6-2007

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

NCETE Faculty

Year Three Annual Report

Activities, Findings and Evaluators' Reports

2006 - 2007

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National Center for Engineering and Technology Education
www.ncete.org

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Major Research and Education Activities: 2006-2007

Overview of Center Activities

1. Reverse Site Visit: The Center submitted its Reverse Site Visit (RSV) response to NSF on October 30, 2006. Karen Zuga, NSF program officer, accepted the RSV response and has been working with the Center to help achieve the revised mission and goals.

2. Revised Mission and Goals:
   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.

   The goals of the Center are 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,

   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,

   Establish and maintain a communication program to inform all stakeholder groups of NCETE activities and accomplishments.

3. NCETE Management Team:
   The NCETE Management Team was reconfigured to align with the revised goals. Christine Hailey, Kurt Becker and Rod Custer are concerned with Center oversight. Scott Johnson is leading the efforts to achieve the research goal. Maurice Thomas is leading the efforts to achieve the leadership development goal and Roger Hill is leading the effort to achieve the communication goal.

4. Significant Center Meetings:
   - July, 2006, NCETE management and other center representatives met in Chicago to discuss the RSV concerns.
   - September, 2006, NCETE colleagues associated with professional development (PD) met in Chicago to revise PD activities.
   - September, 2006, representatives from NCETE met with Inverness Research Associates (IRA) to discuss external evaluation needs.

- October, 2006, NCETE fellows and faculty assembled at UW-Stout for the annual fall meeting in conjunction with the 53rd Annual University of Wisconsin-Stout Technology Education Conference.
- November, 2006, a meeting was held at ISU to work on the PD model activities.
- December, 2006, NCETE representatives met in Salt Lake City to discuss activities associated with the leadership development goal.
- January, 2007, a PD meeting was held in Salt Lake City.
- January, 2007, members of NCETE management assembled in Washington, DC, to meet with the doctoral fellows and the Advisory Board.
- March, 2007, NCETE fellows and faculty attended a two-day meeting prior to the ITEA Conference in San Antonio.
- May, 2007, NCETE fellows and faculty attended the Third Annual Summer Workshop hosted by UIUC and ISU.

In addition to the above face-to-face meetings, numerous videoconference and teleconference meetings were held throughout the year.

5. Leadership Development:
NCETE provided the following opportunities for the doctoral fellows to develop leadership skills:
   - NCETE obtained supplemental funds for four fellows, Jenny Daugherty, Cameron Denson, Doug Walrath and Yong Zeng, to attend the 5th Annual American Society for Engineering Education (ASEE) Global Colloquium on Engineering Education. The conference was held October 9-12, 2006, in Rio de Janeiro, Brazil. A brief write up describing the NCETE presentations is in the February 2007 ASEE *Prism*.
   - The NCETE fall meeting was held in October at UW-Stout in conjunction with the UW-Stout 2006 Technology Education Conference. NCETE doctoral fellows, Todd Kelley, Zanj Avery and Katrina Cox, made presentations at the conference.
   - The fellows participated in an NCETE-sponsored workshop in Washington, DC, in January, coordinated by Maurice Thomas and the Leadership Development Team. The fellows were given presentations by Patty Curtis, Managing Director of the Washington Office of the Boston Museum of Science on "Influencing Federal Policies" and by Kendall Starkweather, Executive Director of the International Technology Education Association (ITEA), on "Leadership through Professional Organizations." They were hosted at NSF by Karen Zuga, program Oofficer, who introduced them to NSF and funding opportunities. She arranged for the fellows to meet other NSF program officers and provided an opportunity for the fellows to briefly describe their research interests to these program officers. The fellows also met with the NCETE Advisory Board and provided short presentations on their progress.
   - On Friday, March 16, Karen Zuga highlighted the work of the doctoral fellows in a special poster session that she chaired at ITEA.
   - Ed Reeve from Utah State University obtained NSF funding from an international program initiative for an international exchange on the status of engineering and technology education between Griffith in Australia and the Center. Four doctoral fellows, Katrina Cox, Jenny Daugherty, David Stricker, and Doug Walrath, traveled with faculty members Ed Reeve and Maurice Thomas to Australia in June.

6. Advisory Board:
   On January 30, NCETE representatives met with the Center Advisory Board to share progress and to obtain insights from their perspectives. Representing the Advisory Board were Christine Cunningham (chair), Pat Wilson, Gene Martin and Mel Robinson. Norman Fortenberry and Janet Kolodner could not attend. The NCETE doctoral fellows also attended the meeting and gave five minute presentations on what they have learned during their experiences as doctoral students and where they see themselves after graduation. Karen Zuga and external evaluators Jen Helms and Michelle Phillips also observed the session.

7. Collaboration with the National Academy of Engineering (NAE):
   NCETE and NAE partnered to survey current and past efforts to implement engineering-related K-12 instructional materials and curricula in the United States. This work forms a component of one of the NCETE research sub-goals: "to define the current national status of engineering design experiences in engineering and technology education in grades 9-12," (Ken Welty lead).

8. Additional Status Studies:
   To further achieve an NCETE research sub-goal "to define the national status of engineering design experiences in engineering and technology education in grades 9-12," NCETE management has requested proposals for three other status studies: one concerned with professional development (Rod Custer lead), one concerned with in-service teacher backgrounds (Bob Wicklein lead), and one concerned with the status of empirical research in engineering and technology education (Scott Johnson lead).

9. Professional Development Symposium:
   Rod Custer was PI on "National Symposium to Explore Effective Practices for the Professional Development of K-12 Engineering and Technology Education Teachers," an NSF-funded TPC Conference award. Christine Cunningham, Tom Erekson, Chris Hailey, and Dan Householder served on the steering committee, working with the planning and conduct of the Symposium. The Symposium, which was held in February, assembled over 40 experts in professional development from mathematics, science, engineering and technology education. Many of the papers presented at the Symposium were of very high quality and will assist with the development of an NCETE model for professional development.

10. Doctoral Program:
    NCETE has successfully retained ten doctoral students in the first cohort. Most of the doctoral students are completing their course work this semester and preparing for comprehensive examinations this summer. Bob Wicklein, David Gattie, and Sid Thompson from UGA developed and taught core course three in the fall. Ed Reeve and Tim Taylor from Utah State University taught the fourth core course. Recruiting is underway for the second doctoral cohort which will begin in the fall. The Center goal is to recruit eight new doctoral students.

11. Professional Development:
    The five teacher educator sites completed their year two professional development programs. Inverness Research Associates has completed an external evaluation at each of the sites (see item 16 below). The year two PD experiences have provided considerable insights for the PD model development activities.

12. Internal Research:
    In year three, NCETE awarded one-year grants to Center doctoral fellows and faculty in response to an internal research solicitation. In year four, the internal research process will be modified to provide support for the doctoral fellows' dissertation work. NCETE will also solicit proposals from faculty for research projects that align with the revised goals. For example, several NCETE faculty members were approached to develop proposals for status studies. The NCETE Research Oversight committee is responsible for reviewing the proposals for research quality and impact.

13. CTTE Yearbook:
    The 2008 Yearbook of the Council on Technology Teacher Education, "Engineering and Technology Education," is in press and will be published in February 2008. The team of authors, led by Tom Erekson and Rod Custer, includes a large number of Center faculty members and fellows.

14. Summer Workshop:
    The third annual NCETE summer workshop was hosted by UIUC and ISU on May 16 - 18. Center faculty, doctoral students and an Advisory Board member attended the meeting. On May 16, the meeting was held on the UIUC campus and Linda Katehi, Provost of UIUC and former Dean of the College of Engineering at Purdue, provided an opening session where she highlighted issues in engineering education. Mary Kalantzis, Dean of Education at UIUC, provided remarks on contemporary issues in education. Ty Newell, Assistant Dean in the College of Engineering at UIUC, discussed engineering disciplines, fields, and careers and introduced a unique example of engineering optimization in the design of a solar house. Details about the Solar House Design Competition project at UIUC helped contextualize engineering optimization and design as well as the role of systems engineering. On May 17, the meeting was held on the ISU campus where a panel of classroom teachers described their experiences in infusing engineering design into the classroom to help connect Center research with practice. Center faculty and fellows continued their work on the professional development model. For the morning of May 18, the doctoral fellows developed the workshop activities which consisted of a series of formal debates on three topics: The Role of Engineering in Education, Operational Perspectives on Integrating Engineering into the Classroom, and Psychological Foundations for Engineering Design. For each of the topics, one of the fellows provided formal comments on one position. Another fellow provided comments on the opposing position and each had an opportunity for rebuttal. The fellows also sponsored a panel discussion of the professional challenges faced by new university faculty members as they begin their careers as assistant professors in engineering and technology education. During the afternoon of May 18, the Center sponsored a Research Symposium. The symposium program consisted of fellows and faculty members

reporting on the findings of the six exploratory studies funded during the first year of Center operation. Following the presentations, a team of fellows and consultants provided critiques of the research and reports.

15. Inverness Research Associates:
    The firm of Inverness Research Associates (IRA) was selected as the new external evaluators for NCETE. A meeting with Mark St. John and Jen Helms of IRA was held in Salt Lake City in September. Jen Helms represented IRA at the Center meeting held at UW-Stout in October where she provided an overview of the IRA-developed CLT drivers as a way of evaluating NCETE. Jen Helms and Michelle Phillips proposed an evaluation protocol for years one and two of professional development that was presented to NCETE colleagues during a meeting in Salt Lake City in January. Jen Helms and Michelle Phillips held a preliminary meeting with the cohort one doctoral fellows in Washington, DC, in January. At the San Antonio meeting, Jen Helms and Michelle Phillips presented preliminary findings from their initial meeting with the fellows as well as detailed plans for the evaluation of years one and two professional development. In addition, they also provide an overview of other year three evaluation activities. At the May workshop, they presented additional findings from their interviews with the Center fellows. They also provided their perspective on the first two years of professional development work. Jen Helms, Michelle Phillips and Jim Dorward, the Center internal evaluator, are working together to better coordinate the external and internal evaluation efforts.

Research Activities

The Center continues to strengthen the research climate across the institutional settings. A number of activities have been directed at this effort: internal funding of small student and faculty research projects; development of an internal funding process for doctoral student research; and presentations by researchers at Center meetings and professional conferences.

The internal research program has been successful in providing relatively non-threatening experiences with proposal preparation, review, negotiation, and the conduct of small research projects. Six proposals were funded for exploratory research projects in 2005-06 and five projects were funded in 2006-07. As these projects are completed, findings are shared with their Center colleagues and at professional conferences.

In year three, the internal research program has shifted focus to proposal preparation and funding of dissertation work for the first doctoral cohort. Doctoral fellows are encouraged to respond to a request for proposal preparation that resembles a mini-NSF solicitation. Proposals must include a project description section that describes the contribution of the project to solving an educational project, relevant background literature, research plan and references cited. Each proposal must contain a realistic budget with a detailed explanation of the funding request. The dissertations that are selected for funding will align with the NCETE research program that focuses on understanding teaching and learning issues surrounding the infusion of engineering content and predictive analytical methods into high school technology education. Funded

research can explore critical issues related to student learning, pedagogical practices, teacher preparation, and curriculum. Funded studies can also examine expert and novice approaches to problem solving and engineering design.

The Center supported a research symposium on May 18, 2007 as a feature of the Third Annual Summer Workshop on the University of Illinois campus. This event provided the faculty and fellows with a comprehensive look at the outcomes of the first cycle of research funded by the Center. The symposium program consisted of fellows and faculty members reporting on the findings of the six exploratory studies funded during the first year of Center operation. Questions from the audience followed each presentation. A fellow and a faculty member served as reactors to each of the panels of three reports. Reactors provided critiques of the design, methodologies, findings, and reports of the studies and offered suggestions for improvement of the studies as well as the reports. The afternoon session helped to acquaint all participants with the research productivity of the efforts within the group and served to strengthen the potential of the group to build increased research capacity.

The Center has teamed with the National Academy of Engineering (NAE) to portray the status of current and past efforts to implement engineering education in the United States. This study supports an NAE study entitled "The Nature and Status of K-12 Engineering Education in the United States." One of the aims of this study is to describe the content and strategies used to introduce young people to engineering principles and habits of mind. Another objective of this work is to depict the ways in which K-12 engineering education initiatives address concepts, skills, and dispositions related to the study of mathematics, science, and technology. This study seeks to uncover evidence regarding the impact that prominent initiatives have on formal and informal educators, their institutions, their programs, and their participants; especially young people.

As this report is prepared, three additional status studies have been proposed by Center faculty. The first proposed study is motivated by the Center's effort to develop its own model for engineering and technology education professional development and the importance of determining the status of current and past PD in STEM disciplines and identify best practices. This status study, titled *The Nature and Status of STEM Professional Development Effective Practices for Secondary Level Engineering Education*, will be directed by Rodney Custer of Illinois State University, and Brian McAlister of University of Wisconsin-Stout. The second proposed study, led by Bob Wicklein of the University of Georgia at Athens, will determine what engineering curriculums or activities are currently being taught in technology classrooms around the country. These first two studies are presently under review by the Center's Research Committee. The third study is an analysis of the research in engineering and technology education that has been published in the last ten years. The work is being directed by Scott Johnson of the University of Illinois at Urbana Champaign. Similar studies have previously been done by others in the engineering and technology education field; therefore, this study updates and expands the body of the available data. This study is nearing completion and will appear in the 2008 CTTE Yearbook.

Doctoral Study Activities

In year one, the Center focused on recruiting twelve exceptional students to be named NCETE fellows. The first cohort began their doctoral program in year two. At the completion of year three, ten doctoral students remain in the first cohort; six white males, two white females and two African American males. One has completed his comprehensive examinations and eight will take their examinations this summer. Two of the original cohort who left NCETE were a married couple who had to balance personal and professional lives and decided to become part-time students. The Center is finalizing selection of the second NCETE cohort to begin course work in the fall. Six students have been accepted as NCETE fellows: one white female, one African American female, one Hispanic male and three white males. Four additional students have been offered NCETE fellowships and their acceptance is pending.

To support the dissertation work of the cohort one doctoral students, the Center has developed a proposal solicitation process. One of the goals of the process is to provide a relatively non-threatening experience with proposal preparation. The dissertations that are selected for funding will align with the NCETE research program that focuses on understanding teaching and learning issues surrounding the infusion of engineering content and predictive analytical methods into high school technology education and technology teacher education programs. Funded research can explore critical issues related to student learning, pedagogical practices, teacher preparation, and curriculum. Funded studies can also examine expert and novice approaches to problem solving and engineering design.

To continue to promote leadership development within the first cohort, in January 2007, the doctoral fellows participated in an NCETE-sponsored workshop in Washington, DC. They were given presentations by Patty Curtis, Managing Director of the Washington Office of the Boston Museum of Science on "Influencing Federal Policies" and by Kendall Starkweather, Executive Director of the International Technology Education Association (ITEA), on "Leadership through Professional Organizations." They were hosted at NSF by Karen Zuga, Program Officer, who introduced them to NSF and funding opportunities. She arranged for the fellows to meet other NSF program officers and provided an opportunity for the fellows to briefly describe their research interests to these program officers. The fellows also met with the NCETE Advisory Board and provided short presentations on their progress.

In March 2007, the doctoral fellows attended the 69th annual conference of the ITEA. All fellows presented their research during an NSF Special Interest Poster Session organized by Karen Zuga. In addition, eight of the fellows were co-authors of other presentations or posters presented during the ITEA meeting. Of particular note, a cross-institutional team of NCETE fellows and faculty was recognized by the Council on Technology Teacher Education for their research on delivering core engineering concepts to secondary level students through the Council's Outstanding Research Award.

At the Third Annual Summer Workshop, the fellows developed the program for a session designed to address their own professional growth. They were interested in learning more about three topics that they have addressed continually during their interactions during their two years together: the role of engineering within the educational framework and operational perspectives of integrating engineering into the classrooms. They used a formal debate format to present three

issues to the larger audience. The first debate centered around the question of whether engineering should be a part of general education at the high school level or whether it should be considered preparation for college study of engineering. The second debate explored the relative merits of engineering design and engineering science as the focal point for high school engineering programs. The third debate examined the pedagogical bases for the study of engineering. This session gave the entire group of Center participants an opportunity to learn about fundamental issues that must be addressed in implementing the Center mission and also provided insight into the progress the Fellows have made in addressing those issues.

The fellows also sponsored a panel discussion of the professional challenges faced by new university faculty members as they begin their careers as assistant professors in engineering and technology education. Three Center faculty members with recent doctoral degrees, Tamara Moore of the University of Minnesota, Mauricio Castillo of California State University Los Angeles, and Nadia Kellam of the University of Georgia were joined by Michele Dischino from Central Connecticut State University and Terri Varnado from North Carolina State University for this stimulating discussion. Each of the panelists provided insights into their unique situations and offered suggestions to the fellows for preparing for their early faculty careers. Fellows asked provocative questions and the panelists provided useful mentoring during the session.

The Center was awarded supplemental travel funds to permit four doctoral fellows to attend the 5th Annual American Society for Engineering Education (ASEE) Global Colloquium on Engineering Education. The conference was held October 9-12, 2006, in Rio de Janeiro, Brazil. The colloquium theme was "Engineering Education in the Americas and Beyond" with program tracks that addressed the core issues of primary and secondary education, curriculum for the global engineer, and engineering for the Americas. Prior to the colloquium, NCETE fellows participated in a daylong Student Forum where students from around the globe met to exchange ideas and learn about how engineers are educated in other countries. The NCETE fellows were also active participants in the main conference of the Global Colloquium. The opportunity to participate in a major international conference focused on engineering education provided a unique experience for the fellows. The topics that were discussed covered a wide range of critical issues facing engineering and technology education. These included how to attract a more diverse clientele to engineering, how to improve the quality of the teaching and learning process in engineering and technology education, and strategies for internationalizing the curriculum. In addition to hearing about cutting edge ideas and current research efforts, the fellows had the opportunity to establish professional networks with students, faculty, and industrial representatives from around the globe. The NCETE fellows served as ambassadors for both the Center and the field of technology education. Their active involvement in scholarly discussions raise the awareness of engineering educators and corporate sponsors to the current status and potential of technology education as a contributing partner in the advancement of engineering education.

A core course instructor and a Center Co-PI obtained funding from NSF for a workshop planning meeting with Griffith University in Australia (NSF Number 0703976). Four NCETE fellows were selected to attend the meeting. During the trip, fellows had the opportunity to participate in all aspects of the planning meetings where they learned how technology education was practiced in Australia. They also had the opportunity to visit local schools to see technology education in

action. In addition, each fellow was required to prepare a presentation for the Australian faculty on an assigned topic related to technology and engineering education in the U.S. Fellows gave presentations on the following topics: Engineering and Technology Education as Practiced in the U.S.; Preparing Engineering and Technology Education Teachers in the U.S.; Current and Future Research and Educational Needs in Engineering and Technology Education in the U.S.; and Collaborating and Conducting Research and Education Activities via the Internet. Overall the trip was major success, especially for the fellows, as it provided them with an international experience early in their careers so that they can start to build an international research, teaching, and service agenda.

The NCETE fellows have completed the set of four core courses. 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 courses focused on cognitive science in engineering and technology education, the theoretical foundations of engineering design, and the application of engineering design. This two-year sequence of courses was developed especially for NCETE fellows and represents an important contribution to the field for other institutions interested in preparing teacher educators with a foundation in engineering design.

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.

In the second core course, Design Thinking in Engineering and Technology Education, the fellows continued to be consumers and producers of educational research. 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. One instructor has expressed his willingness to help the students develop their synthesis paper into a journal article at the conclusion of the course.

In the third NCETE core course, Engineering Design: Synthesis, Analysis and Systems Thinking, the fellows were exposed to engineering design techniques. In class they 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.

The fourth NCETE core course, Dynamic and Network Engineering Processes for Technology Education, emphasized issues in assessment. 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. The engineering design challenge was comprised of a student guide that contained the challenge and a teacher's guide that was developed using the 5E lesson planning model, a model that is used in science and supports the constructivist approach to learning.

Professional Development Activities

During this transition year, efforts have been focused on finalizing year two professional development activities, the assessment work of the internal and external evaluators, and the development of a model to guide professional development in engineering and technology education. These efforts are detailed in the Training and Development section of this report.

The long-term goal of the Center professional development activity is to provide leadership to the profession by developing a generalizable model for professional development. The Center will examine the design and delivery of effective professional development with a focus on selected engineering design concepts for high school technology education. The Center has identified three core engineering concepts (constraint, optimization, and predictive analysis) that distinguish engineering design from the traditional technology education design process, and conducted a preliminary study to examine gains of student learning of these core engineering concepts. The research findings showed that the core engineering concepts could be taught to high school students as learning gain showed after the instruction. The different levels of prior math and science of students didn't affect the learning of the three identified engineering concepts. Based on the outcome of this preliminary study, the Center is developing a model that focuses on working with high school teachers to introduce constraint, optimization, and predictive analysis concepts within the context of engineering design into their technology education classrooms.

A related professional development activity was a NSF-funded National Symposium to Develop an Effective Model for the Professional Development of K-12 Engineering and Technology Education Teachers (NSF Number 0533572). The goal of the National Symposium was to assemble a group of key stakeholders with specialized expertise in professional development from mathematics, science, engineering and technology to share expertise and explore best practices for standards-based professional development. Key goals of the symposium were to: (a) examine the applicability of existing teacher professional development models for engineering and technology education and (b) develop a foundation for developing models for technology education professional development, based on contemporary pedagogy. The Symposium was held in Dallas, TX on February 12-13, 2007. NCETE members were substantially involved in leadership roles with the planning and implementation of the Symposium and NCETE provided financial support for several NCETE faculty members to attend the symposium. The outcomes of the Symposium are being used to inform the Center's efforts to develop a model for professional development.

Supplemental Funding Activities

At the suggestion of NSF, the Center requested supplemental travel funds for four doctoral Fellows to attend the 5th Annual American Society for Engineering Education (ASEE) Global Colloquium on Engineering Education held October 9-12, 2006, in Rio de Janeiro, Brazil. The colloquium theme was "Engineering Education in the Americas and Beyond" with program tracks that addressed the core issues of primary and secondary education, curriculum for the global engineer, and engineering for the Americas.

Fellows interested in participating in the colloquium were asked write a one page essay on how the colloquium would benefit their research plans. The NCETE management team reviewed their responses and selected four NCETE fellows, Yong Zeng of UIUC, Jenny Daugherty of UIUC, Cameron Denson of UGA, and Doug Walrath of USU, to participate in the colloquium. Prior to the colloquium, NCETE fellows participated in a daylong Student Forum where students from around the globe met to exchange ideas and learn about how engineers are educated in other countries. The students divided into groups to discuss such topics as elementary and secondary education and how it might attract more students to engineering; engineering education research; the strengths of various methods of preparing engineering students around the world; and sustainability and globalization. The students moderated the breakout discussions and reported the highlights of their discussion to the full group. An evaluation of the Student Forum resulted in a very positive response. The Forum helped to foster cross-cultural discussions on global issues that face engineering in the future.

The NCETE fellows were also active participants in the main conference of the Global Colloquium. The opportunity to participate in a major international conference focused on engineering education provided a unique experience for the fellows. The topics that were discussed covered a wide range of critical issues facing engineering and technology education. These included how to attract a more diverse clientele to engineering, how to improve the quality of the teaching and learning process in engineering and technology education, and strategies for internationalizing the curriculum. In addition to hearing about cutting edge ideas and current

research efforts, the fellows had the opportunity to establish professional networks with students, faculty, and industrial representatives from around the globe. The NCETE fellows served as ambassadors for both the Center and the field of technology education. Their active involvement in scholarly discussions raise the awareness of engineering educators and corporate sponsors to the current status and potential of technology education as a contributing partner in the advancement of engineering education.

Scott Johnson, Research Director of NCETE, accompanied the fellows and helped organize the Student Forum activities. He presented an invited paper entitled "Promoting Educational Research through the National Center for Engineering and Technology Education" at the colloquium. The NCETE fellows reported on their experiences at the 69th Annual ITEA Conference held in San Antonio at a session entitled "Global Insights on Engineering Design as Content."

The Findings Section of the Annual Report consists of two components:

- Major NCETE Findings: 2006-07
- Annual Report External Evaluation Addendum from Inverness Research Associates

Major NCETE Findings: 2006-2007

Significant outcomes of the year include: increased research activity; the success of the cohort model for doctoral study; active participation of Center minority serving institutions and increased diversity among the Center faculty; and increased emphasis on leadership development. These achievements are aligned with the 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 invited the Center to do a background study for the NAE committee on K-12 engineering. 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. Another indication of the Center's emphasis on research is the design and establishment of internal review procedures for evaluating the quality of proposals for internal funding. Center activities have been instrumental in facilitating increased proposal submissions. Two successful NSF TPC awards, one NSF international award, and one MSP award have been received and a number are still under review. Synergy among Center partners has resulted in new collaborations and proposal preparation 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 small group of fellows has been outstanding this year. 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 improved substantially during the current year. While the number of anticipated publications is still relatively small, there is a growing inclination to communicate the findings and contribute to the development of the meager body of knowledge in engineering and technology education.

The Center is pleased with the organization strategy of the cohort model. In year one the Center focused on recruiting a cohort of students that 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 support one another

during and after their doctoral experiences. Twelve students were recruited to the first cohort and they began their doctoral program in year two. At the completion of year three, ten doctoral students remain in the first cohort; six white males, two white females and two African American males. One has completed his comprehensive examinations and eight will take their examinations this summer. Two of the original cohort who left NCETE were a married couple who had to balance personal and professional life and decided to become part-time students. Findings from the external evaluators indicate that the doctoral students feel connected to center partners as well as to the broader technology education community, value the connection and feel they will maintain these connections throughout their careers.

The center is finalizing selection of the second NCETE cohort to begin course work in the fall. Six students have been accepted as NCETE fellows: one white female, one African American female, one Hispanic male and three white males. Four additional students have been offered NCETE fellowships and their acceptance is pending. Many members of the first cohort are excited about becoming mentors to the newly-recruited second cohort. The first cohort has been very willing to share suggestions for ways to make the cohort experience even more valuable to the second cohort.

The Center has found that partner institutions North Carolina A&T State University and California State University, Los Angeles were instrumental in recruiting and retaining diverse students for both cohorts. All African American students in cohorts one and two were recruited by faculty at NCA&T and CSULA as well as the Hispanic student entering cohort two. 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.

The Center has increased the involvement of underrepresented groups in the Center faculty by the addition of Nadia Kellam and Mauricio Castillo. Nadia is a Chemical Engineer on the faculty in the School of Engineering at the University of Georgia. Mauricio recently completed his doctorate at Colorado State University and has joined the faculty in the College of Engineering, Computer Science and Technology at California State University, Los Angeles.

Contributions to leadership development have focused on the development of the capabilities of the fellows through a range of opportunities. They have been involved in planning, conducting, and evaluating center workshop sessions. Fellows have met with organization professionals in outreach, public information, policy advising, and communication roles. In addition, they have interacted with a group of NSF program officers on strategies for preparing successful proposals and working effectively with funding agencies. Particular efforts have been directed toward building opportunities for center personnel in two organizations: the International Technology Education Association and the American Society for Engineering Education. These efforts have been quite successful in terms of the number of presentations made by the fellows and faculty members. In addition, the center has provided a positive example of leadership through its presence at the annual conferences of the organizations.

Internal Evaluation Activities and Findings

Jim Dorward was the internal evaluator for NCETE during year three. He worked with the Management Team to:

- Interpret the WestEd Year 2 report and provide recommendations for future project evaluation.
- Advise the NCETE management team during negotiations with Inverness Research Associates.
- Develop a Memorandum of Understanding with Inverness Research Associates regarding shared evaluation responsibilities for year three.
- Conduct evaluation of the third doctoral course.
- Advise Yong Zeng, a doctoral fellow, on evaluation of the fourth doctoral course.
- Develop the evaluation plan for the new professional development model.

Jim Dorward reported the following changes to Center activities resulting from the internal evaluation findings from years one and two:

- NCETE contracted with Inverness Research Associates to direct overall project evaluation.
- Refined the second-cohort doctoral fellows' orientation to emphasize how the engineering design emphasis is a thread that will be evidenced within all NCETE activities.
- Doctoral core course one was redesigned to incorporate engineering design processes with cognitive science.
- Refined evaluation plan for the second doctoral cohort to enable stronger causal links to NCETE activities.

External Evaluator Findings

After a careful search for a new external evaluator, NCETE contracted with Inverness Research Associates (IRA) in October. IRA submitted their first annual report to NCETE on June 12, 2007. While IRA makes some rather critical point, members of the NCETE Management Team feel it is a fair treatment and provides much more valuable feedback to help the Center improve than reports received from the previous external evaluators. Plans are underway to address the challenges described in the document.

National Center for Engineering and Technology Education

Annual Report External Evaluation Addendum

Submitted by

Inverness Research Associates

June 2007

EVALUATION APPROACH

Inverness Research Associates was contracted in October 2006 to conduct the external evaluation of NCETE. Drawing on previous work as external evaluators of CILS and ACCLAIM, we developed a framework for evaluating 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 eight months, we have primarily served as "critical friends" to NCETE, providing formative advice and feedback as the Center revised its goals and management structure. 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 management team meeting in Salt Lake City, September 2006
- Attended NCETE Annual Fall meeting in Stout, October 2006
- Participated via telephone NCETE PD meeting in Salt Lake City, January 2007
- Attended Advisory Board meeting and Leadership Development meeting for doctoral students in Washington DC, January 2007
- Attended Annual conference of International Technology Education Association (ITEA) in San Antonio, March 2007
- Attended NCETE Annual Summer meeting in Champaign-Urbana, May 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
- Drafted reflections on NCETE revised goals
- Conducted focus group interview with Doctoral Fellows in January, 2007, summarized and presented findings in San Antonio in March 2007
- Conducted in-depth individual interviews in March and April 2007 with each of the ten Doctoral Fellows, summarized and presented findings in Champaign in May 2007
- Conducted retrospective study in March and April 2007, of the first two years of professional development lessons learned, summarized and presented findings in Champaign in May 2007

IRA PERSPECTIVE ON CENTER PROGRESS AND CHALLENGES SO FAR

Here we provide a summary of our reflections on NCETE over the past eight months. These reflections are based on the studies we have done, in addition to the numerous meetings and conversations we have had with the Center and among ourselves.

PROGRESS

In general, NCETE has been responsive to the concerns and questions raised by their evaluators and the NSF review panel, and have engaged the Advisory Board to help guide their revised focus and research agenda. The Center's new structure has been in place only a few months, but they seem to be committed to moving forward and working through the challenges. The following bullets summarize the highlights of the Center's progress since Inverness came on board late last fall.

- The Center has responded to a request from NSF to revise their goals, research agenda, and evaluation strategy in October 2006.

- The NCETE Management Team was restructured to align with the Center's revised goals. The teams are focused on Center oversight, research, leadership development, communication, and the graduate program. This structure seems to be working well so far – however it is too soon to tell whether or not this kind of arrangement will facilitate cross-center interactions and cohesiveness.

- The Center has created goal teams that include six Research Sub-Teams to study Curriculum, Professional Development Landscape, Teacher Landscape, Research Landscape, PD model Development, and Teaching and Learning Research.

- The Center leadership has moved forward on revising the Center research agenda. In order to understand well, and to document, the domain of technology education the Center has initiated landscape studies in order to capture and portray the realities of classroom practices, professional development, and curriculum used in this field. Doctoral students are involved in all of the studies.

- NCETE and the National Academy of Engineering (NAE) have partnered to conduct a study of current engineering curricula, led by Ken Welty, and he has involved several Doctoral Fellows in the research.

- The Center created and delivered four core courses for the Doctoral Fellows, via distance learning technology. While students' evaluations of the courses have been mixed, the Center is working on revising and improving the content and sequence of these courses.

- The Doctoral Fellows have successfully completed the four core courses as well as the coursework required by their institutions, and are preparing for comprehensive exams this summer (2007). It appears that they are all committed to continuing with the program.

- The Center developed a national symposium on effective professional development of K-12 Engineering and Technology Teachers, in February 2007.

- NCETE's Professional Development Team is making some progress on the next phase of work. All original institutions are committed to participating.

CHALLENGES

The NCETE partner institutions are attempting to form a Center to organize and shepherd a quite nascent domain. The people leading this effort are highly committed and want to serve the needs of the domain and advance the mission of the Center. However, they face concurrent challenges: the domain is not yet a domain; the leaders of the Center are relatively inexperienced in organizing complex collaborative educational organizations, and the NSF CLT initiative does not provide a strong, clear vision of what a Center should be and what CLTs should accomplish.

Thus, we have a case of good people struggling to formulate a shared vision of what good engineering-infused technology education should look like. They are simultaneously trying to understand the current landscape in terms of capacities, practices and barriers; looking for the interventions and models that work best in improving the domain; and trying to organize a Center that can coordinate and promote all of this work. This is very different from a Center that focuses on science curriculum or math teacher professional development - these are domains with a long history, many strong players, and active research groups.

Therefore, a major challenge for this Center is that it is attempting to establish a national Center in an embryonic domain – engineering-infused K-12 technology education. As noted, 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. While the Center has sought in some ways to address this, it has been particularly challenging for the doctoral students as they attempt to understand the nature of this domain and their roles as future leaders within it.

Further, the Center is challenged with trying to bring together disparate communities with strong cultural differences – technology education, engineering, and engineering education. This "clash" of communities was felt most strongly in the doctoral cohort, where the different backgrounds of the students proved to be one barrier to building a strong community among the members of the cohort. The diverse professional histories and interests of the students had

led to some divisions in the cohort, rather than forming a rich and solid foundation of diverse strengths and perspectives on which to draw and build.

Another major challenge of the Center has been transitioning from the first two years of work in teacher professional development, where the five participating institutions worked almost entirely independently, to now creating a Center-wide vision for professional development and a plan for the second half of the funding cycle. While each site was successful along many dimensions in developing and delivering professional development for technology teachers, there is no clear path for drawing on those successes to inform the next phase.

Overall, we believe the biggest challenge for the Center at this stage is the leadership coming together to determine what the enduring products of the Center will be; that is, what capacities will be left behind when the Center funding comes to an end? We believe the job of the Center is to create leadership, knowledge, and tools that will inform, develop, and strengthen the domain. We believe it is important that the Center think carefully and strategically, and develop a vision for what their contribution to technology education will be.

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

- 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.

- There does not seem to be strong linkages among the Professional Development strand and other strands of the Center, although the Center plans to address this in the next phase.

- The Professional Development strand, while moving forward, has been very slow and difficult to get going. There is considerable disagreement about the focus and goals of professional development, and the nature of the Center's "model" for professional development, and how the Center will go about developing it.

- The Doctoral Fellows are not confident in their understanding of the domain the Center is supposed to be improving;, particularly, the intellectual landscape of this domain. Hopefully as they participate in various Landscape research studies, their understanding will improve.

- The Doctoral Fellow experience is highly variable among the four institutions, in terms of required coursework, workload, and advisor support. The four core courses serve as the primary unifying activity for students.

SUMMARY OF STUDY FINDINGS

Doctoral Fellows Study

Following a focus group interview in January 2007, we conducted in-depth 90 – 120 minute interviews with each student, focusing on coursework, advising, research, and professional community. We summarize the data below, starting with what the students perceive as major strengths of the program, followed by perceived challenges or issues.

Strengths

- Most students feel that the connections they have made through the Center will stay with them throughout their career; students appreciate the value of the network they are both creating and becoming a part of
- All students have been engaged in some kind of research project and most have started their dissertation research
- Most students feel comfortable providing feedback about their experiences to Center leadership
- Nearly all students commented on the value of the opportunities they have had to travel to conferences, meetings, and other events

- Many students reported that the Center has provided them with opportunities to increase their research knowledge and skills
- Most students reported being impressed that the Center has brought together 9 different institutions with different strengths

Challenges/Issues

1. The students in the cohort have a diversity of backgrounds, professional experiences, perspectives, goals, and purposes.

    - Some students perceive that some Center faculty privilege or value certain background experiences over others.
    - Several students feel an unspoken expectation that they pursue particular professional avenues – or that particular professions are valued more than others.
    - Some students perceive they have experienced inequitable opportunities to participate in research.

2. Students have a range of understandings of the "intellectual landscape of the field."

    - Students do not agree on what "the field" consists of, and several perceive a lack of agreement among Center faculty on this issue
    - Students do not agree on their understandings of the major purpose of the Center
    - Students perceive a lack of agreement across the Center about the meaning of "infusing engineering design into technology education"
    - Lack of clarity on the intellectual landscape stems, to some degree, from lack of clarity regarding Center expectations for students, and/or what future opportunities exist for students
    - Many students are planning to create a specialized niche for themselves in the field.
    - Some are more worried about finding a job in a field that is on the decline than thinking about how they might advance the field

3. Students agreed that the quality of the core courses varied and that there was a lack of coherence among them

- Students agreed that the sequence of the courses was not optimal, and there was a lack of coherence or continuity across the courses
- Students reported it was sometimes difficult to see how the courses furthered the mission of the Center

4. The requirements for doctoral work vary widely across institutions and departments

   - Students have different opportunities
   - Students may not be able to round out their experience and knowledge in balanced ways
   - Some students are required to take courses that are not immediately relevant to the Center mission, and further constrain their opportunities to participate in the Center

5. Students felt the Center should have standards and guidelines for advisors

   - Some students suggested that the Center should have expectations/guidelines - for how advisors will support their fellows and how they will interact - in order to provide continuity and a more common Center experience.
   - Students felt strongly that the details of a potential Fellow's funding situation and work requirements should be made very explicit, before they agree to join the Center

6. Most students reported feeling comfortable offering feedback to Center leadership and faculty.

   - Some students felt that giving feedback to Center leadership or faculty was futile – that they have in the past and it did not lead to any change

<u>Retrospective Professional Development Study</u>

IRA was asked to conduct a study to extract lessons learned from the first two years of the Center's professional development work. While there was extensive descriptive documentation of what the five sites had done, and some feedback from participating teachers, the sites had not reflected to a great extent on what lessons they learned that they could bring forward to the next phase of their work. Additionally, IRA wanted to assist the Center in documenting lessons learned from this work as a contribution to both the Center and to the field – a core function of a Center.

We asked the leaders at each site to fill out a "template" that summarized goals, design, program features, audience, challenges and lessons learned from the previous two years of professional development work. We then conducted 60-90 minute follow-up telephone interviews with at least 2 representatives from each site. We also examined several documents either generated by the site or by evaluators about the site.

Lessons learned about use of external resources

- The involvement of engineering faculty is a benefit. Carefully choosing faculty who understand and support your goals, and can get along and communicate with others, is important to the success of that partnership.

- Involving engineers in designing and implementing professional development can further their understanding of and involvement in technology education. Ultimately this is a way to garner support from engineers to become advocates for and leaders in technology education.

- High school math and science teachers can be valuable and credible resources for technology teachers in a professional development setting and potentially back at the school site.

- General PD resources are useful - to a point. Technology education differs in important ways from science education and math education. Hence professional development may also differ for these three disciplines.

Lessons learned about the professional development experiments

- There is a growing interest across the Center in COPA as a conceptual focus. Two of the five sites used COPA and each used different content as a vehicle, both with good results.

- The design challenge is the focal activity that leads to conceptual learning about engineering design. The design challenge needs to be engaging, "doable" in most

classroom settings, and not overly complex. Further, the design challenge can serve as the "red thread" that meaningfully connects the 100 hours of PD experience.

- Making engineering design accessible to any technology teacher means imagining multiple possible entry points and methods of engagement. It also entails grounding teachers' experiences in the realities and values of classroom life.

- Teachers tend to emphasize an activity-based, experiential approach to teaching technology, versus a conceptual or theoretical approach. Finding a balance should be a key goal for PD in this field.

- Teachers want and need more time to reflect on their learning and work on their own lessons.

- Teachers with a range of STEM experience can be successful in implementing engineering design-infused technology education.
- Engaging technology teachers in a learning community through PD is a way of supporting their continued growth over the school year.

- The dearth of curriculum in this field (i.e., instructional materials, assessments, other classroom supports), both for PD and for classroom use, presents a challenge for professional developers and teachers in infusing engineering into the classroom.

Lessons Learned about the audience for NCETE professional development

- The profile of NCETE's audience is technology teachers, which might include math and science teachers.

- As the next generation of technology teachers, pre-service teachers can benefit greatly from participating in this kind of professional development.

- Investing in the professional development of highly qualified technology teachers increases the leadership capacity of the field.

Lessons learned about overall outcomes of the professional development

- NCETE professional development leaders got smarter about designing and implementing PD over the two years. They all refined their year 2 practices based on feedback from year one.

- There is not consensus across the sites about the conceptual focus, an approach to design, or the best way(s) to infuse engineering design into technology education.

- Sites were able to recruit technology in-service and pre-service teachers to commit to 100 hours of PD.

- Given the relative success and enthusiastic reviews from the teachers, the idea of infusing engineering design into technology education is probably a good one.

- Teachers successfully engaged in a variety of design activities and challenges.

- Teachers' implementation of the intended learning outcomes back in their classrooms was mixed. Some sites were able to follow up in classrooms, some were not. Some found classrooms with high levels of implementation.

- Once teachers leave the PD sessions, communication is extremely challenging. The creation of a communication infrastructure, such as an online course, proved at one site to alleviate this problem considerably.

- School, district, and state contexts will influence the extent to which teachers are able to implement engineering concepts in technology courses. In the face of this potential barrier, the amount and nature of ongoing support can determine how extensively teachers actually change their practice.

Summary thoughts about the professional development work in years 1 and 2

The five experiments resulted in rich examples of ways to engage different kinds of teachers in engineering design. The challenge now is for NCETE leadership to figure out what they agree

on for the way forward. In terms of building capacity in the field, there may be something NCETE could offer that is in between the five experiments and one definitive model. Careful documentation of the Center's agreed-upon guiding knowledge, tools, principles, and strategies would help others in the field improve the professional development work they are doing.

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?