REDE Rice Engineering Design Experience

A Summer Workshop for Secondary School Teachers

The Problem Of the thirty projected fastest-growing occupations through 2016, sixteen of them require substantial mathematics or science prepration.[1] The Texas economy relies heavily on the energy, biomedical, space/electronics systems, and chemical industries, all of which require workers with strong science, technology, engineering and mathematics (STEM) skills. These industries are facing a shortfall in available talent at all levels: technicians, operators, health workers, and engineers.[2] Historically, engineering and STEM careers have been a primary upward economic path for students from disadvantaged backgrounds. That opportunity still exists, but today such students, and females, are severely underrepresented in STEM careers, and too few students overall are prepared to meet projected STEM workforce needs. To meet the growing shortfall, all students need to be prepared to pursue STEM careers, yet only 35% of Texas students are at or above proficiency in mathematics, and the grade 8 science score for Texas students ranks only 35th among the 50 states. Only 30% of Texas graduating high school students took the ACT college entrance exam in 2007, and of those, only 41% scored at a level indicating they were ready for college level algebra, a ranking of 36/50; ACT science scores were even lower, ranking 39/50.[3] Clearly a significant change in the approach to STEM education and curriculum is needed to engage and motivate Texas students.

Research Base Recent studies show that design-based teaching of science concepts results in superior student knowledge gain, engagement, and retention compared to scripted-inquiry teaching.[4] The engineering design pedagogy was most helpful to low-achieving African American students. Students working to solve interesting, real problems see the relevance of science and mathematics skills, are motivated to master those skills, and have the opportunity to practice them in a process that is fundamentally different from learning science and mathematics through traditional methods.[5] Project-based, design-centered instruction can teach students to "think like an engineer," and to dream beyond what exists to what *can* be. Based on such research results, Texas, like many states, has adopted a high school course on Engineering Design and Problem Solving, with TEKS standards, as one of the new fourth-year science electives. However, few teachers are familiar with or prepared to teach engineering design and problem solving or to include design problems in science classes.

Empowering Teachers Rice University and the UTMB-Galveston Southeast Regional Texas STEM Center propose a two-year program to provide 45 teachers with the experience, knowledge, and skills necessary to guide students through engineering design problems that integrate science and mathematics concepts and meet the new engineering TEKS standard. Teachers also will be able to integrate design projects into science courses to enhance learning. Intensive two week summer workshops (80 contact hours each) are followed by one day workshops, school visits, and support activities during the academic years (70 hours). In the summer workshops, teachers are immersed in authentic engineering design problems that highlight problem solving

techniques, team development, project management, effective documentation, and assessment of project results and participant performance. Drawing on these experiences, and the content material, teachers will develop classroom implementation strategies for design-based curriculum. Activities during the summer and academic year will also familiarize teachers with engineering practice and ethics, engineering areas and careers, and educational options; plus, prior to the second summer workshop, selected teachers will have two-week internships in local industry engineering groups to gain real-world perspective. Based on these experiences, teachers will be able to describe engineering practice, degrees, and career paths to students, giving them a vision of the excitement and rewards of a STEM career, and motivating them to follow that path. Teachers completing the two-year program will receive 6 graduate credit hours in Education from Rice.

Outcomes Following the Rice Engineering Design Experience, participants will be able to:

- Explain the steps of the engineering design process and their purpose;
- Form and guide the development and organization of effective student teams to solve design problems;
- Guide student teams through the steps of an engineering design problem;
- Integrate design-based exercises in science classes to enhance learning;
- Implement procedures to document design projects, both written and oral;
- Assess team project outcomes and apportion credit between members;
- Define intellectual property and the various means of protecting it.
- Describe the various areas of engineering, engineering practice, careers, and rewards;
- Use case studies to illustrate engineering ethics, responsibility to the public, and the interface with business management, and
- Explain engineering degrees, and how to prepare for them, including 2-year technical degrees.

Program Organization The REDE workshop is organized by the Rice University George R. Brown School of Engineering[6] and the Southeast Regional Texas STEM Center,[7] and will be given on the Rice campus in the new Oshman Engineering Design Kitchen. Key personnel include Dr. James F. Young, Program Director and Professor of Electrical and Computer Engineering at Rice, Dr. Deborah Jensen, Program Coordinator, and Dr. Monique Micheaux-Gordon, Director of Instruction, both with the SRT-STEM Center. Dr. Young led the Dean of Engineering's task force on engineering education, developed and teaches a graduate course on Teaching Engineering, and has taught engineering design for 10 years to engineering and non-engineering students.[8] Drs. Jensen and Micheaux-Gordon have extensive experience in developing and presenting professional development workshops for secondary school science and mathematics teachers. Rice University has a long, successful history of hosting professional development workshops for secondary AP and IB teachers from across the state and nation.

Conclusion REDE teachers will have the experience, skills, and confidence to direct students in design-based learning experiences, experiences that have been shown to improve student's learning of science concepts. Further, design-based curriculum and teachers familiar with design and engineering can give students a vision of the excitement and rewards of a STEM career. REDE teachers will become agents of change for STEM education in their schools; they will:

- provide rigorous design-based STEM classroom experiences for all students;
- connect STEM learning to career opportunities and community issues;
- use research-based best practices to inform STEM instruction, and
- participate in learning communities online and in person to disseminate best practices.

References

1. U.S. Bureau of Labor Statistics, *Occupational Outlook Handbook.*

2. Texas Workforce Commission, Texas Labor Market & Career Information Data Link (http://www.tracer2.com/cgi/dataanalysis/?PAGEID=94&SUBID=142) ; for 2006-2016 projections, see *www.tracer2.com/admin/uploadedPublications/826_826_Tx_OCC.xls* (accessed 10/15/08).

3. STEM Education Coalition 2008, *Texas' K-12 STEM ED Report Card*, http://www.usinnovation.org/state/pdf_stem/STEMEdTexas08.pdf (accessed 11/11/08).

4. M. M. Mehalik, Y. Doppelt, and C. D. Schuun, "Middle-School Science Through Design-Based Learning versus Scripted Inquiry: Better Overall Science Concept Learning and Equity Gap Reduction," Journal of Engineering Education, vol. 97, pp. 71-85, January 2008.

5. H. Marks, "Student Engagement in Instructional Activity: Patterns in the Elementary, Middle, and High School Years," American Education Research Journal, vol. 37(1), pp. 153-184, Spring 2000.

6. Information at http://engr.rice.edu/ (accessed 10/15/08).

7. The Southeast Regional T-STEM Center is chartered and funded by the State of Texas. The lead organization is the University of Texas Medical Branch in Galveston; its major collaborators are Texas State University at San Marcos College of Education and Rice University. More information is at http://www.utmb.edu/tstem/. The Center works with the Texas High School Project, http://www.thsp.org/home/ (accessed 10/15-08).

8. For extensive information on the Rice course Introduction to Engineering Design, ELEC 201, see http://www.owlnet.rice.edu/~elec201/; the course Teaching Engineering, ENGI 501, is detailed at http://www.ece.rice.edu/~young/engi501/ (accessed 10/15/08).