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Year Four Annual Report: Activities, Findings and Evaluators' Reports

NCETE Faculty

Year Four Annual Report

Activities, Findings and Evaluators' Reports

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National Center for Engineering and Technology Education

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National Center for Engineering and Technology Education

Year Four Activities

Activities Outline

The Activities Report is a fairly comprehensive review of the Year Four work and is divided into the following sections.

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NCETE Mission

The National Center for Engineering and Technology Education is a collaborative network of scholars with backgrounds in technology education, engineering, and related fields. Our mission is to build capacity in technology education and to improve the understanding of the learning and teaching of high school students and teachers as they apply engineering design processes to technological problems.

NCETE Goals

The goals of the Center are:

1. To conduct research to:

   a) define the current status of engineering design experiences in engineering and technology education in grades 9-12;

   b) define an NCETE model for professional development by examining the design and delivery of effective professional development with a focus on selected engineering design concepts for high school technology education;

   c) Identify guidelines for the development, implementation, and evaluation of engineering design in technology education.

2. To build leadership capacity by developing a collaborative network of scholars who work to improve understanding of the process of learning and teaching of engineering design in technology education.

3. To establish and maintain a communication program to inform all stakeholder groups of NCETE activities and accomplishments.

Research Goal 1a: Activities

The first research goal was suggested to the Center by our external evaluators, Inverness Research Associates. They argued that the introduction of engineering into high school settings was a relatively new endeavor in education and that the Center would be well served to provide the profession with a understanding of the current status of this new effort. Their guidance resulted in Goal 1a: to conduct research to define the current status of engineering design experiences in engineering and technology education in grades 9-12. Three status studies were designed and conducted. Two core courses taken by the doctoral students at the four doctoral-degree granting institutions also addressed this research goal.

<u>NAE/NCETE Curriculum Status Study</u>

In 2006, the National Academy of Engineering (NAE) Committee on K-12 Engineering Education received funding to carry out a study of the status and prospects for K-12 engineering in the United States. One of the NAE study objectives was to survey the landscape of current and past efforts to implement engineering-related K-12 instructional materials and curricula in the United States.

The NAE approached NCETE to partner with them to conduct a curriculum status study. To date, over two-dozen curricula have been analyzed for elementary, middle and high school grade levels. The analysis begins with a cursory review of each curriculum piece followed by

a thorough review to highlight, tag and code noteworthy concepts, skills and dispositions that are being addressed. The detailed review identifies specific instances where mathematics, science, technology and engineering content are being addressed. This work is in progress. Preliminary findings indicate there is a need for a curriculum theory that proposes an epistemology of engineering, presents sound practices in the context of engineering education, provides an intellectual foundation for future engineering education initiatives and serves as a basis for assessing what a curriculum is or is not relative to the study of engineering.

Two presentations have been produced to describe the preliminary results of this work (Welty, 2007 and Welty, Katehi, Pearson & Feder, 2008), as well as substantial content within the "Project Summary for Public Comment of Understanding and Improving K-12 Engineering in the United Sates," the Committee on K-12 Engineering Education, National Academy of Engineering.

In February, 2008, the NAE approached NCETE with a request to present lessons we have learned and research studies underway in professional development. NCETE developed a position paper which was presented to the K-12 Committee on February 25 (Householder).

Research Status Study

Investigators examined and assessed the current status of engineering and technology education research over the past ten years to determine the types of studies that have been conducted, the focus of research studies, and the differences and commonalities between the two disciplines' research. Leaders in the field of engineering and technology education identified six key journals to be included in the study (*Journal of Technology Education* (JTE), the *Journal of Engineering Education* (JEE), the *Journal of Technology Studies* (JTS), the *Journal of Industrial Teacher Education* (JITE), the *International Journal of Technology and Design Education* (ITDE), and the *Journal of STEM Education)*.

This status study has resulted in one publication (Johnson, Burghardt & Daugherty, 2008), one presentation (Daugherty, 2007) and one manuscript submitted for publication (Johnson & Daugherty, 2008).

High School Technology Teacher Status Study

The Center funded a doctoral dissertation to examine the status of high school technology education programs and their role in teaching engineering content. A survey instrument was created using information from current research within the Center (Asunda & Hill, 2006; Rhodes & Childress, 2006; Smith, 2006; Gattie & Wicklein, 2005) The survey also solicited input on challenges faced by teachers in teaching engineering design in their educational settings. High school teachers who were members of ITEA were the target population for the study. Surveyed teachers indicated time spent in the school year on seven categories of engineering content: engineering analysis, engineering design, application of engineering design, engineering communication, design thinking as it relates to engineering design, engineering and human values and engineering science.

This study has resulted in one doctoral dissertation to be defended in June (Kelley).

Efforts Supporting Status Study Research

Two core courses provided doctoral fellows with the status of research on design thinking as well as design instruction in a typical higher education setting. In the second core course, Design Thinking in Engineering and Technology Education, the fellows were consumers and producers of educational research. Theodore Lewis was the lead teacher with support from Karl Smith, both from the University of Minnesota. The course explored the concept that design is the primary conceptual anchor for technology education, drawing the subject ever more tightly toward engineering. As the doctoral students reviewed contemporary literature in design thinking, they were asked to identify the conceptual framework against which the study was set, the quality of the research problem, the design/methodological approach of the study, the findings and recommendations, and study limitations. The students were expected to analyze a body of research and develop a journal-quality synthesis paper.

In the third NCETE core course, Engineering Design: Synthesis, Analysis and Systems Thinking, the fellows were exposed to engineering design techniques that are typical of a freshmen engineering class. David Gattie from the University of Georgia was led instructor with support from Bob Wicklein, Sid Thompson and Roger Hill. In class students were presented lectures involving design methodology and systems thinking. As part of this class the fellows were asked to develop and solve an open ended design problem involving a community in Costa Rica. The students were given background information involving the community and the region and they were then required to define a design problem which they worked on throughout the semester. Most of the background material involved environmental problems associated with the community's drinking water supply, solid waste disposal and waste water disposal. The fellows were split into three different design groups which consisted of fellows from each of the four research institutions. Throughout the semester the students were required to give presentations associated with their design problem involving problem definition, design constraints and attributes, concept development, design analysis and then a final design solution.

Research Goal 1b: Activities

The second Center research goal builds on experiences of the first two years of the Center where individual sites conducted professional development to infuse engineering design into high school classrooms. These early experiences lead to the following research goal: to define an NCETE model for professional development by examining the design and delivery of effective professional development with a focus on selected engineering design concepts for high school technology education. A wide range of research investigations are underway to achieve this research goal. One of the core courses taken by the doctoral students at the four doctoral-degree granting institutions helps support this goal as well.

Early Studies

In years one and two of the Center, five sites developed and implemented professional development (PD),working with teachers to infuse engineering design into high school classrooms. These early experiences resulted in a series of presentations including Becker (2007), Merrill, Custer, Daugherty, Westrick & Zeng (2007), Shumway, Berrett, Swapp, Erekson & Terry (2007), Merrill, Childress, Rhodes & Custer (2006), and Tufenkjian, Maurizio & Lipton (2006). Of particular note is the Council on Technology Teacher Education Outstanding Research

Award for the work of Custer, Merrill, Daugherty, Westrick & Zeng (2007) entitled "Delivering core engineering concepts to secondary level students using the STL."

In year three, the Center moved from conducting PD as part of teacher enhancement toward developing a research program. Several studies were conducted to help the Center understand the effectiveness of the first two years of PD. Asunda and Hill (2007) conducted a collective multisite case study of two sites, NCA&T and CSULA. Data were collected through individual interview sessions that lasted 30-40 minutes, video footage, observations and artifacts. A total of 15 interviews were individually analyzed, and then compared through a cross-case analysis. Professional development emerged as a core theme and comprised the following sub themes: planning, communities of practice, professional development administration and learning environment, professional development for technology education teachers, professional development activities in the classroom, assessment, expertise, and meaning making.

Final synthesis of a related professional development activity provided guidance to the Center on essential features of effective PD, especially those learned from the mathematics and science communities (Custer, Hailey, Cunningham, Erekson & Householder, 2008). This work built on a spin-off project of the Center, the National Symposium to Develop an Effective Model for the Professional Development of K-12 Engineering and Technology Education Teachers (NSF Number 0533572).

Progress toward Model Development

The Center held a series of meetings to understand lessons learned from two years of PD pilot studies that were conducted at five of the partner sites. Partners from USU, BYU, NCAT, ISU and CSULA met in Chicago, Illinois on July 6th and 7th to plan a PD review workshop. During the week of July 30, 2007, a one-week workshop was held that involved NCETE professional development providers, exemplary teachers, who had experienced one of the NCETE site-specific PD programs, beginning teachers, high school students, and evaluators. The limited number of workshop participants were selected because of their willingness to reflect on their experiences in an attempt establish the characteristics of an effective PD program for high school teachers infusing engineering design concepts into a variety of STEM classrooms. Teacher demographics included eight white males, three white females, one African American male, two African American females and one Hispanic female. The demographic of the professional development providers included seven white males, one African American male, one Asian male, and one African American female. The professional development workshop was guided by three goals. 1) Increase high school STEM teachers' content knowledge regarding constraints, optimization, and predictive analysis in an engineering design context; 2) Increase high school STEM teachers' ability to develop, use, and assess curriculum materials that addressed engineering design; and 3) Involve all participants in reflection on their experiences in order to establish the characteristics of an effective PD program for high school teachers infusing engineering design concepts into STEM classrooms. Achievement of the final goal was important to inform the planning for the development of a PD model.

A formative evaluation plan was designed to acquire immediate feedback on select components of the July 30 one-week workshop. The feedback was also important to the developmental processes of NCETE's professional development initiative. A mixed methods approach was chosen to obtain a richer representation of the needs and experiences of NCETE stakeholders. The data collected included written reflections completed by participating teachers and

developers at the end of the workshop, an online survey for teachers and developers following the workshop and post-survey phone interviews with a select group of teachers and developers. All teachers and key developers (who were present for a minimum of three full days of the summer workshop) were asked to complete a short online survey specifically developed for their group. Interviews were conducted with key developers and with teachers who had completed the full professional development. Collecting data from key developers and teachers is not often done. (Cullum, Hailey, Householder, Merrill & Dorward, 2008).

Following the PD review workshop, NCETE management determined that two sites held great promise as test-bed PD sites: CSULA and NCA&T. Both sites had positive involvement from engineering faculty as content experts and access to diverse teacher and student populations. CSULA had access to STEM academies through Long Beach Unified Schools and NCA&T had access to both STEM academies and traditional technology education program. Team members from NCA&T, CSULA and NCETE met Monday, December 17 and Tuesday, December 18 in Salt Lake City to outline the year-long PD program, its evaluation and opportunities for research.

The year-long PD program began in January at NCA&T and CSULA. Both sites spent several sessions providing teachers with background on the nature of engineering design with several hands-on activities which permitted the teachers to participate in the design process. During the week-long summer session, the teachers will work closely with the engineering faculty to modify instructional materials already used in their classrooms. Since there are few widely accepted curricula for introducing engineering concepts into high school settings, the teachers want to be empowered to infuse engineering into their existing curriculum. The Center anticipates a great likelihood of implementation of engineering design in the classrooms because of the involvement of the teachers in developing materials for their classrooms. This novel approach to PD provides rich opportunities for research. A qualitative study is underway at NCA&T and CSULA to examine the Influences of professional development in engineering design upon high school instruction in the STEM disciplines (Householder, Becker, Draper, Wixted).

Additional Study to Guide Model Development

Another important study underway is entitled "The Nature and Status of STEM Professional Development: Effective Practices for Secondary Level Engineering Education" (Custer, McAlister & Daugherty). The goal of the study is to develop a foundation of knowledge on which to ground a professional development model for engineering-oriented technology education. This includes an analysis of current and past efforts to design and implement professional development for 9-12 teachers in the STEM disciplines and identification of best practices in professional development programs designed to prepare teachers for secondary level engineering programs. The study consists of a comprehensive review of the literature and case studies of selected professional development programs designed to prepare secondary teachers to deliver engineering-oriented technology education. The scope of the case studies consists of approximately 5-6 professional development programs that are representative of the best efforts to prepare teachers to deliver engineering education at the secondary level. For the purposes of this study, engineering-oriented education is defined broadly to include programs designed to prepare students for both post-secondary engineering education and for broad-base technological literacy for all students. The literature review is complete and site visits for the case studies will occur over the summer.

Efforts Supporting PD Research

To inform the development of a PD model, the Center held a workshop on September 24, 2007, at North Carolina A&T State University. The purpose of the workshop was to involve Center faculty as reflective practitioners in an authentic PD workshop. Carolyn DeCristofano and Christine Cunningham from the Boston Museum of Science demonstrated a typical PD workshop. They presented a design challenge to the Center faculty using a format they would use with high school teachers followed by a session where they reflected on the process they used to develop the PD session.

The fourth NCETE core course, Dynamic and Network Engineering Processes for Technology Education, laid ground work for cohort one doctoral fellows interested in study professional development. Using the National Academy of Engineering's Committee on Assessing Technological Literacy publication *Tech Tally*, fellows reviewed the in-depth report that examined the challenges and requirements needed to assess technological literacy in the U.S. The fellows had an opportunity to put theory into practice as teams at each university worked to put together a high school level engineering design challenge. The purpose of this engineering design challenge was to show how engineering fundamentals and resources could be infused into a technology education program or PD experience.

Two cohort-one doctoral fellows are in the preliminary stages of developing dissertation proposals to conduct research to examine the design and delivery of effective professional development to guide model development (Avery, Daugherty).

Research Goal 1c: Activities

The third Center research goal is to identify guidelines for the development, implementation, and evaluation of engineering design in technology education. Studies are underway to provide guidelines for increasing the participation of underrepresented groups in engineering and technology education. Foundational studies in teaching and learning design and problem solving are underway as precursors to developing guidelines for the development, implementation and evaluation of engineering design.

Increasing Participation of Underrepresented Groups

An internal research program has been successful in providing relatively non-threatening experiences with proposal preparation, review, negotiation, and the conduct of small research projects. During 2005-06 and 2006-07, three proposals were funded that focused on increasing participation of underrepresented groups.

Duncan and Zeng (2005) conducted a study to understand what factors support women in engineering and what factors attract women to and help them persist in a career in engineering. Their research method consisted of a search of related research to identify probably factors followed by qualitative interviews with program persisters and switchers. The most frequently cited factors were selected for inclusion an interview protocol study. This study resulted in a presentation at an ASEE conference (Zeng & Duncan, 2007).

Denson and Avery (2007) conducted a study to investigate the perceptions held by African American students grades 9-12 toward engineering and technology education as a profession

and career choice. Purposeful selections of seven African-American students (four from Atlanta and three from Los Angeles) in grades 9-12 were sampled to examine their conceptual knowledge of engineering and technology. Audiotaped interviews provided the investigators with insights to help inform areas of research concerning diversity issues, and provide insights that can be used to develop curriculum that are more culturally responsive. Denson developed and defended a dissertation proposal to conduct a follow-on study to examine the impact of mentorship programs to influence African-American high school student's perception of engineering. With support from Center funding, data collection has been completed and a draft dissertation for committee review is underway.

Another proposed study is to examine the factors affecting career decision-making self-efficacy and engineering related goal intentions among African-American high school students (Austin). This work is in the preliminary stages of dissertation proposal development.

Roue (2007) conducted an exploratory study to examine four areas that might present barriers for women in technology and engineering. They were young women's perceptions, self-esteem, self-efficacy, and perceived social support as they relate to their interest in science, technology, engineering, and mathematics. The study examined pre-test measures of a group of about 2,800 girls participating in the Summer Technology and Engineering Preview at Stout (STEPS) program. The girl's camp provided young women entering the seventh grade a chance to work in a laboratory setting with their peers with the goal of piquing their interest in the areas of technology and engineering. Roue is in the early stages of developing a dissertation proposal that will build in this exploratory study.

Studies in Teaching and Learning Design and Problem Solving

During 2005-06 and 2006-07, the Center's internal research program funded five proposals that focused on research in teaching and learning design.

Lawanto (2005) investigated how a group of engineering students exercised their self-management of cognition, through the way these students planned, evaluated, and regulated their cognitive activities, during the design process to build an engineering artifact. Using Paris and Winograd's lens of self-management of cognition, two research questions were constructed to guide this instrumental case study. They were: 1. How did individual members of the team execute their meta-cognitive ability as reflected in the way they plan, regulate, and evaluate any task they encounter throughout the project time? and 2. How did the way they plan, regulate, and evaluate any encountered task fit together as the team evolved their design? This work was part of Lawanto's early research problem, required at UIUC. A manuscript for submission to a referred journal is underway.

Childress and Rhodes (2006) conducted a study to determine engineering outcomes that should be studied in high school when the high school student intends to pursue engineering in college. The results of the study can be extended to those engineering student outcomes that all technology education high school students should learn in order to aid them in becoming more technologically literate. A modified Delphi approach as used for the study. The participants were a panel of experts consisting of engineers, engineering educators, or those expertly familiar with engineering education such as a government expert or learned society employee. This work resulted in a referred journal article (Childress & Rhodes, 2008) and was the foundation for a book chapter (Childress, Rhodes & Welty, 2008).

Asunda and Hill (2007a) developed a study to find critical features of engineering design that could be incorporated within technology education learning activities, and developed a rubric for assessing these features. Data were collected through semi-structured interviews with three professors actively involved in engineering education. Supporting documents such as engineering design course outlines and rubrics were also examined. Using a phenomenological approach, this study identified the concept of engineering design, key features of the engineering design process, and critical elements that should be assessed in an engineering design activity in the context of technology education. A key product of the study was development of a rubric to be used in evaluating integration of engineering design as a focus for technology education.

Smith and Wicklein (2006) developed a study that contributed to the research base in technology education on the subject of incorporating the engineering design process into the technology education curriculum. It addressed the need for the development of a framework for understanding engineering design and the related academic concepts that can be used by professionals in the field of technology education seeking to incorporate the engineering design process into the technology education curriculum. The purpose of this study was to address the question "What are the essential aspects and related academic concepts of an engineering design process in secondary technology education curriculum for the purpose of establishing technological literacy?" A four-round Delphi process was the research methodology employed in this study to give multiple opportunities for the group opinion to coalesce. The resulting data from the Delphi process was analyzed and categorized. Participants in this study identified forty-eight concepts.

Kelley and Hill (2007) developed a study to understand cognitive strategies used by high school technology education students who have participated in technology education instruction with an engineering design focus. Specifically, this study evaluated the cognitive strategies of students participating in *Project Lead the Way* curriculum programs compared with students participating in technology education programs partnering with the Center. High school students from these two groups were studied as they worked through an ill-defined problem: moving drinking water in developing countries. The data collected from these protocols was analyzed using a coding process and a list of universal technical mental processes and OPTEMP software to record frequency and time of each mental process employed by the students. The study identified common cognitive strategies employed by students and identified where greatest emphasis was placed in the design process among the two groups. This study provides important insight for technology education as it seeks to implement engineering design.

The studies of Lawanto (2005) and Kelley and Hill (2007) were results of cognition course work developed at UIUC and introduced to the NCETE doctoral fellows. In the first NCETE core course, The Role of Cognition in Engineering and Technology Education, the fellows were expected to be both consumers and producers of educational research. The majority of the course readings described empirical studies of cognition that focused on technical learning and thinking. Each student was expected to analyze a research study and present the major concepts from the article to the class. The fellows were also expected to write and present a major paper that reviewed and synthesized the literature on a critical issue related to cognition in engineering and technology education. Each fellow was also expected to conduct an analysis of expertise in a

domain of his or her choice using the protocol analysis method. This method of research was introduced in class as a way to empirically capture the thought processes that are used as the research participant completes a task. The fellows designed and conducted the research study and wrote a technical report that included a description of the problem being addressed, the methods used to collect and analyze data, and the results and conclusions. The fellows also made formal presentations of their research study to the class.

Three cohort one fellows have received funding to support their dissertation studies for foundational studies in teaching and learning design and problem solving as precursors to developing guidelines for the development, implementation and evaluation of engineering design (Mentzer, Stricker, Walrath). In addition, two dissertation proposals to examine problem solving are in preliminary stages of development (Franske, Nehring).

Research Goal 2: Activities

The second Center research goal is to build leadership capacity by developing a collaborative network of scholars who work to improve understanding of the process of learning and teaching of engineering design in technology education.

Doctoral Fellows: Cohort One and Two

Since the inception of NCETE, the Center has worked to develop a community of doctoral fellows that reside at the four research partner institutions and that take core courses together. The NCETE doctoral fellows come together during annual workshops to share research results and strengthen their sense of community. Consequently, the fellows, and associated faculty, experience the strengths of the four research partners rather than that of a single partner.

The Center has retained nine of the original twelve in the first cohort. The first-cohort fellows have completed three years of course work including four NCETE-specific core courses. They are at various stages of dissertation preparation. The demographics include two African American males, two white females, three white males, and one Asian male. One of the doctoral students successfully defended his dissertation in April and four are in the final stages of dissertation preparation. One fellow has been offered and accepted a tenure-track position at Purdue. One fellow has accepted an adjunct position at the University of Wisconsin-Stout.

The Center developed a process for doctoral students to prepare proposals to request dissertation funds. The purpose of the proposal request process was to give fellows more experience in preparing proposals for funding. Submitted proposals were funded for amounts up to $10K of justified direct costs for dissertation work that aligned with the goals of the Center.

The Center successfully recruited ten fellows for the second cohort. These fellows have completed the first year of their doctoral studies, including a core seminar and the first core course, and all are retained. The fellows' demographics are two African American females, one white female, one Jamaican male, one Asian-American male, and five white males.

The Center views the NCETE doctoral fellows as a select group of doctoral students that share similar backgrounds because of the core course sequence and opportunities to gather and discuss research results. In addition to the NCETE fellows, the Center has funded NCETE doctoral students who have helped conduct the research of the Center. Paul Asunda and Cameron Smith have completed doctoral programs at UGA, John Duncan and Oenardi Lawanto have completed doctoral programs at UIUC and Jodi Cullum is completing her doctoral work at USU. Asunda, Smith, Duncan, and Lawanto have doctoral degrees in the area of technology education. Cullum is completing her doctorate in psychology.

Doctoral Core Courses

NCETE faculty developed a two-year sequence of courses especially for the fellows. Each semester a course was taught at a doctoral-degree-granting partner institution and distance-delivery software was used to reach students at the other three doctoral sites. The "core courses" focused on cognitive science in engineering and technology education, the theoretical foundations of engineering design, and the application of engineering design. Cohort one fellows completed the core-course sequence in years two and three.

Faculty and representatives from cohort-one fellows from USU, UIUC, UMN and UGA met in Chicago, Illinois on July 10, 2008, to refine the core courses and other aspects of the fellows' doctoral program. One significant outcome of the meeting was the need to provide an introduction to engineering design, including opportunities to engage in engineering-like design experiences, early in the core course sequence.

Based on outcomes from the Chicago core-course meeting, an eight-hour introduction to engineering design was developed and provided as part of the cohort two orientation program held at Utah State University in August 2007. Fall semester 2007, a two -hour seminar course was developed to further introduce cohort two fellows to engineering design and research opportunities within NCETE. Ty Newell, a mechanical engineer from UIUC, conducted four seminar sessions on the engineering profession and engineering design as seen through the eyes of an engineering educator. In addition, David Gattie, a biological engineer from UGA conducted a seminar on systems thinking in engineering and Ted Lewis, UMN conducted a seminar on selecting a dissertation research topic.

The first NCETE core course, The Role of Cognition in Engineering and Technology Education, was revised and taught for the second time during spring semester 2008 by Scott Johnson. The majority of the course readings described empirical studies of cognition that focused on technical learning and thinking. Each student was expected to analyze a research study and present the major concepts from the article to the class.

The second NCETE core course, Design Thinking in Engineering and Technology Education, will be revised and taught for the second time during summer semester 2008. Theodore Lewis will be the lead teacher with an engineering perspective provided by Gary Benenson. The course will explore the concept that design is the primary conceptual anchor for technology education, drawing the subject ever more tightly toward engineering.

Research Leadership Development

Consistent with one of the goals of the Center, NCETE fellows were given opportunities to develop as research leaders in the fields of engineering and technology education. The Center also expanded its leadership development role to include early-career faculty members in technology education from across the country.

On Thursday and Friday, August 9 and 10, 2008, the Center hosted an orientation for the cohort two fellows at Utah State University. Center faculty provided the fellows with an opportunity to understand the mission and goals of the Center, the research framework, and a demonstration on the distance delivery system used for the core courses. Cohort one fellows described their experiences with NCETE and provided suggestions for early success in doctoral course work. Cohort two fellows were given an opportunity to describe their preliminary thoughts about research topics they find interesting. A significant aspect of the orientation was a two-afternoon workshop that introduced the fellows to engineering design thinking presented by Mark Tufenkjian, professor of civil engineering at California State University, Los Angeles. An external evaluator from Inverness Research Associates attended the two-day orientation and met with cohort two fellows as well.

NCETE sponsored the CTTE Twenty-first Center Leader Associates (TCLA) in a professional development experience in Washington, DC, on September 11 and 12, 2007. TCLA participants are early-career faculty members. As part of capacity building for the engineering and technology education profession, NCETE covered travel expenses of the TCLA faculty. Highlights of the experience include presentations from Greg Pearson from NAE on Tech Tally and Technically Speaking and from Karen Zuga from NSF on research opportunities.

On February 20, 2008, the NCETE Leadership Development Team, lead by Maurice Thomas, sponsored a graduate fellows and new faculty leadership development seminar in conjunction with the NCETE spring meeting in Salt Lake City, Utah. NCETE graduate fellows cohorts one and two, and CTTE 21st Century Leaders Associates cohorts one and two participated. The purpose of the seminar was to promote networking and collaboration, share research, and explore international opportunities in technology education.

The NCETE Summer Workshop will be held at the University of Minnesota May 22-23, 2008. Ted Lewis, NCETE PI at the University of Minnesota site, is hosting this event. Research in the field of engineering and technology education will be the focus of the meeting. The first day's theme will be *Doctoral Research in Engineering and Technology Education.* NCETE fellows will be joined by doctoral students from Tufts University, Virginia Tech, Colorado State University, Purdue University, and Ohio State University as they share research interests and build professional networks.

Research Goal 3: Activities

The third major goal of the Center is to establish and maintain a communication program to inform all stakeholder groups of NCETE activities and accomplishments. We have made significant progress in our efforts to improve internal communication among Center participants and to provide accurate, up-to-date information on Center activities to external stakeholder groups. In an attempt to bolster our communications program, NCETE has employed a University of Georgia graduate student to help the in its public information efforts.

Communications initiatives designed to reach external audiences include the NCETE Web site, CLT Net, the NCETE Newsletter, the 2008 CTTE Yearbook, conference presentations, poster sessions, and publications in the scholarly and professional journals. Internal communication media relies heavily upon e-mail messages and conference telephone calls, in addition to the distance delivery of instruction to the fellows at the four doctoral sites. Center-wide meetings play an important role in internal communication; these gatherings of fellows and faculty were held at North Carolina A&T State University in October 2007, prior to the ITEA Conference in Salt Lake City in February 2008, and at the University of Minnesota in May 2008. The Conference on Research in Engineering and Technology Education in May included invited doctoral students and faculty members from Colorado State University, The Ohio State University, Purdue University, Tufts University, and Virginia Tech University.

The NCETE Web site, http://ncete.org has undergone substantial revision during the current year. In addition to routine additions of news items and the revisions of earlier materials, the external Web site now provides ready access to a variety of instructional resources that professional developers and researchers in engineering and technology education will find helpful. In addition, the internal Web site, accessible to NCETE personnel, has been populated with a rich array of presentations, professional development materials, and photographs. The Partner Resource Site includes news releases, directory information, document templates, and a series of design challenges developed at North Carolina A&T State University. The Professional Development Resources section, intended to provide NCETE professional developers with ready access to drafts of internally developed materials, is being populated with the 2008 materials being used at the two pilot sites. In addition, we plan to provide selected materials from earlier professional development workshops at other institutions. To date, materials from North Carolina A&T State University is the only institution whose professional development materials have been received, edited, and posted. Materials from other institutions will be added as they are received and edited.

Three issues of the NCETE Newsletter were developed during the current year for distribution to officers and board members of the International Technology Education Association, the American Society for Engineering Education, the Center for the Advancement of Science and Engineering Education; to engineering educators in universities across the country and to participants in the NAE State Educators' Symposium on Technological Literacy; and to state supervisors of technology education, mathematics education, and science educators. The primary purpose of the Newsletter is to reach an audience of stakeholders who share our vision of engineering and technology education, but who are not necessarily aware of the range of NCETE activities, and who may not regularly visit the NCETE Web site.

Custer and Erekson's *Engineering and Technology Education* was presented to the profession at the CTTE Yearbook Dinner in Salt Lake City in February 2008. This major contribution to the literature of the field provides a strong foundation for an expanded program of research aligned with the NCETE mission. The preparation of this landmark study of an emerging field not only provides the catalyst for inter-institutional collaboration in research, its long-term development cycle has increased the interest of NCETE professionals in communicating their work to a broader audience. As the book becomes available to the profession and a more general audience, external stakeholders will have increased opportunities to understand the work of Center personnel.

It is important to note that the increasing number of presentations and the increasing number of NCETE personnel involved in those presentations contribute substantially to the accomplishment of the external communication goal. The people who are most interested in the emerging field of engineering and technology education are the likely audience for conference presentations, and the expertise of Center personnel is being recognized by an increasingly wider audience.

While much has been accomplished during the current year in the area of communication, much remains to be done and additional improvements in the communication program are planned for the year ahead.

Realignment of Center Budgets to Achieve Mission and Goals

As an outcome of the reverse site visit, NCETE was asked to refine our mission, refocus our goals, and tighten our research framework. In order to respond to the request from NSF, we have shifted from teacher enhancement programs at five teacher educator sites to research on professional development model. This shift in emphasis has resulted in carry over budgets in excess of 20% at four of the sub-award institutions: California State University Los Angeles, Illinois State University, North Carolina A&T State University, and Brigham Young University. We have also shifted the management team to better align with the refocused goals. This shift has resulted in excess budget at two sub-award institutions: Illinois State University and University of Georgia. The University of Georgia also had carry over in excess of 20% because they supported two doctoral fellows during years two and three rather than three.

In order to support the new NCETE management structure and to strengthen our research program, we redirected resources from the sub-awards line for year four. Daniel Householder was added as a Co-PI and resources were moved to fund dissertation research, faculty research, to develop a resource center, and to conduct a symposium.

Center Management

To better accomplish our mission, we have revised our management and leadership structures. This revision was precipitated, in part, from feedback from Inverness Research Associates who noted that “the current management structure does not support a Center with so many, geographically isolated partners. Further, Center leaders are being promoted to administrative positions within their home institutions, which may impinge on their ability to participate in and support the Center.” This observation was included in their year-three evaluation report which was submitted to NSF.

The NCETE Management Team consists of the Center PI and Co-PIs who are responsible for directing the work of the Center. The Management Team is assisted by staff members who help with the day-to-day operation of the Center. The PI will be accountable to the NSF program officer. Utah State University will be the fiscal home of the Center. Weekly Management Team meetings were held throughout the year.

The NCETE Leadership Team consists of a representative from each of the eight sites not located in Logan, Utah. The Leadership Team serves in an advisory capacity and works with

the Management Team in guiding the work of the Center. They are responsible for communicating the work of the Center to NCETE faculty and students at their specific site. The Management Team and Leadership Team communicate through a bi-monthly teleconference as well as through e-mails and face-to-face meetings. Teleconferences were held on September 21, October 29, November 12, January 16, 30, March 12, March 26, April 9, April 23 and May 7.

Significant Center Meetings

NCETE held a workshop September 24, 25 at North Carolina A&T State University. The meeting consisted of a workshop to demonstrate effective professional development, a research session, and a business meeting. The professional development (PD) workshop was conducted by Carolyn DeCristofano and Christine Cunningham from the Boston Museum of Science. They demonstrated how they would present a design challenge to a group of teachers followed by reflections on the process they used to develop the PD session. The research session began with presentations by three former journal editors. Mark Sanders founding editor of *Journal of Technology Education*, Janet Burns past editor of *Journal of Industrial Teacher Education,* and Marie Hoepfl past editor of *Journal of Industrial Teacher Education,* each addressed the question "What must NCETE do to meet the challenge of leading the research effort in engineering and technology education?" Their ideas included changing the culture to a research paradigm, mentoring students and young faculty, taking cues from other fields, and promoting research interests.

NCETE held a preconference meeting on February 19 and 20 in conjunction with ITEA. The meeting on February 19 focused on Center updates and business. The February 20 meeting was entitled "NCETE Graduate Fellows and New Faculty Leadership Development Seminar." In the morning, NCETE faculty, cohort one and two doctoral fellows and CTTE-Twenty-first Century Leader Associate heard research presentations from five of the cohort one fellows who close to completion of their dissertation research. Early in the afternoon, a panel described the opportunities and pitfalls of international work. Later in the afternoon, the cohort two doctoral students met with Scott Johnson to discuss the research project assigned in core course one while the cohort one doctoral students were led in a discussion by Tom Erekson on interviewing and negotiating for their first faculty position.

A research conference was held at the University of Minnesota May 22-23, 2008. A doctoral student conference was held during the first day of the meeting. The theme of the student conference was "Research in Engineering and Technology Education." NCETE cohort one and two doctoral students presented papers. In addition, doctoral students and their faculty advisors from Tufts, Ohio State, Virginia Tech, Colorado State, and Purdue were invited and presented papers. The meeting concluded with observations from doctoral advisors from Ohio State, Virginia Tech Colorado State, and NCETE. A number of advisors commented on the importance of a graduate student meeting so that the field has an opportunity to come together and see the scope of research done in the area of engineering and technology education. The second day of the meeting focused on re-envisioning research within the fields of engineering and technology education and NCETE's role in building capacity for conducting reputable engineering and technology education research.

Major NCETE Findings: 2007-2008

Findings

Significant outcomes of the year include: (1) a substantial increase in scholarly productivity of Center personnel, indicated by publications, presentations, poster sessions, and research under way at the time this report is prepared in late May, 2008; (2) a stronger priority devoted to research; (3) the successful recruitment of the second cohort of doctoral students; and (4) active participation of Center minority serving institutions and increased diversity among the Center faculty. These achievements are closely aligned with Center goals and indicative of substantial progress during the year.

The number and quality of research presentations reflect the strengthening program of research being conducted under Center auspices. One indication of the quality of the Center's research capability is the fact that the National Academy of Engineering (NAE) invited the Center to do a background study for the NAE Committee on K-12 Engineering Education. The faculty member and fellows involved in this effort have kept others in the Center informed about their work and have sought comments from the group to strengthen the research. The NAE Committee also asked NCETE to provide comments on what we have learned about professional development; that response featured the lessons learned from the 2007 summer workshop at ISU. These results were also utilized in the organization of the professional development approach being pilot tested this spring in California and North Carolina.

The 2008 Yearbook of the Council on Technology Teacher Education, *Engineering and Technology Education*, edited by two key professors from NCETE institutions, features NCETE personnel among the authors of 11 of its 12 chapters. This premier publication of the technology teacher education community summarizes the current research in the field and provides a foundation for an enriched research effort.

Another indication of the Center's emphasis on research is the rigor of the internal review procedures for evaluating the quality of proposals for internal funding. Center activities have been instrumental in improving the competitiveness of proposal submissions for external funding. Outcomes from the May 2008 Conference on Research in Engineering and Technology Education at the University of Minnesota have led the Leadership Team to begin plans for an invitational NCETE Research Symposium for late summer 2008 in an attempt to continue to strengthen the overall research initiative of the Center.

Synergy among Center partners has resulted in new collaborations across institutions. The Center has provided strong support and encouragement for the fellows and has facilitated their involvement in presentations in a wide variety of venues. The local, regional, national, and international involvement of the group of fellows continues to be outstanding. In several instances, faculty members and fellows have collaborated successfully in presentations and in the preparation of proposals and manuscripts. Both the number of scholarly products and the quality of those efforts has improved substantially during the current year. There is a growing tendency for NCETE personnel

to communicate their findings and contribute to the development of the meager body of knowledge in engineering and technology education. Publications, presentations, poster sessions, and research in progress are listed at the end of the activities report preceding this section.

The Center is pleased with the success of the cohort model for doctoral study in the four research institutions. In year one, the Center focused on recruiting a cohort of students who would share a number of common experiences, including course work and leadership development activities. The goal of the cohort model was to develop an enduring network among the doctoral students that would serve to support and encourage them during and after their doctoral experiences. Twelve students were recruited to the first cohort and they began their doctoral program in year two. One has completed the dissertation defense and three others are expected to complete their doctoral requirements this summer. Ten students were recruited into the second cohort. Cohort two began graduate study in Fall Semester 2007 with an orientation session on the Utah State campus in August. Both cohorts have been full participants in the activities of the Center during 2007-2008. Findings from the external evaluators indicate that the doctoral students feel connected to Center partners as well as to the broader technology education community, and that they value those connections and expect to maintain them throughout their careers.

The Center found that partner institutions North Carolina A&T State University and California State University, Los Angeles were effective participants in the recruitment and retention of diverse students for both cohorts of fellows. Faculty members at both institutions have mentored underrepresented students in the first cohort and are, in part, responsible for good retention of underrepresented students in the first cohort. These institutions were selected as field test sites for the 2008 pilot professional development program.

In response to the suggestions of the evaluators, the Management Team plans to continue to sharpen our focus so that the resources of the Center are directed toward the accomplishment of the mission and goals of NCETE in the year ahead. While it is clear that capacity building, including the doctoral study of the group of fellows, and leadership development efforts must continue to receive emphasis, it is also clear that our research effort must be strengthened. Dr. Zuga has reinforced that conclusion in the report of her site visit to the Center Conference on Research in Engineering and Technology Education.

The Center will continue to support the cadre of current fellows contingent upon their satisfactory progress in their graduate programs and in their research efforts aligned with Center goals. The Center also plans to conduct and sponsor specific research projects directed toward the accomplishment of the NCETE research agenda. Professional development in research and grant seeking will be scheduled as appropriate. The Center does not plan to continue to fund on-going activities that are not contributing to the new direction. Sub-awards will be modified to align expenditures with the changing emphases.

directed toward the accomplishment of the NCETE research agenda. Professional development in research and grant seeking will be scheduled as appropriate. The Center does not plan to continue to fund on-going activities that are not contributing to the new direction. Sub-awards will be modified to align expenditures with the changing emphases.

Internal Evaluation Activities and Findings

Jim Dorward was the internal evaluator for NCETE during year four. He mentored a graduate research assistant, Jodi Cullum; the two of them worked closely with the Management Team to:

- Conduct and report on an evaluation of a pilot professional development for NCETE Technology and Teacher Education partners at Illinois State University.
- Advise the NCETE management team during development of the external evaluation plan by Inverness Research Associates.
- Develop a Logic Model, Evaluation Plan, and associated instruments and protocols for a new Professional Development program offered by North Carolina A&T, and California State at Los Angeles.
- Conduct initial data collection and analysis for the new Professional Development program.
- Interpret Yong Zeng's evaluation of the doctoral core courses.
- Assist Inverness Research Associates in instrument development for evaluation of the second cohort of doctoral core courses.

Jim Dorward reported the following changes to Center activities resulting from the internal evaluation findings from year three:

- NCETE incorporated many of the recommendations from evaluation of the pilot professional development program into the new model.
- Refined the second-cohort doctoral core courses to include a seminar focused entirely on defining the work of engineers.
- NCETE professional development partners appeared more focused on objectives and intended outcomes as a result of evaluation accountability.

National Center for Engineering and Technology Education

Annual Report External Evaluation Addendum

Submitted by

Inverness Research

June 2008

EVALUATION APPROACH

Inverness Research Associates was contracted to conduct the external evaluation of NCETE. Drawing on previous work as external evaluators of CILS and ACCLAIM, we developed a framework for evaluating Centers for Learning and Teaching (CLTs) based on the perspective that Centers represent a central "node" in particular domain within STEM, and should build capacity for the improvement and growth of that domain.

Centers, we argue, exist and operate based on a *theory of action* that includes the following principles:

- Leadership development and knowledge production and flow are the primary purposes of Centers;
- The work of the Center is grounded: research and leadership development are closely tied to the real challenges and issues that exist in the field;
- Centers connect K-12 and Higher Education;
- Centers are comprised of different initiatives or strands with their own integrity but also overlap and support each other toward the larger mission of the Center; and
- Synergy is essential: the Center has to be greater than the sum of the parts
- Centers not only help steward the growth of their domains, but they also represent and advocate for their domains to the broader field.

Our approach to evaluating Centers is based on this theory of action, and is guided by what we describe as CLT "drivers:" **Leadership; Knowledge Generation and Flow; Relationships and Connections; Structures, Policies, and Programs; and "Centerness**." These drivers provide the basis upon which our evaluation tasks are designed, conducted, and reported.[1]

EVALUATION TASKS

Over the last 12 months, we have primarily served as "critical friends" to NCETE, providing formative advice and feedback. In addition, we focused on two areas: The Cohort 2 doctoral students, and the advising and teaching faculty. In both cases we were exploring the extent and ways the Center is increasing their capacity for leadership in the field.

We engaged in the following specific tasks:

[1] See Appendix A for a fuller description of the CLT Drivers and how they may be used in the NCETE evaluation

- Attended NCETE Professional Development Workshop at Illinois State University in Normal Illinois, July 31 – August 3, 2007
- Attended NCETE Cohort 2 Doctoral Fellow orientation at Utah State University, Logan, UT, August 2007
- Conducted focus group interview with Cohort 2 Doctoral Fellows at Utah State University, Logan, UT, August 2007
- Attended NCETE project planning conference call, September 2007
- Attended and presented at NCETE Annual Fall meeting in Greensboro, North Carolina, September 2007
- Compiled a summary of feedback from doctoral fellow orientation and professional development workshop, September 2007
- Completed an update on Center activities and a revised evaluation plan, November 2007
- Coordinated evaluation activities with Jim Dorward, December 2007
- Participated in teleconferences with Chris Hailey and other management team members
- Participated in phone calls with Jim Dorward
- Conducted numerous internal IRA planning meetings
- Conducted in-depth individual telephone interviews with each doctoral fellow in Cohort 2, January and February 2008
- Attended and NCETE annual meeting prior to annual conference of International Technology Education Association (ITEA) in Salt Lake City, UT, February 2008
- Presented NCETE's progress along Center drivers to entire NCETE community, Salt Lake City, UT, February 08
- Conducted individual telephone interviews with 12 NCETE advising faculty members April and May 2008
- Attended NCETE Research Symposium at University of Minnesota, Minneapolis, MN, May 2008

INVERNESS PERSPECTIVE ON NCETE'S PROGRESS AND CHALLENGES

Following is a summary of our reflections on NCETE's progress over the past twelve months, along the five drivers. These reflections are based on the studies we have done, in addition to the numerous meetings and conversations we have had. After this section, we highlight summary data from the two areas of focus for this year: the cohort 2 doctoral student interviews, and the teaching and advising faculty interviews.

PROGRESS

According to the CLT drivers, leaders are people who have a deep working knowledge of their domain and are skilled in promoting improvement in that domain, particularly through fostering relationships with others who are skilled in complementary ways. NCETE has made substantial progress in providing leadership opportunities for Center faculty and especially, for students. In addition to creating a cadre of potential leaders in engineering and technology education by supporting 19 doctoral students in two cohorts, this year, the Center has been proactive in assuring that students' dissertation research will improve the understanding of teaching and learning in this domain. NCETE leadership also made efforts to align students' topics and methodologies with the mission of the Center and to balance them, providing for a more comprehensive portfolio. The Center has also been finding new ways to encourage some doctoral students to play a leadership role in NCETE-related projects and work.

There are multiple levels of knowledge a national Center is well poised to collate, generate, use, and disseminate, including knowledge of the policy, practice, improvement, and curriculum landscape. This year, NCETE leadership has turned greater attention to the full complement of knowledge that it has gathered or generated to date, and what remains to be done. Students in cohort 2 were encouraged, beginning with their first day of orientation activities, to think hard about defining their research topics and methodology early and often. The Center is also sponsoring a landscape-oriented research project of professional development practices and curriculum used in this domain. Some doctoral students are also involved in Center-sponsored or externally sponsored research studies (in collaboration with Center faculty). Importantly, the Center hosted its first research symposium in May to facilitate knowledge flow and dissemination in this domain.

NCETE's research symposium is just one way in which the Center has been cultivating and expanding relationships with other organizations and individuals in the field. NCETE invited leaders in several relevant organizations (e.g. ITEA, ASEE, CTTE, CASEE) to speak at or attend NCETE's meetings, and in some cases, NCETE partnered with existing programs within these organizations to provide more leadership opportunities for Center doctoral students (e.g. 21st Century Scholars program). NCETE continued this year to cultivate relationships and connections with engineers at the partner universities, as well as with people active in the political and funding arenas.

In terms of NCETE's structures, policies, and programs, the Center made substantial progress in refining their professional development strand of work. It is more focused at fewer locations, provides greater research opportunities, and

includes feedback from teachers. NCETE also re-developed the core courses for the doctoral student strand of work, in an effort to provide additional coherence and structure to the sequence. Finally, the Center has also been publishing a newsletter to update participants and the field about its work.

Several activities and events of this year have contributed to the growing "Centerness" of NCETE. The Center reorganized in an effort to provide a better and more efficient management structure. Biannual meetings brought the Center participants together to move their thinking forward, and the special research symposium in May was designed to create more synergy among the different strands of work and research. Participants in the Center reported having gained a better understanding that NCETE represents a "hybrid" field of engineering and technology education.

Below is a summary list of the Center's progress this year:

- The Center took greater steps to ensure that students' dissertation topics and methodologies are balanced and aligned with the mission of NCETE

- The Center hosted a successful orientation for cohort 2 doctoral students, which helped ground them and their research interests in the mission and goals of NCETE, as well as build community

- NCETE leadership actively worked to develop a comprehensive portfolio of knowledge in the domain

- The Center organized and hosted its first research symposium in the area of infusing engineering design principles into technology education

- NCETE has continued to cultivate and maintain relationships with leaders in relevant professional organizations, engineers, and individuals active in the political and funding arenas

- The Center has refined its professional development strand of work; it is a more consistent approach focused at fewer locations, and provides greater research opportunities

- The core courses for the doctoral student strand of work were re-developed to provide more coherence and structure to the sequence

- There was increasing awareness of how NCETE represents a hybrid field, that brings together the fields of engineering and technology education; therefore, efforts were made to bring different strands of work together

CHALLENGES

Last year, we reported that, "the major challenge for this Center is that it is attempting to establish a national Center in a very nascent domain – engineering-infused K-12 technology education. The field of technology education does not have a strong research base, nor does it have a strong record of professional development that infuses engineering design." This challenge remains true for the 2007-2008 year and it is manifest in similar but different ways. Key faculty have reported that they are still uncertain regarding the practical and theoretical meaning of infusing engineering design into technology education. Similarly, the doctoral students in Cohort 2 expressed concern regarding their understanding of the nature of this domain and their roles as potential leaders within the domain.

While the professional development work has proceeded and gained momentum, some faculty reported being unclear as to the specific reason for the change in vision and were concerned that particular sites did not perform as expected. Furthermore, both students and faculty expressed their concern that the professional development strand was not as well aligned with the research strand, as it should have been.

In terms of Center research efforts, while the students are making good progress toward their dissertations, concerns were raised at the May research conference about the wide range of topics students have taken on to study. Since the field is relatively wide open in terms of unstudied questions, this may not be a problem. However, it appears that at the end of the funding period, there may not be a coherent set of studies or findings that the Center can point to as its intellectual legacy.

On a more positive note, however, the research symposium did provide a good opportunity for participants across the Center to learn about the various research efforts underway in the Center and the challenges researchers are facing. Further, the conference concluded with a hopeful and clearer way forward for future research.

At this stage, perhaps the most formidable challenge the Center faces is determining what Center legacy they want to secure and how to go about securing it. The majority of interviewees described the impressive potential of most of the NCETE doctoral fellows for becoming leaders in this domain. We believe it is important that NCETE think carefully and strategically, and develop a vision for what the Center's contribution to technology education will be.

Below is a summary list of the challenges facing the Center:

- The Center still must grapple with representing a hybrid field – infusing engineering design principles into technology education – for which there is not a strong, pre-existing research base

- Perhaps as a result, the Center has not collated or conducted meta-analyses of the extant research that is foundational to the field (e.g. a current synopsis of the supports and barriers to the field, including policies, such as standards, assessments, course requirements, etc.)

- The Center could expand its advocacy role, by generating a clear vision statement for why infusing engineering design into technology education is important and needs to be done

- The Center still has work to do to create synergy among the professional development, doctoral student, and research strands of work, and to capitalize on opportunities for cross-fertilization of these strands of work

- NCETE faculty and students continue to express concern regarding the lack of a common vision, an understanding of the intellectual landscape, and the potential future opportunities available in the domain

- The Center needs to determine what its legacy will be and develop a strategic vision for how to ensure that legacy.

SUMMARY OF STUDY FINDINGS

1) Study of NCETE Cohort 2 Doctoral Fellows

In 2007-2008, we conducted a study of the doctoral fellows in Cohort 2 that mirrored the study we conducted in 2006-2007 of doctoral fellow Cohort 1. Following a focus group interview with Cohort 2 students in August 2007, we conducted in-depth 90 – 120 minute interviews with each student in Cohort 2, focusing on coursework, advising, research and knowledge, NCETE community, and communication. We summarize our preliminary findings below, according to the primary foci of our interviews, and include quotations from students as illustration.

Overall Strengths of NCETE
Most students believe the greatest strength of the program is the potential to become well connected within the field, and to be a part of a Center that has the potential to impact the field.

Overall Challenges of NCETE
Students discussed a range of issues when asked about major challenges, from getting all of the fellows together and committed to the same vision for the Center to understanding what opportunities are available in their future. About half of cohort 2 students have some idea of what opportunities they might have upon graduation. Some cohort 1 students have gotten tenure track positions, which helps cohort 2 students visualize possibilities.

Coursework
Since we talked to the students after they had only the seminar and maybe a little bit of the first core course, they had more questions than comments about the course work. Most students are satisfied with what they have gotten so far in terms of coursework, but many students wondered what the big picture looked like and how the four core courses tied together and tied with the courses they are required to take at their individual institution.

> *The courses are not quite all tied together. It is still very clear that the classes are run by different sites and the people have not necessarily talked.*
>
> *What I would like to know more clearly is what is the content that we are covering in those courses later? I think it is more important that we do some more courses that are aligned with engineering, and whether they give us the freedom to maybe teach a course… those courses may help you to understand more about engineering design…*

Advising

The level and nature of support that doctoral students receive from their advisors varies tremendously. Some students said they meet with their NCETE advisor every day, some said they meet once per month or so. The students reported having developed relationships and ways of working with their advisors that have been effective so far.

> *I am feeling out how the advisor-advisee relationship is structured at this level.*
>
> *There is no advisement really about course work. If you tell him what classes you are taking when he asks, he might be like, 'oh, you shouldn't take that class but doesn't really offer much as far as what you should be taking.*
>
> *I only speak directly with [my advisor], I think mostly because he is one of the very few [in our department] who are familiar enough with the Center to know what I am expected to do and what avenues are available to me… I always look to him for advice.*
>
> *I know that if I have a question regarding any aspect of the center, I can always speak with him about it and if he doesn't know the answer, he will find it for me. He has an open door policy and he says, 'just come and talk to me any time' and he is very open about every issue that has come up, whether it be small, all the way up to the big stuff. He has always been available whenever I needed assistance. I can't say enough good stuff about him, because he has been, honestly, he has been as accommodating as possible.*

Research and Knowledge

In part because it is early in their program, cohort 2 students do not have a widely shared sense of the intellectual landscape of the field. Most students, when asked about this, could discuss research areas that are currently missing from the landscape. They also discussed their own research interests as areas for potential development. A few students were able to describe the current general landscape, especially with respect to the state of tech education and the kinds of issues it is facing, particularly regarding infusing engineering design principles.

> *There are so few articles or studies that have been conducted in our field and so there is not really even a base knowledge for our field, whereas if you look at science or some of the other fields, there is at least a base understanding about how people learn that subject… whereas in our field that doesn't really exist.*

NCETE Community

For the most part, students feel that as things are just beginning, their connections are not yet solid, both within the Center and connections made outside the center. Many students commented that their lack of connection to the larger scholarly community is mostly due to their own failing in taking the initiative to forge those connections.

> *The orientation that was held for cohort 2 this summer in Utah was actually very well done, very well put together and did a really good job of getting at least the cohort 2 fellows and the cohort 1 fellows who were there to get to know each other a little bit and to get to know what each other's interests are and who some of the major players in the center were, that sort of thing.*

> *I do literature reviews for my research right now and I see a lot of the guys' names from the Center who I have met, that I know and I feel like they are part of the same thing that I am. There is a bit of community in that respect. I feel like I could contact any of them, if I had questions. I think since I have met some of these guys I felt like they would be willing to have me as a member of the community, which has been nice. I had some questions initially about whether or not I was cut out for this stuff, from a background perspective or from an intellectual perspective and I think I could fit in.*

> *I have become more connected to a community that focuses on technology education but at the same time, I don't think that connection is a taut one, a strong one. I think it could be better, because I think the NCETE needs to clearly hold what they do and relates to what other communities of practice do. For example, there is some relationship with the American Society for Engineering Education, but how does it relate to the National Association for Industrial Technology? Engineering education has to relate one way or the other to all of these societies that encourages engineering and technology research.*

Communication

The most frequently cited concern by the cohort 2 doctoral students was the poor quality of communication across the Center. Many students felt that they did not know enough about what was happening across the Center, or were not satisfied with their own communication with Center leadership. Several of the cohort 2 students said they would feel comfortable voicing their concerns to Center leadership; however, they had not done so.

> *I feel like I would be comfortable voicing my concerns, but I don't think I would offer it on an unsolicited basis. I haven't felt compelled to email*

them and tell them how I am doing. I have met all of them and I would feel comfortable discussing stuff with them, if they were interested, or if I felt strongly enough about something that I felt like I should let them know about it.

2) Study of NCETE Advising and Teaching Faculty

The purpose of this study was to better understand the extent to which the Center is developing leadership capacity among the NCETE advising and teaching faculty, as well as among the doctoral and master's students they interact with. We conducted in-depth telephone interviews with eleven faculty members, selected with the help of NCETE leadership. In our interviews with the faculty, we discussed issues related to their roles as graduate student advisors and teaching faculty (for both masters and doctoral level students), their research interests, the professional development strand of NCETE's work, and faculty's perspectives on the Center's strengths and challenges overall. We summarize our preliminary findings below, according to the primary foci of our interviews, and include quotations from faculty as illustration.

Overall Strengths of NCETE

While key faculty admitted that creating and running the Center has been harder than they anticipated, they also acknowledged that participating in the Center has impacted them in a positive way professionally, in terms of how they think about infusing engineering design principles into technology education, and getting smarter about providing professional development. Several also counted the opportunities the Center afforded them to connect with peers across the country among the greatest benefits of being involved in NCETE. Perhaps most importantly, the faculty agreed that the major contribution or legacy of the Center will be the next generation of leaders and scholars it is producing through the doctoral fellows, and the creation of a national community focused on infusing engineering principles into technology education.

Overall Challenges of NCETE

Some faculty reported being concerned about the unanticipated fact that key Center faculty have been promoted, changed roles, or assumed new positions during the life of the project. These changes have impacted the time and energy individuals have available to devote to Center work. The faculty interviewed echoed the doctoral students' concerns regarding communication across the Center. Some faculty had learned after-the-fact about events in which they would have liked to participate, and to which felt they could have made a substantial contribution. Others described feeling like they did not hear an accurate account of why shifts in foci or goals had occurred. Faculty also acknowledged that there are still many unanswered questions surrounding both the practical and theoretical meaning of infusing engineering design into technology education

Roles

Many of the interviewees reported that their roles and their institutions' roles have varied over time. Initially, some were engaged in helping to develop the

proposal, recruiting doctoral fellows, and providing professional development for teachers. Others have assumed different roles within their home institutions, and these new roles have limited the amount of time they can spend on NCETE or have impacted the role they can play in NCETE.

Incentives

Faculty said that money is not the driving incentive for their participation in the Center. Most can count summer support as being the largest financial contribution of the Center. Another external incentive for participation is that participation looks good on a resume when one is going up for tenure. But most interviewees reported that they are involved in the Center because they believe in what the Center is trying to do and "what it stood for," that it provides an opportunity for national collaboration, and that it has potential to unify and bring attention to the field of technology education.

> *I'm motivated by the engineering thrust. I think the Center has real potential for advancing an agenda. To help be in a leadership role and make that happen. The Center has as much potential of having influence of anything I've seen in a long time. And externally, having resources to do the work is an incentive.*

> *All along, one of the major values of the Center was being able to connect with peers at other institutions on a regular basis. Without the Center, that just doesn't happen. You see these people at conferences once a year or once every two years. That's a huge benefit – professional collaborations and opportunities to collaborate even further. …The bottom line is that I hope the Center gives us some visibility in the field and offers us some collaboration opportunities like Ken Welty's work with NAE… That is huge. That would not have happened without the Center.*

> *Internally, all along, I believed in what the Center stood for. And being able to move forward with this initiative to look at engineering design as a central piece and component of technology ed as a field. Whether it's working with the leadership team or developing some proposals, or helping students to get onboard with their research… There are a lot of intrinsic motivations that are involved in both of those things. At this point, it's more intrinsic than extrinsic incentives.*

> *The big thing is to be able to attract doctoral students in this area. I have always had a few, but I would have to come up with other ways to support them, and they would be doing things unrelated to their program. Being able to bring in 2 or 3 people together, just having them altogether at once,*

makes it a lot better for them, having the support. Also, because there is the large grant behind all of this, we get a lot more recognition on campus.

They are intrinsic. I am very committed to the field generally. Well before the center came into being, I was involved on the national scene … and being involved in the journals and so forth, and so NCETE was a continuation of that motivation to be a contributor to the field. And the fact that we were trying to create a next generation of professors who could give leadership to the field was exciting and of course the fact that a good crowd of people nationally who will come together over this thing was exciting. There are some good people in NCETE, and when we bring us all together, out of that, you get a good excitement from it.

Research[2]

At this stage, most faculty interviewees said they were primarily involved in research through their graduate students, rather than through their own autonomous research studies. They felt the Center was moving toward a synergy of efforts in research; however, the level of collaboration across the Center was mixed. Faculty reported that they remain concerned that the "rules of the game" shifted after the Center proposal was accepted; that is, NSF expected more research than the request for proposals indicated. This has resulted in a relatively slow start to defining and rallying around a Center-wide research agenda. The Center has taken an important step toward unifying the research agenda by hosting the research symposium in May.

The importance of NCETE research is that it looks at how we can join forces – tech ed and engineering. How do we take that engineering and infuse it into tech ed? It's already there in terms of our ITEA standards. I think that's important. Also, for both of our fields, it's important to know how students learn. And how can we do professional development to get current teachers to infuse engineering into tech ed. PD is important, student learning is important, and developing curriculum.

As a profession, we haven't made research a primary objective of what we do. It's been hard to get people to step up to the plate to do the research. There are dwindling numbers of people in the professorate… fewer and fewer people in tech ed.

In terms of collaboration in research across the Center, a couple of interviewees said that collaborating across an entire Center was refreshingly anathema to the traditional practice of university researchers.

[2] The large majority of these interviews were conducted prior to the May 2008 research meeting in Minnesota.

To some extent, as researchers, we are accustomed to working individually but when it comes to collaboration, we have people we feel comfortable working with and we know what it's like to work with them. That was not part of the criteria for joining the Center. I think that's carried on through, all the way through. Tends to cause us to work a little more independently at the different institutions.

Even though we in the department of technology preach cooperative learning and doing things in teams, when we do research, as faculty members, we are always the lone ranger. We never do things in teams. Occasionally, we will get together with a colleague and say, 'well you know, we are thinking about publishing this paper and we want all of our names on it' and one person ends up doing all of the writing and the other people take a free ride. That isn't the same, exactly, as doing things in a true collaborative way, where every member of the team has a role to play and you are sort of depending on each other, you know, and the sum, what is that saying, the total is greater than the sum of the parts. …That I think is what I have taken home so far, professionally, that it is so rewarding and so productive to work in these groups. …There is magic that happens, between bringing together these disparate personalities and these disparate technical competencies, all of a sudden, it clicks, and I think so far, that professionally is what I would say I have learned from this, how great it is. Research doesn't have to be holed up in your office, whacking away on the computer.

One faculty cautioned against putting too high of expectations on the doctoral students for defining and delivering the research products for the Center.

We've gone through some shifts in what we said we wanted to do. It's hard to get my head around what we're actually accomplishing. My basic thinking is that even when you're dealing with doctoral students, [it is not necessarily the case that they are then] expert in doing doctoral research. I know we want to build expertise in that area, that's one of the goals. I think that [the Center] may be assuming a lot more about what the doctoral students can do. They need to crawl before they can walk. If you try to move them along too fast, you don't have a very good product when they're done.

Several faculty expressed great interest in continuing to develop a research agenda for the Center, one that could carry the work forward into the future. As noted previously, the final presentations at the May research conference outlined some promising pathways for both current and future scholars in the field.

Graduate Students

When asked to compare NCETE doctoral students to doctoral students not participating in the Center, including students they have advised in the past, interviewees responded with a range of answers, most of which indicated that the Center's fellows are, in general, similar to other doctoral students. What sets the NCETE students apart, according to the faculty, are the experiences and opportunities that the Center provides for them.

> *I think the main thing that the Center brings to these students is… the Center allows them to focus full time on their studies and introduces them to an array of valuable experiences so what they accomplish is greater than what other students can accomplish… They are good quality students but the Center provides opportunities for them that are remarkable and are well beyond what would normally be available.*

> *[NCETE doctoral students] seem to have a little advantage [over non-NCETE students] with the amount of travel that they get to do, and the opportunity to meet with the other fellows and network throughout the country. I think that has really broadened their horizons. So in that respect, I think the fellows have gotten a better graduate experience than the non-fellows, but as far as capability, the students that come in, they are all pretty good, and they have to meet certain benchmark criteria to get into the program, so they are for the most part fairly equal [to non-fellows] in their abilities.*

> *We clearly have a good number of future super stars and there is no question in my mind that we have some of the top people that will be going into this field… I would say though that we are leaning on the higher end of quality because the super stars are just so good.*

Professional Development

When asked about the professional development strand of work, the faculty identified providing sound curriculum to accompany the professional development, and most importantly, to integrate the professional development and research strands of the Center as important aspects of the work – aspects which have not, to their knowledge, been accomplished to date. They felt the Center could make its largest contribution by producing good research on professional development in this domain. However, several faculty commented that the challenge currently facing this work is that the professional development is being approached with a practice focus instead of a research orientation, therefore it is not clear yet what research findings can be produced.

> *I think a lot of the folks at the teacher ed sites are really approaching this as a practitioner problem, rather than a research issue. They are doing the*

best they can to put together a good workshop and work with the teachers and all of that, but actually taking the time to stand back and think a little more critically about what they are having the teachers do and why they are having them do it and what is working and what is not and then documenting that in some way, I don't think that is happening. I think the current attempt to approach it from whatever research perspective is going to help, some.

There is a need for some people in the center with that sort of holistic notion of how you make capital of professional development initiatives and how you convert them to research, and I don't know if we have been able to do that, to make the professional development activities research and I think some of them who are involved in it, we are not sure, or are skeptical that the work they were doing had research merit and I think that is a hurdle.

Several faculty also commented that they felt the Center should have taken more time to plan the professional development strategy, or provide a clearer purpose and outcome.

In some ways, I am disappointed that we didn't plan better at the beginning. We came out with this ready, fire, aim model because we thought that we had to move this thing along quickly, and looking back, we probably would have been better off to think this through, spend a year in organizing and planning and then run with it, rather than just jump right in. You can't worry about what happened in the past, but looking back, we realized that everybody kind of did their own thing and we didn't plan in a way that would have probably served the center in an optimum way. I think we kind of wasted some time, but we learned a few things from all of that as well. We are still making mistakes and I am looking at what is going on now and realizing that we still have a long way to go.

We really had to hit the ground running. I felt that it was a huge mistake at the time, and many of us voiced our concerns that we should have had a planning year and then started the training…

Finally, some faculty questioned the utility of trying to formulate a specific model, rather than articulating a few key design principles that are important for professional development.

I understand the desire for us to stop and take a look at a PD model but anytime you make a model, it's only going to fit a certain number of situations.

I don't know that we need to develop a model at all. I think there are models of professional development. You are trying to get teachers engaged and to change their behaviors, that is what you are trying to do in professional development, and whether those teachers are in science or in mathematics and so on, how you get them out of the regular routine to accept change… I don't know that every discipline requires its own model for that.

Teaching

Most interviewees felt there needed to be better coordination among the core courses themselves, as well as with the mission of the Center. Reportedly, the extent to which the courses were aligned with the goals of the Center was mixed. Distance learning has meant different things to different instructors of the core courses. Pedagogy matters more than most believe, in fact, some instructors believe it matters more than in a traditional classroom. The delivery of the core courses has been somewhat uneven in quality of instruction, as reported by both students and instructing faculty.

It is well known that the core courses have been a source of contention among some of the faculty. One of the main questions on the table related to the extent to which the courses that were developed are the appropriate ones for students in the Center. One faculty put the problem this way:

If we're only going to have four inputs to give these students, I'm not convinced that these four are the best we can offer to bring engineering design to life for someone at a university who hasn't had the benefit of knowing what is going on in the Center. Before they can be good quality researchers, they have to know what they're talking about. You can do it through seminars and informal conversations, but you can also have some dedicated courses that speak to it.

Some aspects of the courses have been revised, but concerns about the courses persist, especially in the context of conversations about life after the current funding cycle – should they remain as is, or should other kinds of structures for doctoral study be design and tested?

APPENDIX A – The CLT Drivers

Leadership

Leaders are people who:

- Have deep working knowledge of their domain
- Understand and are skilled at the processes of promoting improvement in their domain
- Have mutually supportive relationships and connections with others involved in the improvement of the domain

Evaluation Tasks

- In-depth interviews and surveys of doctoral students re: extent and ways Center is building their leadership capacity
- Interviews with leading practitioners
- Interviews with key faculty
- Case studies or "vignettes" of students and faculty to document growth in leadership skills and knowledge

Knowledge Generation & Flow

More than research – Centers create "knowledge-rich milieu" that serves the domain

Types of Knowledge – multiple levels of focus (grain size)

- About engineering & technology education improvement
- About policy related to engineering & technology education
- About the landscape of engineering & technology teaching and learning
- About the cognitive aspects of learning in engineering & technology education
- Knowledge of influential practices; curriculum

Increased capacity for collating, generating, using and disseminating knowledge

Evaluation Tasks

- Track doctoral research experiences through surveys and interviews
- Attend and document research conferences or symposia
- Track progress of research goal group
- Conduct interviews with knowledgeable outsiders, like a tenure and promotion review
- Apply "healthy research community" indicators

Relationships & Connections

Examples include:

- Professional Networks
- Higher Ed – K-12 Connections
- Engineer – Educator Connections
- Regional – National Connections
- Engineering – Technology Education Connections
- Communication Channels and Avenues

Programs, Structures, Policies

Structures and Programs

- New graduate program
- New professional development models
- New research organization/newsletters
- Networks/communities
- Value added to existing programs

Policies

- Influencing policies to infuse engineering into HS technology education
- Influencing values and priorities
- Long term support of an "improvement infrastructure" for engineering & technology education
- Funding that can sustain future reform efforts

"Centerness"

Development of a national Center that:

- Aligns all parts toward its mission
- Creates synergy among its individual parts
- Moves toward independent, self-sustaining stature
- Generates and sustains its own leadership
- Is visible, known and valued nationally
- Is well connected with other regional and national institutions, organizations, agencies and leaders

How, and to what extent, has the Center created internal coherence among the strands of work/effort? Was their a symbiosis created, was the whole greater than the sum of the parts?