

# TEXAS TECH UNIVERSITY Center for Engineering Outreach

Inspiring and preparing tomorrow's engineers



## Developing Resources for Aligning K-12 Engineering Education to State Standards in Texas

### About the Center for Engineering Outreach

Engineers are problem solvers. Computers, safe water and highways are just a few things invented by engineers that we use everyday. Using math, science and technology, engineers make life safer and easier.

Engineers are in short supply. Nation-wide enrollment in engineering programs continues to decline. Schools don't teach engineering in their classes, and students don't understand what engineers do and how they impact our world.

Engineers are important. We want people to understand how important engineers are to society. At the Center for Engineering Outreach, we're working to educate people about engineering, encourage students to pursue engineering careers and prepare students to be successful in college engineering programs.

#### Our Programs

Committed to inspiring and preparing tomorrow's engineers, the Center for Engineering Outreach works to integrate engineering into all levels of education.

Targeting students, teachers, and administrators from elementary schools to community colleges, our current programs include the Pre-college Engineering Academy, Teacher Training Institute, Engineering Camp and Engineering Outreach Mentors.

Whether preparing teachers to teach engineering concepts, encouraging students to see math and science in a new way or supporting both teachers and students in the classroom, our outreach programs impact all areas of education.

#### Pre-college Engineering Academy

Focused on introducing students to engineering, the Pre-college Engineering Academy partners with school districts to provide an engineering-based curriculum for classroom use.

Each component of the academy's curriculum teaches engineering concepts while emphasizing problem solving, teamwork, and project management. Lessons are aligned to state of Texas standards, giving teachers an opportunity to easily incorporate academy content into their classrooms.

Recently, students from Lubbock Independent School District's Pre-college Engineering Academy set a national record by becoming the first high school team to launch a large-scale, supersonic rocket powered by solid propellant. The successful classroom project incorporated physics, mathematics and engineering in the design, construction and launch of the rocket.



Teacher Training Institute: Teachers collaborate on a robotics project during the Introduction to Robotics workshop offered as part of the Teacher Training Institute.



Engineering Camp: Two fifth grade girls team-up to design and build their week-long project during Engineering Camp.



Pre-college Engineering Academy: Students and advisors from Lubbock Independent School District's Pre-college Engineering Academy pose with their supersonic rocket, Mentor 1.

#### Teacher Training Institute

Teachers from across the state participate in this series of rigorous workshops focused on engineering education topics.

Each workshop is taught by academic and industry professionals. Engineering-based topics include robotics, aere science, geoscience/petroleum engineering and environmental engineering.

All participants receive professional development credit. Each workshop provides teachers with lesson plans and activities to use in the classroom along with supplies for those projects.

#### Engineering Camp

Geared for 5th and 6th grade students, Engineering Camp is an exciting, hands-on experience that introduces kids to math, science and technology as they discover engineering.

Project-based learning and excursions to local engineering sites, make Engineering Camp a fun and educational atmosphere where kids discover what engineers do and how engineering affects society.

#### Engineering Outreach Mentors

Bringing the expertise of the university to the K-12 classroom, Engineering Outreach Mentors are the field agents of the Center for Engineering Outreach Program.

Our student mentors partner with teachers and their students as engineering experts within the classroom. Mentors help to support and facilitate engineering lessons, but more importantly they serve as role models for the students.

Engineering Outreach Mentors are selected annually from current Texas Tech engineering students; each mentor receives a scholarship for their participation.

#### Contact Us

The Center for Engineering Outreach is always interested in hearing from our partners in the academic community. For information about any of our programs visit our website or contact us.

Center for Engineering Outreach  
P.O. Box 43103  
Lubbock, Texas 79409-3103  
806.742.3451  
806.742.3493 fax  
engineeringoutreach@ttu.edu  
http://www.outreach.coe.ttu.edu



www.outreach.coe.ttu.edu

A. Dean Fontener, John R. Chandler, Robert D. Waller, Betsy O. Carpenter, Matti Travis and Marti Smith

Increasing the number of students entering engineering colleges and insuring that those students are successful in engineering disciplines depends, in many ways, on the role that higher education plays in providing engineering resources to K-12 teachers<sup>1</sup>.

By providing engineering resources, content and training that meet state standards for K-12 teachers, higher education can make a difference in the number of students applying to engineering colleges as well as the success rate of those students.

#### State Standards in Texas

In 1990 the Texas Legislature mandated that all students be tested according to a standardized body of knowledge, the Texas Essential Knowledge and Skills (TEKS).

In 2002 the first set of Texas TAKS Assessment Levels Assessment of Knowledge and Skills (TAKS) tests were administered to schools as shown in Figure 1.

Content Area	Grade Levels
Reading	3-9
Writing	4, 7
Language Arts	10, 11
Mathematics	3-11
Science	5, 10, 11
Social Studies	8, 10, 11

Each school's performance on the TAKS figures strongly into a school district's evaluation, significantly affecting formula funding from the state.

#### Rationale for a Standards-Aligned Engineering Resource Guide

For most Texas school districts, success is based on student performance on the TAKS test. As a result, the majority of classroom curricula is focused on teaching and reinforcing the TEKS.

To provide K-12 teachers with an engineering resource guide they would actually use in the classroom — without jeopardizing their students performance on the TAKS test — any resource guide being developed would have to be aligned to state standards.

From the start, this engineering resource guide was designed to integrate engineering concepts and skills into the core curricular areas and align the lessons to the TEKS. Such a plan achieved two goals.

- 1) Engineering-based lessons provided teachers a hands-on method for reinforcing the TEKS.
- 2) Introducing engineering content in grades K-12 provided interest in engineering concepts and disciplines from the earliest school years until graduation.

These goals form the basis for the horizontal and vertical alignment of our engineering curriculum. The lessons are horizontally aligned to the TEKS across all content areas at all grade levels (Figure 2), and the lessons are vertically aligned to distribute graduating

levels of engineering mastery that build through all grade levels (Figure 3).

#### Horizontal Alignment Across Content Areas

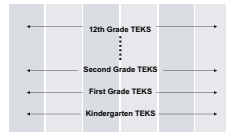


Figure 2: Horizontal alignment across

#### Vertical Alignment Through Grade Levels

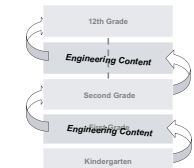


Figure 3: Vertical alignment through grade levels

As students progress through this model, they are introduced to broad engineering concepts in the early school years. These concepts spiral through the grade levels and increase in scope and exposure to engineering disciplines. Eventually, in high school, more rigorous engineering learning experiences like peer mentoring with younger students or internships with industry can be implemented.

The benefits of this model are its adaptability for school districts and the exposure to engineering disciplines that it provides students.

With this methodology students could be better prepared for collegiate engineering programs, and engineering content could be easily integrated into core courses at each grade level, meeting goals of both statewide education officials and engineering education advocates.

The successful implementation of this model requires not only well-documented curriculum but also teacher training and classroom support that provides structure and reinforcement for K-12 teachers and students.

#### Developing the Resource Guide

In developing a standards-aligned engineering resource guide for our Pre-college Engineering Academy, we needed expertise in curriculum assessment and state standards. Hiring a qualified curriculum consultant was a critical first step to our success.

Because we planned to pilot the Pre-college Engineering Academy engineering resource guide in a region of the Lubbock Independent School District with a large minority population<sup>2</sup>, nine teachers from elementary, middle school and high school campuses were invited to contribute to the discussion.

What emerged from the dialogue with these experienced teachers is an eight-volume, engineering resource guide that is both horizontally and vertically aligned to state standards. The guide is divided by grade level with each grade level having six engineering categories.

- Systems
- Critical Thinking
- Scientific Tools
- Communication
- Patterns and Structures
- Technology

By focusing on broad themes common to all engineering disciplines, the teachers were able to integrate engineering concepts into these six categories. Lesson activities ranged from kindergarten students identifying patterns with Duplo<sup>TM</sup> blocks to high school students identifying and managing complex manufacturing processes.

To provide structure for the resource guide, the teachers developed a lesson plan template that could be applied uniformly across all grade levels. This template is flexible and adaptable, allowing the teacher to make adjustments for each class.

Figure 4 is an example of this lesson plan template. This sample lesson plan demonstrates the possibilities for teaching engineering concepts at the kindergarten level using the story of *The Three Little Pigs*.

With online resources like TeachEngineering.com<sup>3</sup> and engineering resource guides like the one developed for the Pre-college Engineering Academy, teachers can feel comfortable introducing their students to engineering while simultaneously continuing their preparations for standardized tests, like the TAKS.

#### Supplementing the Resource Guide

Developing and distributing an engineering resource guide is only a first step. Providing resources or activities for the classroom is not enough. Teachers and students must be supported in the classroom if engineering curricula is to take root in our school systems<sup>4</sup>.

For our Pre-college Engineering Academy, the Center for Engineering Outreach provides a variety of enrichment components. Foremost are our Teacher Training Institute and Engineering Outreach Mentors.

The Teacher Training Institute provides professional development opportunities that help equip teachers for introducing engineering content into their classrooms. Similarly, the Engineering Outreach Mentors support teachers in our pilot programs by visiting schools, assisting teachers and facilitating engineering activities as role models for K-12 students.

#### Conclusions

Integrating engineering content into the K-12 curriculum is a complex but necessary task if interest and preparedness for collegiate engineering programs is to increase. Such a goal requires cooperation from K-12 school districts, state education entities and institutions of higher education.

By focusing our efforts on developing engineering content that can be seamlessly integrated into the current education system and supported both in professional development and classroom support, higher education has the opportunity to impact recruitment, retention and graduation rates tomorrow's engineers.

**TEXAS TECH UNIVERSITY  
Center for Engineering Outreach**

**Building with the Three Little Pigs**

Grade Levels:	PreK - Kindergarten	TEKS Addressed:	2.1.2, 4.5, 5.1.2, 6.1.2
Content Levels:	Science		6.1.2

**Purpose:** Students will learn about building materials and construction modeling techniques by reading *The Three Little Pigs*, discussing their reading, and building a model house.

**Materials:** The Three Little Pigs  
Picture of construction using different materials  
Paper  
Tape  
Duplo<sup>TM</sup> blocks

**Preparation:** Prepare for the lesson by reviewing the story of *The Three Little Pigs*. Prepare samples of large, strong, and Duplo<sup>TM</sup> blocks that students can investigate. Make a printed packet of large, strong and Duplo<sup>TM</sup> blocks for students to sort during the lesson activity.

**Activity:**

1. Read about the story of *The Three Little Pigs*.
2. Discuss the story with children.  
What materials did the pig build with?  
What buildings did you build?  
What buildings do we use to build buildings today?
3. Show the students pictures of construction projects. Discuss the projects.  
How do people use different building materials?
4. Provide students with the small samples of the large, strong, and Duplo<sup>TM</sup> blocks.  
Have the students sort out the building materials.
5. Let the students build a model of their house out of the provided materials.

**Evaluation:** Have the students describe an animal and what the story experience have each student contribute to the story setting of what they did for the pig.

**Extension:** Have students draw pictures or sketches of their houses. Discuss how materials are fitted and how they describe the animal and the house.

**Resources:** Deane, Nancy. *Illustrator: The Three Little Pigs*. Margaret Press, 1971.

Figure 4: Sample engineering lesson plan for kindergarten

1. Greater Expectations: A New Vision for Learning as a Nation Goes to College. (2002). Association of Colleges and Universities National Center for Higher Education. Washington, DC, 2002.

2. Douglas, J., Iversen, E., and Kaplanovich, C. "Engineering in the K-12 Classroom: An Analysis of Current Practices & Guidelines for the Engineering Education Research Program." American Society for Engineering Education, 2004 K-12 Center, American Society for Engineering Education. 2004

3. TeachEngineering.com. Hands-on Resources for K-12 Educators. http://teachengineering.com/. Accessed 2004 Dec. 30.

4. Chandler, J. R. and A. Dean Fontener (2003). "TTU College of Engineering Pre-College Engineering Academy Program: Teachers Training Program." Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, American Society for Engineering Education, Session 2350, CODRM, 2004.