

2006-2371: SUPPORTING K-12 TEACHER PROFESSIONAL DEVELOPMENT THROUGH THE NATIONAL CENTER FOR ENGINEERING AND TECHNOLOGY EDUCATION

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Supporting K-12 Teacher Professional Development through the National Center for Engineering and Technology Education

Introduction

William Wulf [1], president of the National Academy of Engineering, noted in his summary remarks at the IEEE Engineering and Education Deans' Summit Conference I, that encouraging engineers and educators to work together to address issues of technological literacy is a brilliant idea. The dialog between engineering educators and technology educators shows great potential for a symbiotic alliance to benefit both. The dialog has been facilitated by the publication of the *Standards for Technological Literacy* [2] that is national content standards for technology education similar to, and aligned with, the national standards for mathematics education and for science education. The Standards for Technological Literacy (STL) were developed by the International Technology Education Association (ITEA) with funding from NSF and NASA. The STL were reviewed and endorsed by the National Academy of Engineering (NAE) and William Wulf wrote the forward to the document [3].

Salinger describes the breadth of standards for science, technology, engineering, and mathematics (STEM) education and concluded that standards should cause cross curricular teaching and learning and that the standards should be geared toward higher levels of achievement. He is not specific regarding what to teach, however, he strongly emphasized the need for curriculum integration among STEM subject areas.

The collaboration between engineering and technology educators is an important initiative that has tremendous potential for benefiting both. Therefore, the National Center for Engineering and Technology Education (NCETE) has been established.

Goals and Purpose

The ultimate goal of NCETE is to infuse engineering design, problem solving and analytical skills into technology education to increase the quality, quantity, and diversity of engineering and technology educators. This is being accomplished by teaming engineering faculty and technology educators to build capacity and infrastructure including collaborative technology teacher pre-service and professional development, funding for doctoral studies, and research.

Perspective: The Relationship Between Engineering and Technology Education

Introducing K-12 students to engineering concepts occurs formally in mathematics classes, science classes and technology classes, and informally through experiences in places such as science museums and discovery centers. NCETE emphasizes introducing engineering design and analysis formally through standards-based instruction in technology classes. One question that should be addressed is: Why did NCETE choose to introduce engineering concepts in technology classes? Why not work with K-12 science or mathematics teachers? The answer most simply stated is that design taught in technology education in K-12 is most closely related to engineering design. NCETE investigators think exposing K-12 students to engineering design will excite young people about the engineering profession. Furthermore, technology education exposes

students to open-ended problem solving, a skill required of future engineers.

Technology education is often misunderstood – it has undergone a significant transformation since the mid-1980's. At the core of this transformation is a transition from education associated with the industrial arts to education associated with technological literacy and engineering education in K-12 schools. This transformation is hardly complete, in part, because of stereotypical attitudes held by many. Greg Pearson [4], a Program Officer with the National Academy of Engineering, candidly points to some of the problem, "Let's face it, engineering is filled with elitists and technology education is for blue-collar academic washouts." In the same article, he recommends, "Leaders and influential thinkers in both professions have to decide that the benefits of collaboration outweigh the risks."

With the publication of the Standards for Technological Literacy [2], reshaping the technology education curriculum provides an important opportunity for engineering and technology education collaboration. The standards prescribe design concepts be introduced throughout the K-12 curriculum. Four of the 20 standards for technological literacy specifically address design: standard 8 deals with the "attributes of design," standard 9 with "engineering design," standard 10 with "troubleshooting, research and development, invention and innovation, and experimentation in problem solving," and standard 11 with "applying the design process." In the forward to the standards, William Wulf noted, "It is not enough that the standards are published. To have an impact, they must influence what happens in every K-12 classroom in America."

Technology education shares engineering education's desire to emphasize open-ended problem solving and the design process. For example, Standard 8 delineates design steps very similar to those introduced to engineering students. In order to recognize the attributes of design, students in grades 9-12 should learn that the design process includes:

- defining a problem,
- brainstorming, researching and generating ideas,
- identifying criteria and specifying constraints,
- exploring possibilities,
- selecting an approach,
- developing a design proposal,
- making a model or prototype,
- testing and evaluating the design using specifications,
- refining the design,
- creating or making it,
- and communicating processes and results.

The design process described by Standard 8 is iterative in nature so that students may make a number of models or prototypes that are tested and refined until the final solution is achieved. One difference between the design process prescribed by Standard 8 and engineering design is the role of engineering analysis in achieving the optimum solution. One goal of NCETE is to find ways to teach engineering analysis as part of the 9-12 design experience.

Method

NCETE Partners

NCETE is a collaborative partnership between universities and school districts in regional teams located in the West, the Upper Midwest, the Central Midwest, and the Southeast. Regional teams engage in collaborative research, professional development, capacity building, and dissemination of research findings and model practices.

NCETE also facilitates collaboration between teacher education programs and 9-12 partners to build capacity and to share effective strategies and practices. Center partners have strengths in engineering and in technology education. Four categories of partners have been identified: 1) PhD granting university partners, 2) technology teacher education partners, 3) school district partners, and 4) professional society partners. A list of the NCETE partners is included in Table I.

Table I

NCETE Partners

<u>PhD Granting Partners</u> <ul style="list-style-type: none">• Utah State University• University of Georgia• University of Illinois• University of Minnesota	<u>Technology Teacher Education Partners</u> <ul style="list-style-type: none">• Brigham Young University• California State University, LA• Illinois State University• North Carolina A&T State University• University of Wisconsin-Stout
<u>School District Partners</u> <ul style="list-style-type: none">• Teacher education partners team with school districts in their geographical area	<u>Professional Society Partners</u> <ul style="list-style-type: none">• International Technology Education Association• Council on Technology Teacher Education• American Society for Engineering Education

Partner Collaboration

NCETE is also organized for collaboration among the various levels of partners. The four doctoral university partners link and collaborate in strengthening PhD programs, developing four common core courses for PhD programs, developing effective recruitment strategies to ensure that a high quality, diverse cohort of PhD students is admitted to NCETE sponsored PhD programs, and developing a community of scholars among faculty and PhD students. The five teacher education partners collaborate by refocusing TTE programs, sharing effective recruitment strategies to attract a diverse student body, and sharing effective strategies to infuse engineering into technology education programs. The 9-12 partners link and collaborate by sharing best practices in terms of infusing engineering into the 9-12 schools.

Mode of Inquiry

Professional Development

One focus of the Center is to deliver professional development to technology teachers in the partner 9-12 schools. An important emphasis of the professional development component of the Center is on assessment-driven, open-ended problem solving applied to engineering design utilizing mathematics and science concepts.

In an article in Prism Online [5] it was discussed that the key to success is the relationship with the teachers. Mrtha Cyr, a leader in the creation of the new engineering framework standards in Massachusetts said that "the greatest percentage of our work is in direct support of the teachers, who can be intimidated by the prospect of teaching engineering material." Professional development helps, Cyr says, but "much of it depends on the approach you use with the teacher. It's that interpersonal communication helping them understand how they can do this material in their classroom."

The main objective of the professional development is to prepare technology teachers to incorporate engineering concepts into classroom and laboratory activities. During 2004-05, implementing a concentrated series of professional development experiences, NCETE faculty and graduate students used a set of activity-based engineering design challenges, intensive discussion, field trips and other activities to prepare teachers to incorporate engineering concepts into their courses. The technology education teachers assumed two distinct roles during the professional development: 1) learning as students would learn, and 2) developing the knowledge and skills needed to deliver engineering-oriented technology education.

As a first step toward establishing best practices for delivering engineering design and content through professional development, engineers and technology teacher educators from each of the technology teacher education (TTE) partner institutions have conceptualized, developed, and delivered a series of workshops. While the format and specific content varied across the five professional development sites, a balance between theoretical content and activity-based experiences has been maintained. At the conclusion of each workshop, participating high school teachers complete similar surveys, which were designed to facilitate analysis and reflection. Building on lessons learned during the initial year of the Center, the TTE institutions will move toward a more common professional development experience during year two of the project.

Rod Custer [6], PI for the NCETE TTE institutions observed that for participants in the workshops "the engineering design challenges clearly shifted the focus from trial and error problem solving to a more predictive process using mathematics and science tools. This is new to technology education and is an important key to aligning the profession more closely with engineering."

The engineering design challenges (EDC) developed and used during the professional development workshops were implemented in secondary level technology education classrooms during fall 2005. The EDC consist of learning activities that require three to five weeks to deliver. The key aspect of these activities is the predictive, analytical aspects of engineering design and problem solving.

Professional Development Activities

NCETE goals include the following activities related to professional development:

- 1 Conduct teacher professional development experiences to help teachers infuse engineering content and design into their instruction.
- 2 Evaluate current pre-service programs and begin to refocus them to infuse engineering analysis and design content into the curriculum.
- 3 Develop teachers' instructional decision-making so that it focuses on the analytical nature of design and problem solving needed to deliver technological as well as engineering concepts.

- 4 Facilitate teacher initiated change into program design, curricular choices, programmatic and student assessment, and other areas that will impact learning related to technology and engineering.
- 5 Develop teachers' capabilities as learners so they assume leadership and responsibility for their professional development activities, including recruiting and mentoring colleagues.
- 6 Develop engineering analysis and design skills in technology teachers, including strengthening their mathematics, science, and engineering knowledge and skills.

Results

The specified results of professional development component of NCETE include: 1) technology education teachers will be successfully prepared to deliver engineering design content, 2) technology education students will engage in and reflect on open-ended engineering design challenges, 3) develop effective communication with Center participants. These results guide the professional development experiences as well as assist with refocusing the pre-service technology education programs. During the five years of the project teacher professional development workshops are being conducted in school districts across the country, providing over 120 hours of professional development education to more than 150 teachers.

Among the information collected in the evaluations are that the teachers appreciated having engineers and mathematics persons on hand for support throughout the workshop. They are also motivated and optimistic about being able to implement engineering design into the existing technology education curriculum and emphasizing mathematics and science in order to optimize and/or describe designs, and they feel that they need more time to develop portfolios without so much pressure and stress. All teachers rated the workshop highest overall and would recommend the experience.

At the time of the ASEE 2006 conference, the project will have collected data from 25 technology teachers designed to assess the value and focus of the professional development workshops. Evaluation survey instruments, designed by the Center's external evaluator in collaboration with the Center's leadership, were used to collect data from students and teachers to assess the extent to which the project met the objectives and whether the content and delivery mechanisms were effective for technology education students. Additional data was collected using university evaluation (a survey on implementation of professional development in the classroom) and technology teacher education evaluation.

References

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