 and community outreach[5]. Our intention is that the TTU Center for Partnerships in Science and Technology will become a well-recognized point of contact to allow the community more access to the resources and learning opportunities of a major research institution….[in the areas of] math, science, robotics, and other STEM competitions; hands-on exhibits; demonstrations; campus visits; and other similar programs[1].

With regard to these core areas of development, we have made little progress with the first, with the notable exception that some of our activities in the areas of teacher training and mentoring have been funded by TEA grants and have received significant recognition—both of which have

resulted in initial discussions with some TEA administrators about various issues pertaining to pre-engineering curriculum in Texas schools. We have made significant progress in the other areas of development. This paper will focus upon the teacher training component of the Engineering Academy program for two reasons. First, it was the most difficult element of the program to establish. And second, because we have come to recognize that the teacher training model that has emerged has the most potential for expanding the scope of the program and making it sustainable.

Development of Our Teacher Training Model

Many of the problems we have encountered in developing the Academy program stem from the fact that initially we had little experience with the culture and political environment of public schools. We are beginning to move beyond the learning curve and have established significant credibility with the STEM content and learning experiences that we have developed to date.

The TTU Pre-College Engineering Academy program began with a pilot engineering magnet program at Estacado High School in Lubbock. Estacado High School is located in the Northeast quadrant of Lubbock, and its student population reflects that of the surrounding community, which has an overwhelmingly majority population of Hispanic and African-American families. It is also one of the schools mentioned in Texas House Bill 400, which directs State-funded Universities in Texas to work in their regions to improve the number of graduates from underperforming high schools entering post-secondary degree programs [6].

In our original model, Estacado High School teachers were paid stipends by Texas Tech to work with TTU faculty and students to integrate engineering projects into courses they teach and to horizontally align their classroom activities with the other teachers participating in the program. For example, the project we attempted for the Fall 2000 semester required students at Estacado to research, design, and propose building a neighborhood playground. Academy students took some classes in cohort groups, and the engineering problem was meant to serve as an illustration for their classroom activities——i.e., in their physics and mathematics classes students would examine structural considerations and make calculations related to the playground, in their English class they would learn the documentation conventions necessary to carry a project of this nature, in their chemistry class they would examine relevant environmental considerations, etc. There were, and still are, six teachers participating at Estacado High School representing the following disciplinary areas: Math, Physics, Chemistry, English, Social Studies, and Technology.

While this project-based model seemed to have significant potential for educational reform, we found that it was impossible to sustain for a number of reasons. First, it was too difficult for the school administration to schedule cohort group classes, and they could not find a way to provide the teachers time during the week to work together to align what they were doing in their individual classes. Another issue was that the teachers did not have enough experience with engineering projects to even know what kind of help to ask for, even though we provided TTU faculty contacts and student mentors for their classrooms. Conversely, we didn't know enough about the public school environment to provide adequate support that was useful to the teachers or to work through the various administrative issues. We continued to try to implement this model at Estacado for three years before we were forced to reassess our efforts.

Development of the LEGO Thread
At the same time, we were also working with other K-12 schools in the quadrant to develop feeder programs for the Pre-college Engineering Academy, including Dunbar Junior High School Math and Science Academy and Harwell Elementary School. These schools serve the same population as Estacado; however, our focus at these schools was get students excited about math and science instead of trying to implement a school-within-a-school model, as with Estacado. Instead of semester-long, multi-disciplinary, projects, we worked with teachers to develop smaller exercises and activities. One initial success was with an after-school LEGO program, in which we provided LEGO kits and mentors to help students learn about basic mechanisms and programming.

This program became so popular at both of these schools that teachers from both schools asked to participate in a one-week D-Teach training program at the University of Texas in Austin. National Instruments paid the teachers' tuition, and we provided their travel expenses. As a result of this experience, National Instruments and UT encouraged the TTU Center for Partnerships in Science and Technology develop a similar training program to be delivered at TTU for teachers in the West Texas region.

Last summer, we offered the RoboRaider LEGO training program to K-12 teachers, which included site licenses for RoboLab and LEGO kits to seed programs in area schools. One of the teachers from Dunbar Jr. High that participated in D-Teach last year and two TTU Graduate Teaching Assistants from our Computer Science department were paid to develop and deliver the content. TTU mentors participated in the week long training as facilitators, and to receive the 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 this summer and are developing various activities during this school year to engage students in learning about science, technology, engineering, and mathematics. As a result of the success of the RoboRaider training other elementary schools in LISD expressed interest in starting similar Lego programs and we now have new programs at Hodges, Whiteside, and Ramirez elementary schools. TTU student mentors will provide classroom support for these new programs.

These teachers are also participating in follow-up meetings to share experience and receive additional training in short workshops. Developing our own content for the RoboRaider training will make this an ongoing training opportunity for area teachers, and will help with the Center's efforts to develop threads to improve vertical alignment in area schools.

Development of the Aero-Science Thread
Because of the success of the LEGO program, we began exploring every opportunity to develop curriculum and content that is useful in teaching engineering concepts and skills. We were delighted 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 Aero-science 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. Each of these levels of training—stable flight, transonic flight, and high altitude flight—emphasizes different engineering design problems and requires increasingly complex mathematical models. This past summer, 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.

Another component that has emerged within the Aero-Science thread is the PongSat program, which is sponsored by J.P. Enterprises, 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 as part of the aero-science thread that we are developing for the Pre-College Engineering Academy program. PongSat provides opportunities for K-12 teachers to arrange for their students to have experiments that must fit inside a ping pong ball carried on balloon platforms to altitudes approaching 100,000ft. The experiments are returned to the students to study the results with video footage and the flight data from the trip.

Conclusions

One important lesson we have learned from our activities is that the teacher training and the kinds of follow-up support we are developing appears to have a much larger impact with regard to both the quality and quantity of engineering content that is implemented in K-12 classrooms, in comparison to our original model at Estacado High School. We will continue to sponsor the program at Estacado; however, we are using experience gained with the feeder programs to change our approach to how the magnet program is being developed and supported. In addition, we have struggled with the issue of how we could effectively disseminate the TTU Pre-College Academy experience for schools outside of Lubbock.

The insight we have gained to date suggests that the teacher training components we are developing seem to have the most promise for disseminating the program, and we are now working on effective methods to provide the follow-up support that is a unique and crucial part of the Engineering Academy program, especially as the scope of the program continues to broaden. However, we recognize that we need help from K-12 curriculum specialists to ensure that the content we offer aligns with State and local requirements, and that it is packaged so that K-12 teachers can implement the project-based curriculum easily in their classrooms. We have also found that it is necessary to support the teachers we train by providing continuing opportunities for their professional development and for disseminating best practice ideas

The TTU Pre-College Engineering Academy program is the result of over four years of planning and implementation effort. While the program is still in development, and continues to evolve, it is already making a positive impact on STEM education, both in Lubbock Independent School District and other districts in the region, and in Texas Tech University. Currently, the magnet program being piloted at Estacado High School and other schools in quadrant four in Lubbock

still require a lot of attention to keep the momentum we have gained. However, the program is being documented and the training and support mechanisms are being developed for dissemination to other schools that may wish to adopt the program in the future.

Our teacher training model demonstrates benefits of the program that we had hoped would emerge from the magnet program at Estacado, such as the positive impact of having K-12 students and teachers working directly with university students and faculty; integrating public school curriculum both horizontally and vertically; introducing engineering concepts and skills into K-12 curriculum; and having the local school district, university, and other entities collaborate to improve STEM education in Lubbock. The following items are some of the positive outcomes training program.

- Strengthened working relationships and trust between LISD and TTU, particularly with schools in quadrant four of LISD, and increased the scope of some of the components of the program to other ISD's in the region.

- Increased opportunities to provide relevant STEM training to K-12 teachers in Lubbock and the West Texas region——particularly with regard to working with TPAE, National Instruments, and other partnerships that are forming as a result of the program. As we gain experience with what seems to be the most effective strategies for providing engineering content to benefit K-12 education, the focus of the program is turning more toward our teacher training efforts as the most effective means of impacting K-12 STEM education, as we as a means for scaling-up the program to make it more available. We have come to realize that the mentoring program is absolutely essential in developing and implementing our teacher training and support efforts.

- Increased opportunities for K-12 students to participate in meaningful and engaging educational experiences in STEM disciplinary areas——particularly students from underrepresented populations.

- Expanded partnerships to improve STEM education——for example, the City of Lubbock has expressed a desire to participate in the Pre-college Engineering Academy program, and the momentum gained by the TPAE in a very short period underscores the importance of partnerships as the TTU Pre-College Engineering Academy program develops and grows.

- Increased opportunities for Texas Tech students to participate in Service Learning activities and develop the habit of making a contribution to the community in which they live.

A number of the teachers from Estacado participated in the training we offered last summer, and all have reported that the training empowered them to better implement engineering concepts into the curriculum they teach than anything we had tried before. We have stopped paying stipends and trying to impose a school-within-a-school model at Estacado, and mirroring our experience with the feeder programs, we are beginning to see more engineering content and a more rigorous math and science content at this school.

Works Cited

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