

**TTU College of Engineering Pre-College Engineering Academy©  
Estacado High School Pilot Program**

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#### Abstract

This paper reports on progress to-date in the planning, design, and initial implementations in a K-12 Pre-College engineering program being developed collaboratively by Texas Tech University (TTU) and Lubbock Independent School District (LISD). The Pre-College Engineering Academy© is a multidisciplinary, project-based curriculum that presents high school students with realistic engineering problems and supports K-12 teachers by providing mentoring, training, and detailed specifications for design, documentation, testing, and other engineering project requirements. A Memorandum of Understanding between Texas Tech and the Lubbock Independent School District formalizes a partnership in which both entities commit resources to develop the Academy program.

In the pilot, Estacado High School teachers and other K-12 teachers are 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 participating teachers at the high school. For example, the project for the 2002-03 school year requires students at Estacado to research, design, and propose building a neighborhood playground. Academy students take classes in cohort groups, and the engineering problem serves as an illustration for their classroom activities—i.e., in their physics and mathematics classes students examine structural considerations and make calculations related to the playground, in their English class they learn the documentation conventions necessary to implement a project of this nature, in their chemistry class they address relevant environmental considerations, etc.

The TTU College of Engineering is also working with other K-12 schools to develop feeder programs for the program, including Dunbar Junior High School Math and Science Academy, and Harwell and Wheatly Elementary Schools. Teachers in these schools are working with teachers from Estacado and TTU faculty and students to find ways to align the pre-engineering curriculum vertically. Ultimately, the goal of the Academy program is to get students excited about science, technology, engineering, and mathematics (STEM) at an early age, and then to provide them with a consistent learning experience that continually extends their knowledge and practical use of STEM concepts and skills throughout their academic careers from middle school, to high school, and into college.

#### Overview

Estacado High School is located in the Northeast quadrant (quadrant four) of Lubbock, and its student population reflects that of the surrounding community, which has an overwhelmingly

majority population of African-American and Hispanic families. The Texas legislature identified Estacado High School as one of several schools in the state included in House Bill 400 as “among the lowest 10 percent of high schools in the state in the percentage of students graduating from high school and enrolling for the following academic year in a college or university” (Texas Higher Education Coordinating Board, October 30, 2001). Universities nearest the schools cited in HB 400 are required to develop plans to enter a partnership with the school district to increase the number of students going on to higher education. Texas Tech University had begun working with Estacado High School toward developing the pilot for TTU Pre-College Engineering Academy program well over a year before HB 400 was passed.

The TTU Pre-College Engineering Academy initiative is the result of two years of planning and commitment by current partners in the TTU Center for Partnerships in Science and Technology. The goal was to develop a multidisciplinary, Pre-College engineering curriculum and establish the higher education, industry, and community support mechanisms necessary to sustain and disseminate an engineering education model. This model embodies practical applications for science, technology, and mathematics—that, heretofore, have been substantially missing from K-12 education.

The overarching aim of the Pre-College Engineering Academy Program is to provide a framework for engaging students in rigorous inquiry-based learning in science, technology, engineering, and mathematics (STEM)—and for providing pedagogical training, professional development, and recruitment opportunities for K-12 teachers in these fields. Ultimately, the center’s partners are committed to attracting more students to educational and career paths in STEM areas and developing support mechanisms to help ensure their success and to developing a sustainable model for increasing our capacity to provide the highest quality education possible.

#### Rationale

There is wide consensus among institutions and researchers that improving learning opportunities in STEM disciplines is a key approach for “ensuring a diverse, scientific and technical workforce, as well as a citizenry capable of mastering the scientific and technical concepts and skills needed by workplace, social, and home environments that are characterized by increasing technological sophistication”<sup>1</sup>. Over the past three decades, a significant amount of attention has been paid to improving STEM educational programs in K-12 and two and four year higher education institutions, resulting in improved educational opportunities in STEM areas for students<sup>2</sup>. However, these programs continue to attract only a fraction of the number of students into STEM areas that are needed in the workforce. Moreover, women and minority students have remained disproportionately underrepresented in STEM disciplines<sup>3, 4, 5, 6, 7, 8</sup>.

The TTU Pre-College Engineering Academy provides a powerful and practical model to address growing problems related to the alarming shortage of STEM practitioners, particularly in engineering, and the declining enrollments in university STEM programs<sup>9</sup>. Increasingly, science, technology, engineering, and mathematics curriculums are mandated for K-12 institutions. For example, Texas has adopted the Texas Essential Knowledge Skills (TEKS) and the Texas Assessment of Knowledge Skills (TAKS) to improve the STEM skills and performance of K-12 students in the state. However, while these kinds of initiatives underscore the need to attract more

K-12 students into educational and career paths in science and engineering, they do little to ensure engaging, beneficial educational experiences to K-12 students in STEM areas. Nor do they provide any practical means for training public school teachers, who typically have no preparation for teaching engineering concepts and scant understanding of engineering practice, which requires significant practical application of science, technology, and mathematics<sup>10</sup>. The TTU Engineering Academy program seeks to address these fundamental issues by leveraging the resources of our partnering entities to develop accessible STEM course content, engaging project-oriented curriculum, and teacher training and support in STEM disciplinary areas.

While the partnering entities already have committed significant resources to developing infrastructure and individual programs that will form components of the TTU Pre-College Engineering Academy initiative, we recognize that developing a sustainable, well articulated model for pre-engineering education will require a substantial, long-term commitment to affect the educational reform and cultural change that our experience and the literature indicate will be required. Our development plan is based upon Michael Fullan's compelling 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<sup>11,12</sup>.

#### Development Plan and Program Design

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. We will continually assess our efforts in each of these areas, both individually and in aggregate—with formative assessment used by the project directors, staff, and participants to make adjustments as the initiative develops and summative assessment used to evaluate the success of the initiative and for dissemination purposes. These core areas of development are as follows:

- *Standards-based Curriculum Enrichment and Development* – While the Texas Essential Knowledge Skills (TEKS) provide a nationally recognized example of a results-oriented standard for improving STEM content in K-12 education, 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 developing and offering individual courses or magnet programs with an engineering orientation because they are largely restricted to awarding local credit for these offerings—which may not always be transferable. In addition, there is confusion as to what teacher certification requirements are appropriate for pre-engineering courses.

We are addressing these issues by having University and K-12 faculty and staff collaborate to develop pre-engineering content that will enrich existing STEM courses and encourage students to pursue more rigorous Advanced Placement (AP) coursework and distinguished

degree programs in high school. We are extending this enriched content approach to include elementary and middle schools in order to interest more students at an early age in STEM concepts, and to better prepare them for more advanced STEM coursework in the rest of their education. Ultimately, our aim is to develop a four-year pre-engineering curriculum, with articulated standards for student achievement and teacher certification that can be reviewed for adoption by TEA. Teachers will be paid stipends as incentive to participate.

- *Teacher Training and Professional Development* – The Glenn commission report raises disturbing questions about the level of teacher preparation in science and mathematics<sup>13</sup>, 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. Teachers are often more comfortable advising students about careers in medicine or law than advising them about engineering. We recognize that providing both pre-service and in-service teachers with significant exposure to engineering practice and training in applying engineering concepts and skills is a critical component to implementing sustainable pre-engineering curriculum.

We have begun the process of developing undergraduate and graduate courses, as well as short courses, workshops, and other educational and professional development opportunities that will provide both pre-service and post-baccalaureate teachers a foundation in engineering and immerse them in pedagogies that use an engineering approach to illustrate STEM principles. TTU faculty from engineering, education, architecture, mathematics, and the sciences will be provided incentives to jointly develop these training and professional development opportunities. K-12 teachers will be provided incentives to participate and upgrade their knowledge and skills.

- *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. We plan to expand existing mentoring programs among partnering entities, and to develop new mentoring programs where none currently exist. Our intention is to create a rich environment for collaboration in which practitioner engineers, university faculty, and university students serve as mentors and facilitators for K-12 teachers, administrators, and students; K-12 teachers and administrators mentor pre-service teachers, students, and less experienced teachers; high school students mentor middle school students; and middle school students mentor elementary students. Our goal is to expose more students to the practice of teaching to inspire an increased number to consider pursuing rewarding careers as STEM educators. Various incentives will be developed and provided to encourage extensive participation in these mentoring programs.
- *Informal Education and Community Engagement Activities* – Fullan suggests that community involvement is a critical success factor to engendering true cultural change<sup>11,12</sup>. Texas Tech

has a strong track record in K-12 and community outreach<sup>14</sup>. However, while we have been extremely successful in developing a wide-range of beneficial outreach activities, we have not been as successful in leveraging our resources and experience to improve and scale-up these programs. 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 and those of our partners. The kinds of STEM activities that comprise this category are math, science, robotics, and other STEM competitions; hands-on exhibits; demonstrations; campus visits; and other similar programs that make STEM concepts more available to our sister institutions and the community as a whole.

During the planning for this project, which is ongoing, we have identified a significant number of issues that we are in the process of addressing. For example, because there is little experience with K-12 Pre-College engineering curriculum, there are very few available course texts aimed for a secondary school audience. A significant amount of time has been spent researching, evaluating, and developing relationships with publishers, manufacturers, and other entities that produce texts, curriculum, and other resources that may prove useful for the curriculum under development.

#### Progress to Date

In the 2001-02 school year, the program developed and offered a pilot course with engineering content to 9<sup>th</sup> grade students in which they earned technology credits. This course emphasized design, teamwork, and project documentation in a context that engaged students in building robots, bridges, and other devices and structures. During this period, six teachers at Estacado received stipends to develop a multidiscipline, engineering project-oriented curriculum for delivery to 10<sup>th</sup> grade students in the Fall 2002 semester. TTU faculty mentors in the disciplinary areas of each of the teachers (Mathematics, Physics, Chemistry, English, Social Studies, and Technology) helped developed the curriculum that is being piloted this semester.

Additionally, we have developed a mentoring program for TTU students to work with Estacado students and students in the feeder programs. As part of this mentoring program, the TTU student chapter of the National Society for Black Engineering (NSBE) established a junior chapter on the Estacado campus with approximately 60 high school students participating. This junior chapter was selected for a NSBE Vanguard Award for NSBE Region V in Fall 2002.

In keeping with our plan for staged development, we are currently in the initial phases of the first stage of development. While a number of elements of the program are in place, we are currently working with very limited resources, and so much of the planning tentatively hinges on developing funding for technology and lab equipment, stipends, and other costs associated with developing a program of our intended scale.

A Texas Education Agency grant for the program awarded under the auspices of the Texas Alliance for Minorities in Engineering (TAME) during the Spring 2002 semester allowed us to significantly expand the mentoring program; provide increased training opportunities for K-12

teachers, including LEGO training for a robotics program that will be used in the Academy and its feeder programs; purchase classroom teaching equipment for the participating schools, and to deliver several hands-on engineering experiences for students in the quadrant.

### Conclusion

One of the primary weaknesses of K-12 education for encouraging students to succeed in math and science is little practical application of math and science at the K-12 level. At the same time, the majority of students and teachers in K-12 have little or no knowledge of engineering issues or practices. Although technology continues to gain importance, the awareness of the roles that math and science play in designing and developing technology is lacking in K-12 curricula.

TTU is partnering with teachers at Estacado High School in order to advise them on how to adapt the existing TEA curriculum to include engineering issues and practices. Not only will teachers be better informed about engineering and be better suited for advising students to seek engineering education, but also teachers will have an overall better understanding of the role of engineering in society. Students from all of the K-12 schools in this program will have numerous opportunities to visit Texas Tech campus and to interact with engineering, math, and science students and faculty. They will have the opportunity to visit engineering labs to see experiments and research conducted by engineering students and faculty.

We also intend to increase and sustain the number of K-12 teachers by providing TTU undergraduate and graduate courses that they can take for credit, in which engineering principles and skill areas are taught by engineering faculty. These courses will focus on what engineering is, what engineers do, and how math and science play a vital role in preparing students for careers in engineering. This will insure that both pre-service and in-service teachers will have some indoctrination into engineering and be stimulated into discovering the role they can play in providing society with future engineers. In addition, teachers will have a better appreciation of the why students need to be strongly encouraged and directed into advanced math and science courses. Also, TTU will provide in-service teachers summer workshops for professional development. The summer workshops will be designed around the undergraduate and graduate courses, but will be abbreviated in order to serve as many K-12 teachers as possible.

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