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Year Seven Annual Report

Activities, Findings and Evaluators' Reports

2010 - 2011



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National Center for Engineering
and Technology Education

www.ncete.org



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National Center for Engineering and Technology Education

2010-2011 Activities Report

The National Center for Engineering and Technology Education (NCETE) 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.

This year's accomplishments include: completion of doctoral dissertations and post-doctoral research; continuation of research program; exploration of a strategic alliance of engineering and technology education groups in major doctoral-degree-granting universities; development of a caucus on high school engineering design challenges; and ongoing dissemination efforts.

Completion of Doctoral Studies

Twelve NCETE doctoral fellows have completed their doctoral programs. Their dissertation titles are listed below and complete copies of their dissertations are available on the NCETE website (www.ncete.org). Of the twelve, three fellows completed their doctoral programs during 2010-2011 (Dixon, Lammi and Roue). Scott Wetter and Yong Zeng at the University of Illinois-Urbana Champaign (UIUC) are on target to defend their dissertations during academic year 2011-2012. Katrina Cox at Utah State University and Joe Meyer at the University of Illinois at Urbana-Champaign are no longer pursuing their doctoral degrees.

Austin, C. (2009). Factors influencing African-American high school students in career decision self-efficacy and engineering-related goal intentions. Unpublished doctoral dissertation, University of Minnesota.

Avery, Z. K. (2009) Effects of professional development on infusing engineering design into high school science, technology, engineering and math (STEM) curricula. Unpublished doctoral dissertation, Utah State University.

Daugherty, J. L. (2008). Engineering-oriented professional development for secondary level teachers: A multiple case study analysis. Unpublished doctoral dissertation, University of Illinois.

Denson, C. D. (2008). Impact of mentorship programs to influence African-American male high school students' perception of engineering. Unpublished doctoral dissertation, University of Georgia.

Dixon, R. (2010). Experts and novices: Difference in their use of mental representation and metacognition in engineering design. Unpublished doctoral dissertation, University of Illinois.

Franske, B. (2009). Engineering problem finding in high school students. Unpublished doctoral dissertation, University of Minnesota.

Kelley, T. (2008). Examination of engineering design in curriculum content and assessment practices of secondary technology education. Unpublished doctoral dissertation, University of Georgia.

Lammi, M. (2010). Characterizing high school students systems thinking in engineering design through the function-behavior-structure (FBS) framework. Unpublished doctoral dissertation, Utah State University.

Mentzer, N. (2008). Academic performance as a predictor of student growth in achievement and mental motivation during an engineering design challenge in engineering and technology education. Unpublished doctoral dissertation, Utah State University.

Roue, L. (2010). A study of grade level and gender differences in divergent thinking among 8th and 11th graders. Unpublished doctoral dissertation, University of Minnesota.

Stricker, D. (2008). Perceptions of creativity in art, music and technology education. Unpublished doctoral dissertation, University of Minnesota.

Walrath, D. (2008). Complex systems in engineering and technology education: The role software simulations serve in student learning. Unpublished doctoral dissertation, Utah State University

Post-doctoral Research Associates

Chandra Austin and Cameron Denson completed post-doctoral research appointments in August, 2010. Austin declined an offer of a full-time second year of a NCETE post-doctoral fellowship because of personal needs to move closer to her family. She accepted a post-doctoral teaching fellowship at Auburn University. Cameron Denson completed his second year as a post-doctoral research associate. In accordance with NCETE policy, the appointment was not extended for a third-year. Post-doctoral mentorship activities for Austin and Denson included working with them on the preparation and submission of scholarly manuscripts, the development and delivery of formal presentations for meetings of professional organizations; and the preparation and submission of proposals for research and funded activities.

In January, 2011, two short-term post-doctoral research associates were hired to continue the NCETE research work. Matthew Lammi, an NCETE doctoral fellow, was hired following his successful defense of his dissertation to research engineering design challenges for high school students. Michael Drysdale, PhD in Psychology, was hired using USU cost-share funds to assist with the development of an NCETE survey instrument. NCETE is currently advertising for post-doctoral research associates for academic year 2011-12 contingent on the availability of funding.

Of particular note are the successful NSF proposals that included NCETE post-doctoral research fellows Mentzer, Austin and Denson as Co-PIs. The successful NSF proposals are a direct consequence of an effective post-doctoral mentoring program developed by NCETE personnel. Nathan Mentzer is Co-PI on DRL-0918621, Exploring Engineering Design Knowing and Thinking as an Innovation in STEM Learning. The DRK-12 study builds upon preliminary NCETE research conducted during the summer of 2009 with local high school students. The DRK-12 research examines high school students each working on the problem of designing a playground under realistic constraints. Design thinking is operationalized into a series of variables including time allocation across the elements in a design process, transitions between elements of the design process, generation of alternative solutions, prioritization of design activities and congruence between prioritization and practical application. A total sample of 76 high school students were identified at the four participating high schools who are engaged in an articulated sequence of engineering design courses. The sample is representative of a diverse group in terms of ethnicity, gender, economic background, and first generation-college bound. Of the 76 students, pilot data was collected from 16 students in the four schools. Data analysis and dissemination will be conducted in 2011-2012. Results from the pilot study will be presented and compared to results from previous work focused on experts at the 2011 ASEE conference.

Chandra Austin and Cameron Denson are Co-PIs on DRL-1020019, The Influence of MESA Activities on Underrepresented Students. The Math, Engineering, Science Achievement (MESA) outreach programs are partnerships between K-12 schools and higher education in eight states that for over forty years introduce science, mathematics and engineering to K-12 students traditionally underrepresented in the discipline. The DRK-12 study builds upon NCETE work conducted during spring semester 2010 where a preliminary survey instrument was developed to measure MESA students' self-efficacy, interest and perception of engineering. A total of 166 high school students completed the survey instrument at seven MESA sites in California and Utah during spring 2010. The DRK-12 exploratory study examines the influences that those MESA activities have on students' perception of engineering and their self-efficacy and interest in engineering and their subsequent decisions to pursue careers in engineering. The MESA activities to be studied include field trips, guest lecturers, design competitions, hands-on

activities and student career and academic advisement and involves about 1200 students selected from 40 MESA sites in California, Maryland and Utah.

NCETE Research

Internal Research Grants

Seven proposals were received from NCETE alumni fellows and from untenured faculty members at NCETE institutions by the September 17, 2010 deadline in response to the July 16, 2010 Request for Proposals for the 2010-2011 NCETE Internal Research Program. The proposals were independently reviewed by three experienced reviewers who evaluated each proposal on the announced criteria for the research program. Three projects were selected for negotiation and subsequently were awarded NCETE funding on October 15, 2010. These projects are:

Mapping Engineering Concepts for Secondary Level Education, Jenny L. Daugherty, Purdue University. This study built upon an earlier NCETE-supported study by Custer, Daugherty, and Meyer (2009), which identified 13 core engineering concepts appropriate for study by high school students. The research utilized a focus group to work on relationships among engineering concepts identified by Custer, Daugherty, and Meyer as well as the nine concepts identified by Rossouw, Hacker, and de Vries (2010) in their international study using a modified Delphi design. Daugherty's study was recently completed and the report is posted on the NCETE web site at http://ncete.org/flash/pdfs/Daugherty_Final_Report.pdf .

Understanding of Student Task Interpretation, Design Planning, and Cognitive Strategies during Engineering Design Projects in Grades 9-12, Oenardi Lawanto, Utah State University. This study is investigating students' understandings of assigned design activities in an architecture class and a robotics class in a Colorado high school. In addition, the research follows student progress through the design process as documented in their design notebooks and the artifacts they design. This project, which is nearing completion, will provide preliminary data in support of the researcher's long-term research agenda. The final report of the study will be posted on the NCETE web site upon its completion and acceptance.

Design Thinking and Information Gathering, Nathan Mentzer, Purdue University. This study compares the solution quality, time requirements, and information content of high school student solutions to a design challenge under two conditions: with internet access or without internet access. This research, based on earlier work by the researcher as well as a series of studies by Atman and her colleagues at the University of Washington, is nearing completion and will provide data on a previously unexplored dimension of the researcher's long-term research agenda. The final report of the study will be posted on the NCETE web site upon its completion and acceptance.

How High School Students Address Problem Identification in Unstructured Engineering Design Challenges

Effective incorporation of engineering design into high school curricula is seriously constrained by the lack of a clear understanding of the meaning that high school students make of the assigned problems. To study the process of meaning-making in the engineering design setting, NCETE has been bringing small groups of two, three, or four high school students to the Utah State University campus and asking them to design solutions to specific engineering-related problems. Audio and video recordings are made of their interpersonal interactions during the problem-finding, problem-definition, and problem-solution stages of the engineering design process. The design teams have access to computer graphics software for the development of graphic solutions and internet access for data gathering during the consideration of alternative solutions. The computer is equipped with software to monitor web site access and program utilization. These complex experimental arrangements facilitate the reconstruction of the events occurring at each stage of the design process by simultaneously tracking conversations, observing body language, and monitoring computer activity. The outcomes are extremely rich descriptions of all stages of the actual problem solving processes involved in resolving authentic engineering design challenges. This work is yielding significant insights and assisting in clarifying understandings of the complex interactions involved as young learners struggle with realistic ill-structured problem situations. In a continuing effort to refine the experimental protocol, we have recently begun to develop concept maps to provide a visual representation of the content explored as the teams work toward solutions. We plan to continue to gather data as student teams work toward the resolution of a variety of authentic engineering design challenges. As we develop a deeper understanding of the complexity of the learning challenges, we hope to provide guidance for the identification and sequencing of age-appropriate engineering design challenges in high school STEM settings.

Review of Research on Engineering Design Challenges for High School Students

NCETE has made a continuing effort to stay abreast of published research on the infusion of engineering design into high school STEM settings. We are developing a comprehensive summary of the findings of approximately fifty key studies to inform our work, to submit to a scholarly journal for possible publication, and to provide a coherent base for continued curriculum development, instructional design, and educational research. Participants in the August 2 and 3, 2011 Caucus will serve as an initial panel of reviewers of the manuscript, which will be revised as necessary to respond to their critique. The present draft of the review includes sections on relevance, complexness, processes, constraints, and pedagogy.

Development of NCETE Survey Instrument

The lack of appropriate instrumentation is a serious handicap in conducting research on the effects of the introduction of engineering design experiences in the senior high school. NCETE has begun the development of an instrument to assess relevant demographic and academic variables as well as high school student interest in engineering activities, self-efficacy in

engineering, and understanding of engineering. This development effort parallels some of the current work of the DR K-12 project, The Influence of MESA Activities on Underrepresented Students (Award 1020019), which is developing an instrument to assess self-efficacy, interest, and perceptions of engineering among the participants in the MESA (Mathematics, Engineering, Science Achievement) efforts in California and Utah high schools.

In 2008, the National Academy of Engineering (NAE) announced 14 Grand Challenges for Engineering in the 21st Century, a set of exceptionally complex problems associated with national security, quality of life, and a sustainable future. The interest section of the NCETE survey is composed of 36 problems described within the National Academy of Engineering Grand Challenge report. The understanding section of the NCETE Survey is being developed to align with the Technology and Engineering Literacy Framework for the 2014 National Assessment of Educational Progress. The focus is upon the Grade 12 Benchmarks in sections on Engineering Design; Systems Thinking; Interaction of Technology and Humans; and Ethics, Equity, and Responsibility. The NCETE Survey is also intended to provide a comprehensive inventory of demographic variables for the full range of students who participate in afterschool and out-of-school organizations with goals and activities related to engineering, such as Boys and Girls Clubs, Girl Scouts, Boy Scouts, Junior Engineering Technical Society, and Technology Student Association.

Initial item development and pilot testing of the interest and understanding of engineering scales started during spring, 2011. Currently pilot testing on the NCETE Survey is being conducted with participants in a high school summer outreach program entitled Engineering State at Utah State University.

Strategic Alliance - Advanced Graduate Research Preparation in Engineering and Technology Education

NCETE continued work on an initiative to advance the capacity of new and existing engineering and technology teacher educators to design and conduct high quality impactful research in K-12 engineering and technology education. The goal of this program is the formation of a strategic alliance among top research universities offering doctoral level study in engineering and technology education. Six institutions participated in a feasibility study of an alliance: Colorado State University, Purdue University, University of Illinois at Urbana-Champaign, University of Georgia, Virginia Tech and Utah State University.

NCETE hosted a Strategic Alliance Focus Group meeting on April 30, 2010. The participating institutions met to discuss the benefits and challenges of a strategic alliance, important topics for graduate course work in an alliance, delivery systems, and organization of the alliance. Participants of the Focus Group meeting agreed that multiple institutions with small doctoral programs can leverage resources and expertise through the formation of a strategic alliance. Furthermore, the participants felt that the NCETE experience with the development and

delivery of a suite of courses, especially the lessons learned, was valuable. The participants identified the next critical step in forming the Strategic Alliance to be a Planning Phase.

Participants met August 27, 2010 to initiate the Planning Phase which resulted in the following outcomes.

- PK-12 engineering education is an emerging area, consequently there is a need to develop new courses rather than use existing courses. A course framework and guiding questions for three courses were developed.
- Support from several layers of administration at each institution is required – ultimately the alliance will require a Memorandum Of Agreement (MOA) to detail the institutional commitment to the alliance. A draft MOA was developed.
- Instructional design of the distance delivery system has to be considered to ensure a high-quality learning experience. The instructional design and delivery system was determined.
- The Strategic Alliance evaluation plan was developed
- To move forward with the alliance, substantial funding would be required for course development, instructional design, and faculty support.

One of the significant outcomes of the Strategic Alliance planning has been willingness on the part of the partners to develop and provide a seminar series. Participating universities include: Colorado State University, Purdue University, University of Illinois at Urbana-Champaign, Utah State University, and Virginia Tech. The 2011 seminar series was titled: Engineering and Technology Education Research Methodology and featured faculty and graduate student researchers in the field of engineering and technology education. The purpose of the seminar was to engage graduate students in an analysis of current research and methodological challenges associated with engineering and technology education at the secondary and postsecondary level. The seminar series also creates a network and venue for faculty and graduate students to collaborate and share views, discuss, and advance the state of research in engineering and technology education.

Seminar sessions are described below:

| DATE | PRESENTER | AFFILIATION | PRESENTATION TITLE |
|-------------------|-----------------------|---------------------------|--|
| January 18, 2011 | Orientation | All Universities | None |
| February 8, 2011 | Chris Schunn | University of Pittsburgh | STEM integration: Tech Ed examples of how tech/math integration might work with robotics |
| February 15, 2011 | Michael A. de Miranda | Colorado State University | Knowing what engineering and technology teachers need to know: An analysis of pre-service teachers engineering design problems |
| March 1, 2011 | Raymond Dixon | Illinois State University | Experts and novices: Difference in their use of mental representation and metacognition in engineering design problem solving |

| DATE | PRESENTER | AFFILIATION | PRESENTATION TITLE |
|----------------|--|---------------------------|---|
| April 5, 2011 | Brian Cobb; Becky Orsi | Colorado State University | A variation of the cohort control design to examine student outcome effects from a STEM PD intervention with their middle level math teachers |
| April 12, 2011 | Matthew Verleger | Utah State University | Challenges to informed peer review matching algorithms |
| April 19, 2011 | John Wells, Kelly Schurr, Sabrina Provencher | Virginia Tech | Design based biotechnology literacy: impact of professional development on participant's Stages of Concern toward integration of biotechnology content. |
| May 3, 2011 | James Banning, James Folkestad | Colorado State University | STEM-education-related dissertation abstracts: A bounded qualitative meta-analysis |

Caucus on Engineering Design in Grades 9-12

NCETE is inviting a small group of experienced engineering educators, curriculum developers, and professional development providers to the Utah State University campus August 2 and 3, 2011 to develop a set of principles to guide the development of engineering design challenges for grades 9-12 that are: (a) based on a consensus of expert practitioners and theoreticians; (b) substantiated by the body of research evidence and contemporary professional practice; and (c) useful in guiding instructional materials development efforts across the STEM disciplines.

In preparation for the Caucus, NCETE has commissioned brief descriptions of guidelines for the infusion of engineering design challenges into STEM courses for all students. The papers that have been received to date are posted on the NCETE web site at <http://ncete.org/flash/research.php> in the section entitled "Position Papers on High School Engineering Design Challenges" The first listing, "Engineering Design Challenges in High School STEM Courses: A Compilation of Invited Position Papers," includes an introductory section outlining the background of the NCETE interest in the selection of appropriate and authentic engineering design challenges for high school students. Also, all of the papers are included in that document. Each paper is accessible individually via the hot link in the respective listing at <http://ncete.org/flash/research.php>:

- Design Problems for Secondary Students – David H. Jonassen
- Infusing Engineering Design into High School STEM Courses – Morgan Hynes, Merredith Portsmore, Emily Dare, Elissa Milto, Chris Rogers, David Hammer, and Adam Carberry
- Integrating Engineering Design Challenges into Secondary STEM Education – Ronald L. Carr and Johannes Strobel
- Design Principles for High School Engineering Design Challenges: Experiences from High School Science Classrooms – Christian Schunn
- Engineering Design Challenges in a Science Curriculum – Arthur Eisenkraft
- A Possible Pathway for High School Science in a STEM World – Cary Sneider

It is anticipated that the Caucus will result in

1. A degree of consensus among a diverse group of leaders who are actively engaged in the implementation of engineering design in grades 9-12;
2. A suite of statements of principles to guide the selection and development of engineering design challenges for STEM courses in grades 9-12; and
3. A compilation of references on theoretical bases for engineering design, successful implementations of engineering design, and research on engineering design in grades 9-12.

Electronic dissemination of the Caucus reports will utilize the NCETE web site and related portals. Also, it is anticipated that team and individual proposals will be prepared and submitted for presentations and workshops at Conferences of ITEEA/CTTE and the K-12 Division of ASEE.

Communication and Dissemination

ITEEA Pre-Conference Workshop

On March 23, 2011, NCETE sponsored a Pre-Conference Workshop prior to the 2011 International Technology and Engineering Educators Association Conference in Minneapolis. Presentations and papers at the workshop provided an opportunity for participants to learn about five dissertations recently completed under NCETE auspices by Raymond Dixon, Benjamin Franske, Matthew Lammi, Leah Roue, and Zanj Avery. Current status reports on two of the current NCETE-funded research projects were provided by Oenardi Lawanto and Nathan Mentzer and the draft final report of the third NCETE-funded project was provided by Jenny Daugherty. Three of the alumni fellows, Chandra Austin, Cameron Denson, and Nathan Mentzer, provided overviews of their current work on DR K-12 projects funded by NSF. Alumni fellows and NCETE staff enjoyed a Dutch treat dinner in a local restaurant that evening.

NCETE hosted exhibition booths at the 2011 ITEEA meeting in Minneapolis and at the 2011 ASEE meeting in Vancouver.

NCETE was well-represented at its traditional professional society meeting, the 2011 International Technology and Engineering Educators Association (ITEEA) meeting with twelve presentations or posters. NCETE is also actively presenting research findings at the annual American Society for Engineering Education (ASEE) meeting. In particular, the NCETE Fellows are presenting the following papers at the 2011 meeting:

- High School Students as Novice Designers, Nathan Mentzer (Purdue University, West Lafayette) and Kyungsuk Park (Utah State University)
- The Use of Concept Mapping to Structure a Conceptual Foundation for Secondary Level Engineering Education, Jenny L. Daugherty (Purdue University), Rodney L. Custer (Illinois State University), and Raymond A. Dixon (Illinois State University, CeMaST)
- Thinking in Terms of Systems through Engineering Design, Matthew D. Lammi (Utah State University)

- Investigating Influences of the MESA Program upon Underrepresented Students, Christine E. Hailey (Utah State University), Chandra Y. Austin (Auburn University), Cameron Denson (Utah State University), and Daniel L. Householder (Utah State University)

The NCETE website continues to be an important resource for the K-12 engineering and technology education community. Links to the Fellows' dissertations, internal research reports, position papers on high school engineering design challenges, and when possible, links to journal articles and conference proceedings, provide convenient access to the work of NCETE. The web address is www.ncete.org.

National Center for Engineering and Technology Education

2010-2011 Findings Report

Major NCETE Findings: 2010-11

Significant outcomes of the year included: completion of doctoral dissertations; postdoctoral studies; internally supported research; a collection of invited papers providing guidelines for the infusion of engineering design challenges into STEM courses for all students; development of an NCETE caucus on engineering design grades 9-12; exploration of a strategic alliance of engineering and technology education groups in major doctoral-degree-granting universities; and ongoing communication and dissemination programs.

Substantial progress has been made in preparing two cadres of NCETE fellows to do research in engineering education and in providing opportunities for the fellows to develop leadership capabilities. The completed doctoral graduates, individually and collectively, continue to provide evidence of the success of NCETE in recruiting, preparing, sustaining, and placing a significant group of young professionals in engineering and technology education. Placement and performance indicators, particularly of the first cadre, provide supporting evidence of the role the Center is playing in renewing the leadership cadre at this critical time in the development of engineering and technology education. Placement of fellows and career development of the second cadre has been at a reduced pace when compared with the first cadre as budget crises at institutions of higher education across the country have limited the availability of tenure-track positions.

Current and completed doctoral graduates are authors or co-authors of 40 refereed journal articles and 62 conference papers. Three doctoral graduates are Co-PIs on funded research projects from the National Science Foundation and one doctoral graduate is a senior investigator on an NSF MSP project.

A second internal grant cycle designed to support intensive scholarly endeavors was also successful. Seven proposals were received from NCETE alumni fellows and from untenured faculty members at NCETE institutions and three were recommended for funding. Investigators of the three funded proposals are in various stages of preparing manuscripts for submission to journals in the field. Several of the unfunded proposals were weak, highlighting the ongoing challenge faced by some faculty in technology education as they seek to develop competitive research programs.

NCETE commissioned a broad cross-section of experts to provide brief descriptions of guidelines for the infusion of engineering design challenges into STEM courses for all students. The papers were authored by recognized experts in the area of engineering design including: David Jonassen, Christian Shunn, Chris Rogers, Johannes Strobel, Arthur Eisenkraft, and Cary Sneider. The papers are posted on the NCETE website and provide a valuable resource for

individuals conducting research focused on engineering design. NCETE will provide another important resource for the community interested in engineering design following the Caucus on Engineering Design in Grades 9-12 scheduled for early August 2011. The intended outcome of the Caucus is a suite of statements of principles to guide the selection and development of engineering design challenges for STEM courses in grades 9-12 that will be published on the NCETE website as well. Caucus participants represent expertise in engineering education, curriculum development, and professional development.

In its original 2004 proposal, NCETE outlined a plan to build capacity for research; to nurture a cadre of talented, diverse leaders in engineering and technology education; and to infuse engineering content, design, and analytical skills into K-12 schools. Substantial progress has been made in preparing two cadres of fellows to do research in engineering education and in providing opportunities for the NCETE fellows to develop leadership capabilities. The preparation of teachers to incorporate authentic engineering experiences into their high school technology education courses has proven to be extraordinarily complex, in part, because of the evolution of the field of technology education since the inception of the Center. The members of the International Technology Education Association voted to change the name of the association to reflect the emergence of engineering in technology education. An examination of the ITEEA website suggests more interest in STEM education than in engineering and technology education. The evolving technology education landscape provides opportunities for research leading to action plans that might influence the trajectory of the ever changing landscape.

Stressful financial times within higher education have taken a toll on the number of technology education programs. NCETE began with nine partners in 2004. In 2011, only six of those partners have active doctoral programs or pre-service technology teacher education programs. North Carolina A&T State University no longer offers a bachelor or master level course in technology education. The graduate programs at the University of Minnesota and at the University of Illinois at Urbana-Champaign did not fill the positions of Theodore Lewis or Scott Johnson following their respective retirements.

Emerging areas in K-12 engineering and technology education research, increasing the diversity of doctoral program graduates, improving research capabilities within the profession, and strengthening graduate programs with small enrollments are drivers for innovation in engineering and technology education graduate education. NCETE explored one such innovation: a strategic alliance of institutions that utilize partners' expertise to create new academic offerings that focus on improving doctoral students' research capacity. One challenge NCETE faced during this exploratory effort was that collaborative, long range planning was difficult because of financial uncertainties at alliance institutions. Development of a sequence of courses that are shared across institutions is currently on hold. However, the NCETE seminar series offered across alliance institutions has been successful. Results of an internal evaluation of the seminar series by James Dorward found that the faculty overwhelmingly rated the seminar series as a valuable contribution to their graduate programs.

Internal Evaluation of the Spring 2011 Research Seminar

Report Submitted to the NCETE Project Leadership Team

James Dorward

6/6/2011

Internal Evaluation of the Spring 2011 Research Seminar
Sponsored by the National Center for Engineering and Technology Education
Report Submitted to the Project Leadership Team

By
Jim Dorward

June 6, 2011

During Spring Semester 2011, the National Center for Engineering and Technology Education (NCETE) sponsored a doctoral-level, cross-institutional research seminar. The purpose of the seminar was to engage graduate students in crucial analysis of current research and methodological challenges surrounding engineering and technology education at the secondary and postsecondary level. In addition, the seminar was designed to create a network and venue for faculty and graduate students at selected doctoral granting institutions to collaborate and share views, discuss, and advance the state of research in engineering and technology education. Participating institutions were Colorado State University, Purdue University, University of Georgia, University of Illinois-Urbana-Champaign, Utah State University, and Virginia Tech.

The seminar consisted of 8 hour and a half sessions broadcast over an interactive video-conferencing network. The general format consisted of a professor distributing a published article or paper in progress to the doctoral students one week prior to the class, a 30 minute presentation on the research design methodology, followed by a question and answer session. At the end of the semester, the NCETE Leadership Team wanted to know whether students and professors considered this cross-institutional seminar to be of value, and how the structure and format could be improved for possible implementation in subsequent years. Two surveys were disseminated via Survey Monkey to all student and professor participants. Responses were received from 10 of 19 students (53%) and 8 of 10 professors (80%).

Results

Responses from the student survey (n=10) are listed below:

1. How would you rate the value of the cross-institutional Spring 2011 research seminar?

| | | |
|-----------|-------|---|
| Very High | 30.0% | 3 |
| High | 40.0% | 4 |
| Low | 20.0% | 2 |
| Very Low | 10.0% | 1 |

2. In ways might the seminar be improved to increase its value for doctoral students?

Open-ended responses in Appendix A

3. Do you believe that a cross-institutional research seminar contributes significantly to a doctoral program?

| | | |
|-----|-------|---|
| Yes | 60.0% | 6 |
| No | 40.0% | 4 |

4. How might the seminar be modified to increase interactivity between students and with the guest researcher?

Open-ended responses in Appendix A

5. Did the Spring 2011 research seminar meet your expectations?

| | | |
|-----|-------|---|
| Yes | 60.0% | 6 |
| No | 40.0% | 4 |

6. Please describe how the Spring 2011 research seminar either met, or did not meet, your expectations.

Open-ended responses in Appendix A

7. How has knowledge gained from the seminar been useful in your subsequent work?

Open-ended responses in Appendix A

8. How has the seminar influenced your research plans and proposals?

Open-ended responses in Appendix A

Responses from the professor survey (n=8) are listed below:

1. How would you rate the value of the cross-institutional Spring 2011 research seminar to doctoral students?

| | | |
|-----------|-------|---|
| Very High | 37.5% | 3 |
| High | 62.5% | 5 |

2. What additional support should the program provide? (Check all that apply.)

| | | |
|---------------------|-------|---|
| Research assistance | 50.0% | 3 |
|---------------------|-------|---|

| | | |
|---|-------|---|
| Presentation assistance (slide development, graphics) | 16.7% | 1 |
| Studio technical assistance | 50.0% | 3 |

3. What technologies should be in place at each institution to provide a quality learning experience

| | | |
|---|--------|---|
| Video-conferencing capabilities that enable multiple site viewing | 100.0% | 8 |
| Classroom computers with office software | 0.0% | 0 |
| Camtasia (or similiar) presentation and note taking software | 12.5% | 1 |
| Blackboard/Vista/Canvas compatible courseware | 12.5% | 1 |

4. In terms of time spent on your presentation, what stipend amount is reasonable?

| | | |
|--------|-------|---|
| \$500 | 85.7% | 6 |
| \$1500 | 14.3% | 1 |

5. What additional infrastructure support should partner institutions provide to ensure a quality experience for students?

Open-ended responses in Appendix B

6. What questions would your institution want answered if it were to provide ongoing support for a cross-institutional seminar?

Open-ended responses in Appendix B

Findings

In general, both doctoral students (70%) and professors (100%) found the cross-institutional research seminar to be of value. There were some doctoral students (n=4) for whom the seminar did not meet their expectations. There were also 4 students who did not believe that a cross-institutional research seminar contributed significantly to their program of study.

Suggestions for increasing the perceived value of the research seminar include enhancing the quality of the broadcasting technologies, encouraging students to submit

questions prior to the presentations, involving students more in active research, and increase topical relevance by focusing discussions on research within a given institution. This last suggestion may be the antithesis of one of the primary tenants of the research seminar; to broaden student exposure to research within the field.

Appendix A: Open-Ended Responses to Student Survey

2. In ways might the seminar be improved to increase its value for doctoral students?

- *I don't like long-distance communication, the face-to-face interaction is what i prefer.*
- *Current limitations in the technology make it difficult or impossible to clearly see the guest's slides, so if slides are going to be used for a presentation, they should always be sent to participants prior to the presentation.*
- *I think the present format allows students to explore their research interest*
- *engineering- theory and foundation was fine education- educational theory and practice, and cognitive science foundations were weak I would like to see more of the questioning from professors who have served on defense committees and what their line of questioning is like; it's sad that we don't get to see what a defense will look like typically until we're defending*
- *It provides doctoral students a variety of research methodologies.*
- *improve the technology; too many technical problems 2) allow for a wider cross-section of topics 3) allow for, and invite, statistical inquiry... did not feel this happened.*
- *To know more about other studies.*
- *get into real research*
- *Make the seminar primarily within-institution, with occasional cross-institution sessions. We're trying to go across institutions when our own professors and students aren't working together within the institution. It seems at least some professors have greater loyalties outside the institution than within. Again, I suggest we focus on within-institution activities primarily, and supplement with one or two meaningful, focused cross-institution sessions.*

4. How might the seminar be modified to increase interactivity between students and with the guest researcher?

- *Using face-to-face communication.*
- *Have the participants submit questions electronically to the guest researcher or moderator one day before the presentation. The guest researcher or moderator can select questions (or questions that have a similar theme) to answer. 2. Remind participants and presenters that participants have a range of backgrounds from first-year graduate students with little statistical experience to doctoral candidates to post-docs to full professors to professor emeriti. The moderator should inform the guest presenter of the background of the target audience (graduate students?), so that he or she can prepare the presentation*

with that audience in mind. 3. The tone of the seminar occasionally crossed into more of an oral defense type atmosphere with questioners trying to “catch” the guest researcher in an error. Remind the participants that perceived flaws in research methods are fine to bring up, but the primary goal of the seminar is dissemination of ideas and understanding of methodology. 4. It is not necessary to zoom in on participants when they are asking questions of the guest researcher—this practice could inhibit some participants from asking questions altogether.

- *Interactivity is presently good*
- *Researchers should focus on the research process, not just the paper presentation. Often when someone asked a question about a presentation, the researcher would say, "that came out in the research." The process is often of greater interest, not the "package," paper only. Many times questions were asked and the research happened so long ago, the researcher couldn't pull the answer from memory. Looking at your own tables and not knowing what they represent is bad, bad, bad form.*
- *It is a good idea to develop group of students. Ask the students to have discussion(s) and prepare question become participating in the seminar.*
- *I think that Spring 2011 research seminar runs pretty well because the guest researcher or speaker did provide us with his/her related article(s) together with presentation slides a week before the meeting. The only thing that my interrupt the interaction in this research seminar is the technology used in the classroom. Its need to be synchronized among the universities.*
- *i think its fine; just more hours of seminar classes.*
- *I think that it is utilized to promote*
- *I think my previous suggestion of focusing primarily on within-institution seminars will help focus our own institution. Then, I think we can reduce the number of cross-institutional parties to 2 or 3, and only set up meetings if individuals at all institutions have a common interest. This will help increase interactivity, because of the tighter cooperation within-institution, and the more common purpose with a smaller number of participants.*

6. Please describe how the Spring 2011 research seminar either met, or did not meet, your expectations.

- *We learned a lot of interesting studies and those studies and researchers offered useful information for me.*
- *I feel I gained a wide exposure to a variety of issues in engineering and technology education research and became acquainted with the researchers and institutions who are investigating these issues. It was an excellent survey type course—with breadth rather than depth—and the length of the seminar (approximately 1.5 hours) was a good duration, allowing enough time for both presenters and questioners.*
- *It provided a various research paradigm that are being used in engineering and technology education*
- *see number 2*

- *The Spring 2011 research seminar met my expectations. The presenters gave the materials before the seminar and they provided clear explanations in answering the questions.*
- *Spring 2011 research seminar does meet my expectations especially when we have focus our presentation and discussion on specific topic - research methodology in engineering and tech education*
- *Its interesting to know more about studies of other universities.*
- *I thought it would be helpful, but it really did nothing*
- *Did not meet expectations.*

7. How has knowledge gained from the seminar been useful in your subsequent work?

- *I have learned how to select research method, how to design a study, etc.*
- *The biggest benefit to me was the exposure to areas of research that I was unaware of, such as the current issues in professional development and how qualitative methods are being utilized in engineering and technology education research.*
- *Cite supporting evidence from seminal researchers as often as is possible to back your claims...this is a human science. More citations in slide show presentations of shared information is a must unless the theory is yours. Know the cognitive science and educational psychology behind your research backwards and forwards, and having lived experience in your topic area helps. Research that supports only "best case" scenarios of learning quickly become irrelevant and do not increase the body of knowledge, nor encourage practitioners to seek out research to support classroom practice.*
- *really no effect.*
- *How to codify data from different studies to analyze them.*
- *I only learned which stats I should use*
- *No, not likely.*

8. How has the seminar influenced your research plans and proposals?

- *Not really, but it has brought me new ideas for my research plan*
- *The exposure allowed me to develop deeper conversations with other students and professors and gave me several ideas for possible research.*
- *see number 7*
- *It influenced the way I develop my research design.*
- *not so much*
- *I am interesting to work in several areas mentioned in the seminar; probably I will take one of them in my future proposal.*
- *it hasn't*
- *It has not.*

5. What additional infrastructure support should partner institutions provide to ensure a quality experience for students? answered question4

- *Advance question and follow-up question posting*
- *Offer credit for students to take the seminar*
- *The h3.23 capability is important for a quality experience. Some of the participating institutions have some older equipment that does not allow them to view multiple screens. Perhaps we need a specifications sheet that educates participating institutions in the required infrastructure.*
- *Increased interaction during the presentations would be beneficial. Students could submit questions before the seminar germane to the topic/methodology. Professors at each site can give the students topics/questions to look for in the presentations also. Additionally, there should be an increase of collaboration not just dissemination - I am not sure how this would be done.*
- *The current use of VOIP presents disadvantages because of differences in system capabilities and end user access/manipulation of presentations. Point-to-Point synchronous engagement through personal computers as afforded by Adobe Connect allows for individual engagement, sharing of documents, audio/video, recording of sessions, etc*

6. What questions would your institution want answered if it were to provide ongoing support for a cross-institutional seminar? answered question3

- *local enrollment numbers.*
- *None*
- *It was such a great experience on our end that my students are asking what the schedule for next year is going to be. Outstanding series.*
- *Who is collecting and analyzing these responses and how will decisions be made following this analysis? 2. What avenues will be afforded online students who are enrolled in institutions with blended online/on-campus programs (currently, because VOIP is the delivery platform, these students cannot participate)? 3. Will the papers presented be compiled each year in a seminar "proceedings" that is publically accessible? 4. To what extent will the Scholar site set up by Wells at VT continue to be used in the future? 5. What additional use of the Scholar site is anticipated for the spring 2012 seminar? 6. Will there be a fall 2011 seminar?*

National Center for Engineering and Technology Education

Review of Leadership Capacity

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January 2011

INVERNESS RESEARCH

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Introduction

Inverness Research has evaluated three NSF-funded Centers for Learning and Teaching (CLTs). Through this work, we have identified and vetted five dimensions for examining the work that Centers do. These dimensions are: Leadership; Knowledge Generation and Flow; Relationships and Connections; Programs, Structures, and Policies; and “Centerness.” As the external evaluator for the National Center for Engineering and Technology Education (NCETE), Inverness has focused its efforts in year 6 on documenting the progress the Center has made according to these drivers. The focus of this report is the first dimension: *the development and support of leadership*.

Inverness has developed a particular perspective on leadership through our study of CLTs. Our point of view is not limited to the traditional notion of people with followers; rather, we see leaders as people who have the ability, propensity, and expertise to contribute to the improvement of the domain in which they are situated. For example, a leading teacher is not only teaching in the classroom, but has the ability to contribute to the improvement of teaching. A leading faculty member is a faculty member in a university who has the ability and predisposition to contribute to the improvement of their particular area of scholarship, and to support the development of graduate students and scholars new to the field. Graduate students in CLTs are studying problems and issues of the domain such that they gain the knowledge and expertise to launch a career in the improvement of the domain and therefore, have the potential to become leaders. One of the key outcomes of CLTs, therefore, is the development of a diverse group of people who can become part of “the improvement community”¹ for that domain. It is in this light that we explore NCETE’s accomplishments with respect to the development of leadership.

In this document, we highlight the ways and extent to which NCETE has fostered leaders to shepherd the domain of engineering-infused technology education. We provide an overview of the Center’s various efforts to develop leadership, as well as a range of perspectives on the efficacy of those initiatives. Finally, we review NCETE’s approaches to and activities for developing leadership among its students, faculty, post-doctoral students, and the broader community. The primary

¹ St. John, M. and Stokes, L. (2008) Investing in the Improvement of Education: Lessons Learned from the National Writing Project. Available at: http://www.inverness-research.org/abstracts/ab2008-12_Rpt_NWP_ImprovementInfrastructure.html.

audiences for this document are Center leadership and potential funders of future leadership development projects.

Data sources and methods

Our data sources and collection methods for this report included:

- 1) Initial focus group interviews with both cohorts of doctoral students
- 2) Interviews (three) and surveys (two) of doctoral students, regarding the opportunities they had to develop their leadership capacities
- 3) Interviews with faculty members, regarding their own opportunities to develop their leadership capacity and how they encouraged leadership development among the doctoral students
- 4) Interviews with field experts that explored, in part, the extent and ways NCETE has built leadership capacity in the field
- 5) Interviews with Seed Grant recipients
- 6) Interviews with doctoral graduates with jobs

Overview of report

This report summarizes the various formal and informal efforts of the Center to build and support leadership in the domain. By “domain,” here we are referring to the members of the field who work to infuse engineering design principles into technology education. In this report, we highlight a range of perspectives on the quality, cohesiveness, rigor, and contribution of the different leadership-development initiatives of NCETE, including the research strand of the Center. Perspectives include those of the doctoral fellows from both cohorts; doctoral fellows who have graduated and are currently employed; NCETE faculty advisors; seed grant recipients; faculty and students engaged in research at NCETE institutions; experts in the field we interviewed regarding the Center’s work in this domain; and external expert reviewers we recruited to review the Center’s research portfolio. After providing a review of perspectives on NCETE’s efforts within leadership development, we offer our own perspectives on the Center’s progress in creating and maintaining leadership capacity, and discuss potential future directions.

Leadership Development Initiatives of NCETE

In the following paragraphs, we underscore the key efforts the NCETE offered to build leadership among the Center participants, and throughout the technology education community. We focus on two major efforts:

- The doctoral programs at the University of Georgia, University of Illinois at Champaign-Urbana, University of Minnesota, and Utah State University, and leadership opportunities for doctoral fellows outside of the formal doctoral programs
- Faculty leadership opportunities

The Doctoral Programs

A total of 17 Doctoral students were admitted to four degree-granting universities participating in the Center over the life of the grant. Each university offered different programs for eligible students. From the NCETE website:

- **The University of Georgia** offers a PhD in Workforce Education, which prepares individuals for leadership, university teaching, and other roles in career and technical education.
- **The University of Illinois at Urbana-Champaign** offers a PhD in Human Resource Education, which prepares individuals for leadership roles and faculty positions that requires the use of the tools and concepts of inquiry and analysis in activities such as research, evaluation, and curriculum development.
- **The University of Minnesota** offers a PhD in Work and Human Resource Education, which prepares individuals for professional roles that emphasize conducting research.
- **Utah State University** offers a PhD in Curriculum and Instruction with an emphasis in engineering and technology education, which is primarily chosen by people who are seeking teaching/research positions in colleges and universities.

Over the years, we have interviewed and surveyed the doctoral students about their experiences at their home universities, the quality and value of Center-related courses, events, and other experiences, and their reflections on the extent and ways the Center has prepared them for leadership in the field. The following paragraphs summarize some of the key findings from our studies of the doctoral students.

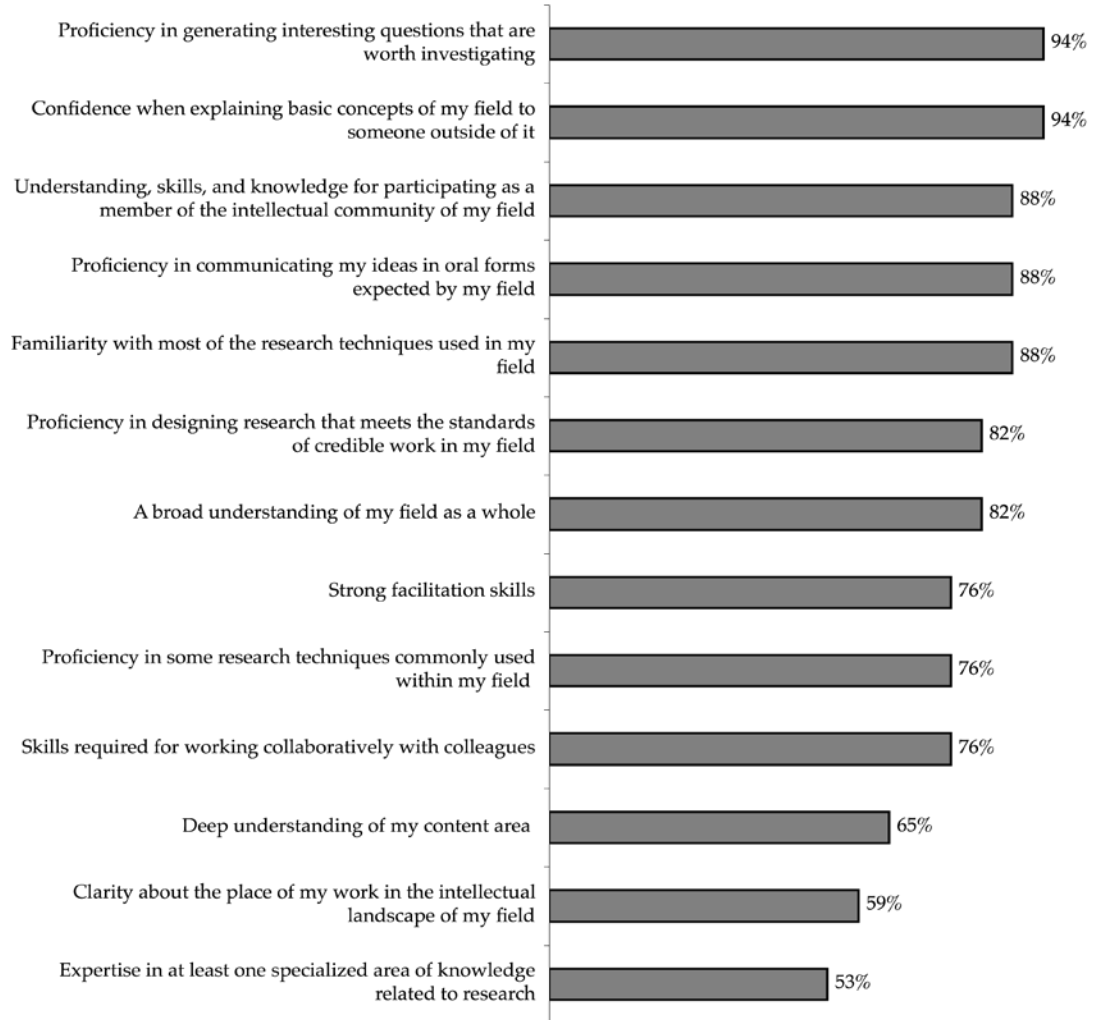
For the most part, the doctoral fellows believe NCETE prepared them to be effective leaders in the field. The vast majority of them reported that NCETE has equipped them to a large or very large extent with understandings in areas that prepare them to play a leadership role in the field, such as: confidence when explaining basic concepts of the field to someone outside of it; proficiency in generating interesting questions that are worth investigating; familiarity with most of the research techniques used in the field; proficiency in communicating ideas in oral forms expected by the field; understanding, skills, and knowledge for participating as a member of the intellectual community of the field; a broad understanding of the field as a whole; and proficiency in designing research that meets the standards of credible work in the field.

From a knowledge and skills perspective I feel prepared to eventually assume a leadership role in my field. I have made many good contacts in the field, and have discussed field issues at length with many of these people, which I think is an important gauge of how my ideas and skills fit into the field. I think I have a good understanding of methodological processes used in the field, and can understand, interpret, and synthesize literature with accuracy and confidence.

The areas where NCETE doctoral fellows were less confident include having gained a deep understanding of their content area, clarity of the place of their work in the intellectual landscape, and expertise in one specialized area.²

² The differences between the cohorts regarding their perceived preparation for leadership roles are not strong, with slightly higher ratings given for most questions by the first cohort, but not significantly higher. One area—skills related to oral communication—may have been significantly stronger for the first cohort.

Percentage of NCETE doctoral fellows who believe that their doctoral program has equipped them with the understanding, skills, and knowledge to prepare them to play a leadership role in the field



From the March 2009 Survey. Percentages represent ratings of 4 or 5 on a scale where 1 = "not at all" and 5 = "to a very great extent."

In the summer of 2010, all NCETE Fellows – graduated or not – were surveyed for their final assessment of their graduate experience (13 Fellows responded to the survey). We asked the fellows to rate the extent to which various leadership components were available, and also to rate the quality of those components. Just over one-half of the Fellows reported that opportunities to learn about and lead while in the program were available to them, and that these opportunities were good or excellent. About the same number believed that the program prepared

them to be leaders in the field upon leaving the program, and that this preparation was good or excellent.

In the same 2010 survey, Fellows had the following comments about the leadership aspects of their graduate experience:

I saw that many of the leadership development opportunities we had were vastly superior to those available outside of NCETE and have since recognized the significant advantage and experience this gives me over many of my current colleagues.

I came into my [current] position with numerous publications, conference proceedings, leadership roles on committees of professional associations, and co-PI positions on funded projects. I'd say that is pretty rare for a first year assistant professor. I credit NCETE with a lot, if not most, of those opportunities.

Very good mentorship is provided.

The cohort structure

NCETE sponsored two cohorts of doctoral students over the life of the grant. The cohort structure of the doctoral program was a significant positive contributor to the students' experience, and to their perceptions of themselves as becoming leaders in the field. In the 2009 survey, a few fellows commented on the value of the cohort:

Being part of a cohort invokes a sense of community and belonging that is needed to provide a collaborative environment for myself and other STEM stakeholders. Cohorts are also vital to capacity building because it serves as a vehicle for increased networking and idea sharing. I do not see any disadvantages with experiencing the program as part of a cohort.

The cohort has provided a critical mass of people who are focused on a similar goal. This is rather unique in my experience since technology education, typically, is a small group of folks. This critical mass has provided a motivating factor in that we support each other. The small disadvantage is that not all fellows are/were ready for the substantial commitment and are struggling members of the team.

My vocabulary lacks the words to quantify the importance of going through all phases of a doctoral program with at least a few others experiencing the same pain simultaneously. Not that the pain is always a bad thing. But there were times I seriously questioned my decision to pursue a PhD and having one other person feeling the same pain, to serve as a sounding board, helped pull me through. In addition, there is much to be gained from the expertise of fellow fellows. The initial pool of candidates that were sought from Technology Education and Engineering was well intended and helped spread a wealth of professional knowledge from within the cohort. I learned a great deal from these cohort members. The greatest disadvantage of a cohort is that if there are a few weak links in the chain, others end up carrying the weight for them. When quality people begin to shut down out of frustration, it weakens the cohort and has negative consequences for the intended goal/mission of NCETE.

Other program experiences

In addition to the cohort structure, NCETE provided other doctoral program experiences that were intended to build leadership, such as meetings where Fellows spent the day in Washington DC, visited NSF, and met and spoke with NSF program officers; research meetings, where Fellows were introduced to key researchers in the field, as well as new researchers outside the Center; NCETE Center meetings, where many students were invited to participate in Center-wide planning and business meetings; support with proposal writing for their dissertations, as well as other research opportunities; and seed grant opportunities. In general, the Center played a large role in providing students with opportunities to build their leadership confidence and skills.

Graduate fellow research opportunities

We call particular attention to the research opportunities that were intended to build leadership skills. Most of the students were given opportunities to participate in research outside of their dissertation work. Some students participated in research within their university departments, some students participated in NCETE sponsored research, and some students proposed and received seed grant money for research.

While early on in their experience, many students reported being somewhat dissatisfied with their preparation to conduct research, by 2009-10 most students felt the Center had prepared them well. In 2010, the majority of Fellows believed that there were high-quality opportunities for them to learn about research, and felt supported to do

so. Fewer (but still the majority) felt that they were prepared to conduct research on their own once they graduated the program.

Ultimately, the doctoral fellows were generally satisfied with the research component of the NCETE program. The fellows had the following final comments about the research component, which highlight both the positive and negative aspects of their experience with research:

We had extraordinary opportunities to meet and work with some of the most influential and best researchers in the field.

I was given many opportunities to do my own research. However, the faculty did not include me on their research papers, projects, etc. I would have learned from being an "apprentice" rather than being thrown into the deep end of the pool.

Seed grants and the opportunity to apply for dissertation funding have provided many fellows with a solid research foundation.

I think the research component was based on the individual institution and it may have been more beneficial to have minimal criteria to the exposure that was provided. Where as I did not have the opportunity to conduct much of my own research, other fellows did and looking back I believe that would have been helpful.

Now from the vantage point of being an assistant professor at a research-intensive university, I am grateful for all of the preparation in research provided via NCETE and my doctoral program.

NCETE exposed us to the various areas in engineering and technology education where more research is necessary, to build the capacity of engineering and technology educators to teach design.

This question is difficult to answer. If the question is, 'how well did the PhD program, meaning the classes at my university, prepare me to conduct research', the answer would be it did an excellent job. However, if the question is specifically referring to how well did NCETE prepare me to conduct research, then I would say a somewhat satisfactory job. I believe the 4 NCETE classes

were beneficial. However, at our university, we were not provided with research opportunities beyond our dissertation, like some of the other universities.

In interviews with graduated Fellows who were employed, several reported that the experiences they had in the Center were instrumental in helping them attain their current position, as well as preparing them to develop and embark on a research agenda in the field. (Please see the separate report: Review of NCETE's Research Initiative for more on the Fellows' research experiences.)

Facilitating collaborations

One critical component to developing leaders in a new field is facilitating connections with others. NCETE made a strong effort to connect graduate students to leaders in the field, from both inside and outside the Center, through supporting their participation in meetings and conferences, and convening invitational meetings sponsored by NCETE. These opportunities to build relationships and connections were consistently highlighted by the doctoral fellows as very important contributors to their growth as scholars.

As a Fellow for NCETE, I can honestly say that I was afforded many opportunities to share and collaboratively create knowledge that has helped spur my professional career. Working on various research projects at my respective university only enhanced this aspect of my matriculation.

NCETE has fostered relationships and connections within and across the engineering and technology education fields by hosting various events that brought together a variety of STEM stakeholders with similar goals concerning the improvement of teaching/learning within our schools. I have participated in these relationships by attending conferences, symposiums, and have been more actively involved with these relationships and connections through my doctoral research.

In our interviews with employed graduates, we asked them to comment on the extent to which the Center prepared them for collaborative opportunities in their current positions. While not all graduates were in situations that presented such opportunities, several commented on how the connections they made while part of the Center continue to be important influences in their careers, and have encouraged them to seek out new opportunities for collaboration.

My new colleague is from NCETE, and he is right next door and so obviously that relationship is strong. I talk to [another Center graduate] at least 2 or 3 times a month. I think I had a pretty good network started already, and so what I have tried to do is connect those folks up and help them, and I know they have helped me as well.

I think the exposure to other professionals within the field was very important from a couple of standpoints. Number one, knowing that there are people out there who are equally enthusiastic and striving toward ways of effectively educating kids [is important]. And understanding that there are good people out there that are more than willing to help, and also having an opportunity to collaborate with people at my own level, understanding that there is a change going on [in the field]. I am associated with people that I will probably be collaborating with for the rest of my career.

Working as closely as we did with the core courses and things, with the multiple instructors at multiple schools, it prepared me for the kinds of political hurdles and cultural hurdles that occur between people with different points of view. In the Center, you have the teaching institutions and the research institutions and they are working collaboratively, but they each have their unique mission that they are trying to accomplish. Similarly, I get to work with high schools, which have a different kind of mission than the colleges do. So, that was very helpful, I would say.

I think honestly being exposed to and interacting with other students on other campuses and people with such diverse backgrounds certainly helps a whole lot. Some of the dynamics that we had, like when we had to partner together across universities, I think that was a great thing. I know that we started that actually with a design course, but we did it with some of the other activities, in some of the other classes as well. That certainly did help [me learn how to collaborate].

Overall, as of summer 2010, most NCETE fellows were satisfied with the leadership component of the Center's doctoral program: 69% said they were satisfied or very satisfied. However, 15% said they were somewhat satisfied, and another 15% reported being dissatisfied. Over the years, we have observed that the Center was very responsive to the concerns and needs of the doctoral fellows. A handful of Fellows not

satisfied with some aspects of their program are to be expected in any doctoral program. The interviews with graduates revealed that while in retrospect they would have liked some aspects of the program to have been improved, overall they felt that their doctoral experience prepared them well for their current positions. Further, they reported that their experiences prepared them to support the effort to advance the field of technology education.

Faculty Leadership

There has been a range of faculty involved in the Center, who have participated in different ways (by conducting research, serving as professional development leaders, advising graduate students, etc.). Interviews with NCETE faculty and field experts external to the Center provide evidence of the ways NCETE added value to faculty members' professional trajectories and provided new opportunities for them to make contributions to the field.

Interviews with NCETE faculty regarding ways the Center has impacted their professional roles have revealed that for the most part, participating in the Center has been a positive experience. While key faculty admitted that creating and running the Center was more difficult than they anticipated, they also acknowledged that it has impacted them in terms of how they think about infusing engineering design principles into technology education, new research opportunities and approaches, and getting smarter about providing professional development in technology education. Faculty also discussed ways the Center connected them with peers across the country, which they identified as being 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.

Ultimately, faculty believed that the Center provided an opportunity for national collaboration and the potential to unify and bring attention to those attempting to integrate engineering design principles into technology education.

I think the Center has real potential for advancing an agenda. To help be in a leadership role and make that happen [is a good opportunity]. The Center has as much potential for 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...

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.

Faculty research opportunities

One of the potential benefits of participating in an NSF-sponsored Center for Learning and Teaching is the opportunity to conduct collaborative research. While this was not necessarily a frequent occurrence in NCETE, for those who did engage in working with others on research projects, it was a very rewarding experience. As one faculty member put it:

...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.

Toward the end of the grant period, a few faculty members participated in seed grant-funded research, and several were in the process of proposing new research projects to the National Science Foundation. One in particular reported that his experience in NCETE was instrumental in supporting his efforts to submit a DRK-12 proposal:

I don't spend a lot of time engaging in research projects and in fact, just this month, I am submitting my very first proposal to the NSF for research. I think being involved with the NCETE and hearing about the research and what others were doing gave me confidence and piqued my interest to try writing a research proposal, a big major one. To be honest, I was always not afraid of the unknown, but the unknown was unknown and so I didn't even know how to get started with the research proposal. I think my experience with NCETE did help me understand what the process was like, even though the learning curve is still huge. I think it helped me gain the confidence to try this research proposal that I am sending in.

In summary, over the past several years of observing the NCETE faculty in project leadership meetings, talking with them in interviews, and listening to conference presentations and other meeting presentations, we have seen a steady growth in sophistication and depth of conversation about the challenges they face in their efforts to promote a new perspective on technology education. The opportunities for national collaboration, the development of the doctoral program across the four universities, and the opportunities for conducting new research have, in our view, grown and contributed to building leadership capacity among these faculty members that will ultimately benefit the field.

Perspectives from the field

As part of our evaluation work, we consulted external experts, to gather their impressions of the Center and its potential to impact the field. One area that the experts agree is currently lacking in the field and is an area in which the Center could potentially contribute, is future leadership: the number of people engaged in the field is declining, and there is a critical need for fresh perspectives and energy. A few of our external experts commented:

I think [building leadership capacity] is probably one of the components where they really did the best, in terms of trying to identify and mentor people, to give them opportunities and give them exposure. In my meanderings at professional conferences and so on, there has been a definite presence of some of those. I can't pretend to say I know all of them, but there are definitely some of them that I have seen out and about and I know that was something that the leadership

team gave a lot of thought to, that exposure and engagement and give them real responsibilities and expectations. I think they did a good job with that.

What the center has been able to do by these universities working collaboratively... is re-energize and re-introduce young faculty into these university programs because we were getting to a point where we were getting a little bit stale, because we didn't have a lot of younger people coming into the field to take over some of these university teaching positions. As people retired, there was just no one on the horizon to take the job. All of that is good. That is why I think that they have the potential to make a good impact. I understand that students takes classes based on their own university, but they also do some distance learning classes and that gives the student the ability to interface with faculty from all over the country, and that really does help to bring a more collaborative brain around it, because you aren't limited to the ideas that you are exposed to on the campus you attend.

I think they do have the potential to make progress, but I think their potential completely hinges upon a larger group of students being engaged, because I think to an extent, their numbers have been few because frankly, as a field, we have very few people that are pursuing Ph.D.'s. The more we can up those numbers, and get more people in the think-tank so to speak, the more momentum and more action can happen.

I would say [one NCETE graduate in particular] certainly has the potential for a great career ahead of her. I think there will be forces bringing engineering into the K-12 world and it is important that technology ed be part of that. There are forces in play beyond technology education to work in that arena. So, and to the extent that there are people like [this NCETE graduate] who are young, energetic and not bound by tradition, I think that is all to the good, because what technology education from an industrial arts perspective is, is not what it should be going forward, even though aspects of that are important. I think they need to examine where they want to be in 5 years, 10 years, and see how you get there.

One expert expressed the concern that the Center may not be able to go far enough to supply the needed human capital to move the field forward:

I think there has been such a decline in the number of people going into technology ed, that even if the Center is very, very successful, I am not sure that there is a critical mass out there to implement all of the good things that the center will have accomplished in terms of its goals, whether it is conducting research, the impact of that research on the profession, or whether it is building leadership within the profession. I think it comes down to the number of people that will be out there promoting the profession and promoting, after the Center goes away, if you will, promoting the ideals of the Center. People in the profession historically do a very good job at building curriculum, but they don't do a very good job in conducting research or building leadership.

I think the Center could have made more of an impact, a collateral impact, on other professionals in the field, but it is hard to say. I know they had various meetings where they brought in people and it would have been nice to see more, and sometimes you see the same people over and over again at the meetings, some of them, and not necessarily the people that need further involvement. They get invited because they are the big names that get invited, but maybe it would have made them better to bring in somebody who is earlier in their career.

Many of the above comments refer to the Center's efforts to train doctoral students and prepare new leaders for future work in the field. While many of our experts did not feel they were sufficiently knowledgeable to comment on details of the Center's doctoral programs or other leadership development activities, they were clear that there is a real need in technology education for fresh perspectives and new leadership.

Summary

There are renewed efforts in the field to address engineering design as a central aspect of technology education (e.g., International Technology and Engineering Educators Association, or ITEEA). NCETE made efforts to develop skills and knowledge in the doctoral fellows and Center faculty to further this mission. There was an important role for the Center community and its relationship-building function in fostering leadership growth, for both Center participants and others. Evidence suggests the Center made headway in developing leaders, and provided

one high profile university program in particular - Purdue - with new faculty who are committed to the vision.

It is important to consider the fact that the field of technology education does not have the strong research and leadership history that mathematics or science education—or even engineering education—has. Indeed, hundreds if not thousands of scholars have engaged in research and development in science and math education. Therefore, as technology education is a smaller and newer field, the Center has made a large proportional contribution, relative to the scale and existing strengths on which the Center was able to build.

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National Center for Engineering and Technology Education

Review of NCETE's Research Initiative
by Inverness Research

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INVERNESS RESEARCH

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Introduction

Inverness Research has evaluated three NSF-funded Centers for Learning and Teaching (CLTs). Through this work, we have identified and vetted five dimensions for examining the work that Centers do. These dimensions are: Leadership; Knowledge Generation and Flow; Relationships and Connections; Programs, Structures, and Policies; and “Centerness.” As the external evaluator for the National Center for Engineering and Technology Education (NCETE), Inverness has focused its efforts in year 6 on documenting the progress the Center has made according to these drivers. It is the second dimension— Knowledge Generation and Flow—that concerns itself with research.

There are multiple levels of knowledge a national Center for Learning and Teaching (CLT) is positioned to gather, generate, use, and disseminate, including knowledge of the policy, practice, improvement, and curriculum landscape associated with the Center’s domain. This report presents and reviews the key features of the research efforts of the NCETE, an NSF-funded CLT, which intended to build capacity in the areas of leadership and research for its particular domain within STEM education: infusing engineering design concepts into technology education.

It is important to note that CLTs were not initially conceived as primarily research centers; instead, the majority of funding within Centers was originally intended for graduate training and practitioner programs. Over time, NSF increasingly emphasized research as an important outcome for CLTs, but did not earmark funding for research. In reality, most Centers focused on creating what we at Inverness Research have come to describe as a “research rich milieu” for the purposes of shepherding the improvement of the domain that the Center represented.

In the following pages, we highlight the important features of the NCETE research initiative. We provide an overview of the Center’s various research initiatives, as well as a wide range of perspectives on the efficacy of those initiatives. The primary audience for this document is potential funders of ongoing and future research efforts initiated by NCETE, and secondarily, other researchers or program leaders interested in learning more about this particular strand of Center work.

Data sources and methods

Our data sources and collection methods for this report included the following (see appendix for protocols and instruments):

- 1) Interviews (three) and surveys (two) of both cohorts of NCETE doctoral students, regarding their research experiences
- 2) Observations of NCETE research symposia and meetings
- 3) Interviews with Center leadership about the history of research in the field
- 4) Interviews of faculty members regarding advising, leadership, and research opportunities
- 5) Interviews with doctoral graduates with jobs
- 6) Interviews with seed grant recipients about their experiences designing and conducting research
- 7) Interviews with seven field experts to comment on their perspectives on the contribution of the center to the field, including research
- 8) Review of the 57th yearbook of the Council on Technology Teacher Education (2008) entitled Engineering and Technology Education
- 9) Extensive reviews of the NCETE research portfolio, provided by five experts in the field of technology education and engineering education, whom we recruited and compensated (these reviewers chose to review the entire portfolio—and provide their comments in writing, as opposed to interview—as presented on the NCETE.org website, along with the CTTE yearbook. See appendix for our invitation to the external reviewers.)
- 10) Review of all of Inverness' previous reports and presentations to NCETE members and leaders

Goals for research strand

The leaders of the Center identified their goals for the NCETE research strand as:

- To define the current status of engineering design experiences in engineering and technology education in grades 9-12;
- To define an NCETE model for professional development by examining the design and delivery of their effective professional development with a focus on selected engineering design concepts for high school technology education;
- To identify guidelines for the development, implementation, and evaluation of engineering design in technology education.

The challenge NCETE faced was to establish, with empirical evidence and theoretical arguments, that infusing technology education with key design principles from engineering would benefit secondary technology education in a number of ways. This required, to some extent, contributions from both technology educators and engineering educators. Therefore, similar to other NSF-funded CLTs, such as CILS (the Center for Informal Learning and Schools) and ACCLAIM (the Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics), NCETE was founded on the basis of the presumed benefits that can come from creating a “hybrid” field. This has implications for the research of NCETE, which will be discussed in detail herein.

Overview of report

Following, we begin with a brief description of the history and current state of the field of technology education, in order to provide context for what the Center has accomplished. What forms the bulk of this report is a summary of a range of perspectives on the quality, cohesiveness, rigor, and contribution of the different research initiatives of NCETE. Perspectives include those of the doctoral fellows from both cohorts; doctoral fellows who have graduated and are currently employed; NCETE faculty advisors; seed grant recipients; faculty and students engaged in research at NCETE institutions; experts in the field we interviewed regarding the Center’s work in this domain; and external expert reviewers we recruited to review the Center’s research portfolio. After providing a review of perspectives on NCETE’s research, we offer our own perspectives on NCETE’s progress in research, and discuss potential future directions.

Technology Education in Context

Even as the National Center for Engineering and Technology Education (NCETE) was deep in the throes of research and leadership development in 2008, the CTTE yearbook, entitled Engineering and Technology Education was published with the goal to “spur a scholarly dialog among the constituent groups and... provide a foundation for a mutually valuable collaboration between engineering and technology education” (Custer & Erekson, 2008). This excerpt serves as a reminder that the goal to infuse engineering design principles into technology education was a relatively nascent idea. Collaboration between engineering and technology education was (again, to stress) not a long-standing existing practice nor a theoretical approach. Traditionally, these fields have worked quite separately with separate research agendas (Johnson et al, 2008).

In his essay, *Technology Meets Engineering: Notes from the Ground* (in Custer & Erekson, 2008) Gary Benenson (an engineer) reported:

The vast majority of engineering educators have probably never even heard of technology education, let alone sought involvement in it. Conversely, many (if not most) technology educators have little or no contact with engineers or engineering educators, nor awareness of any proposed alliance (p. 204).

Another of our external expert reviewers, who happens to be an engineering educator reported:

I've done a lot of work with engineering research centers around the country that are typically NSF-funded. I clearly get the idea that this initiative [NCETE] really is the first time this has been done in the field of technology education—in other words, infusing engineering into technology education teaching and learning—so it is a newer concept. The Center is just trying to figure out who is connected with whom.

Therefore, since its inception, NCETE has always faced the challenge of both forging a hybrid community, while simultaneously researching it. Other CLTs we've evaluated, such as CILS and ACCLAIM, have also faced this challenge. Yet, in the case of CILS, much of the work could build on the solid research foundations laid in science education and cognitive science. In ACCLAIM, the work could build on the solid research foundations laid in rural education and mathematics education.

While they have not typically been interwoven or integrated, research in engineering education and technology education do share an unfortunate similarity: that is, the relatively low status it has traditionally been afforded, relative to other STEM disciplines, such as science education.

In his introduction to the Council on Technology Teacher Education's (CTTE's) 57th yearbook, titled *Engineering and Technology Education*, William Wulf, a professor at the University of Virginia and President Emeritus of the National Academy of Engineering wrote:

Too often in the past, work on both engineering and technology education has lacked a scholarly approach and 'good weight' as a result. For our part at the NAE, several years ago we created the Center for the Advancement of Scholarship in Engineering Education (CASEE), with stress on the word 'scholarship', to address this issue because we felt it so important. One center at the NAE and one scholarly book on engineering and technology education won't wipe out impressions from decades of poor scholarship, but it's a start (p. xvi).

In their essay *Research Frontiers—An Emerging Research Agenda* (2008), authors Johnson, Burghardt, and Daugherty provide an overview of the challenges that research in technology education has historically faced:

Within technology education, concerns about the quality and focus of research have been raised for years (Foster, 1992; Johnson, 1993; McCrory, 1987; Passmore, 1987; Sanders, 1987). More recently, Zuga (1997) examined research that was published in the main technology education journals and dissertation abstracts from 1987 through 1993. Zuga found that half of the 220 studies she reviewed were primarily descriptive and focused on curriculum. Zuga outlined four areas missing from technology education research: a) constructivism; b) integration of other subjects; c) inclusion of all students; and d) cognition (p. 241).

According to Zuga, constructivist, problem-based instruction and the integration of other subjects are both fundamental to technology education, yet few of the published research studies had examined either of these two aspects (Johnson et al., 2008). Furthermore, almost none of the studies she reviewed focused on students or their learning; specifically, no studies explored issues such as gender, ethnicity, or physical or mental challenges that face students. She sharply concluded that research in technology education focused “on descriptions of status and curriculum development points to researchers who are narrow, inwardly-focused, and oblivious to the goals of their own field” (Zuga, p. 213, in Johnson et al., 2008).

A few years later, Petrina conducted a mixed-method meta-study to review research published in the *Journal of Technology Education* (JTE) from 1989 to 1997. Similar to Zuga's findings, Petrina found that out of 96 articles, 62% were descriptive, a scant 35% focused on human subjects, and very few examined issues of class, ecology, gender, labor,

race, and sexuality. He concluded that those who had been reviewing research in the field concluded it to be a “malfunctioning practice” (Petrina, p. 28 in Johnson et al, 2008).

Two of our external reviewers made similar comments, regarding the history of research in technology education and the challenges NCETE faced, in creating a research program.

The Center was born at a time when technology education, as a field, was feeling a crisis: technology education was not being taken seriously enough in K-12 education, but neither did technology education, as a field, have a research history that could be used to convince the powers that be (whoever they are) of the importance of technology education or to show how best to carry it out.

My understanding is that NCETE was set up to help educate the next generation of technology education leadership (i.e., university faculty and researchers) and to generate research findings that would help in making arguments for the importance of technology education and would provide guidelines for carrying it out well in K-12.

It is important to keep these comments in mind when reviewing the work of the National Center for Engineering and Technology Education, since many reviewers have argued that it has not yet achieved the scholarly quality of the mathematics or science education research communities. Throughout this report, we present different perspectives, and sometimes very conflicting views on the quality of the research products NCETE has created. We believe that the unstable or nonexistent foundation in technology education research is in part to blame for these disparate views. Two of our external reviewers commented in similar ways:

People in the profession historically do a very good job at building curriculum, but they don't do a very good job in conducting research or building leadership.

I think given the nature of the field and the nature of where we are in the field, the Center has done well. Keep in mind that technology wasn't taken up as the main driver within our profession until say 1985. That is not all that long ago when you think about the long history of science, math, and the rest of them. Now, engineering has only come into the venue in the last few years and so, it is even newer. Given the circumstances and where we are with all of that, the Center has done a good job.

When we asked a respected engineering educator, “what are some of the issues that you think face researchers in the field of tech education?” he said:

A lot of the challenge is trying to develop a research agenda that is relevant... at the end of the day, a lot of people don't even know where to start. It has to do with the history of our field and research has never been our strong forte and so therefore, how do you even begin to hone and refine and determine what really needs to be done in research? That is something that has to be grappled with. It would be incredible if through the work of the Center, they were really able to set out the research agenda for people over the next 10 years but a lot of people don't even know where to start.

In the end, most reviewers and participants who commented to us on the Center’s research products concede that NCETE has actually made substantial strides in supporting researchers who are likely to make contributions to the field of technology education in the future. Much of NCETE’s potential impact won’t be seen for several years, as new faculty address and increase the standards for rigorous research.

Research initiatives of NCETE

Well aware of the challenges that face researchers in the field of technology education and even engineering education, the Center designed its research initiative around several components: funding research, supporting research, and disseminating and sharing it.

As noted in the introduction to this report, CLTs were not originally conceived as research centers, but took on the goal of conducting research as the initiative matured. Centers responded to this shifting expectation by attempting to create opportunities for Center participants to engage with research in multiple ways. NCETE established numerous venues for faculty and students to interact around the research. For example: the Center organized and sponsored a research symposium for faculty and students from campuses, including some outside of NCETE to share their research ideas and methods; the Center created a “seed grant” program that encouraged NCETE faculty and students to apply for research funding to conduct studies that were aligned with the Centers’ mission; NCETE hosted special sessions at national conferences such as the International Technology Education Association (ITEA), which is now named the International Technology and Engineering Educators Association (ITEEA), where faculty and students presented sessions and posters; and Center students were invited to attend meetings in Washington DC to meet with NSF program officers.

We reviewed five different key research initiatives that NCETE undertook to bolster the research foundation in technology education.

Doctoral program. NCETE provided funding for doctoral students to complete their dissertations, once their committees had approved the topic area and research plans. The participating institutions were: University of Minnesota, University of Illinois at Champaign-Urbana, Utah State University, and University of Georgia. Each of these four universities offered a slightly different doctoral degree and program.

Seed grant program (“Center Studies”). NCETE funds studies to explore various aspects of curriculum, teaching practices, and professional development for infusing engineering into high school settings. The studies were completed by teams of NCETE faculty and students. Seventeen Center studies (or seed grants) have been completed.

Faculty research (“Research Results”). NCETE faculty often collaborated with each other and with students to produce publications reporting results of various research studies they have been engaged in over the years. Many of these were funded through other grants but involved NCETE participants.

Research symposia. NCETE organized and held a doctoral student conference at the University of Minnesota on May 22, 2008. The theme of the student conference was “Research in Engineering and Technology Education.” NCETE Fellows as well as doctoral students and their faculty advisors from Tufts, Ohio State, Virginia Tech, Colorado State, and Purdue were invited and presented papers.

Pre-ITEA conferences. Each year, prior to the annual meeting of the International Technology Education Association, NCETE hosted a meeting for those students and faculty involved in the Center’s research and professional development efforts.

Perspectives on NCETE Research–Accomplishments

NCETE has generated and amassed quite an impressive portfolio of research reports, representing a variety of interests within and outside of the Center. As of July 2010, the work of NCETE has produced or contributed to the following research products: 66 publications, of which many are peer-reviewed; over 125 conference presentations at professional conferences and poster sessions; 9 dissertations (ultimately, 13 will be produced); 18 reports on studies supported by NCETE (including seed grant projects and the research of post-doctoral fellows); and conference proceedings from a research symposium held in Minnesota in May of 2008.

Providing a foundation

The majority of the external expert reviewers of NCETE's research portfolio agreed that the body of research that NCETE has created provides a basis on which to have future conversations regarding integrating engineering education and technology education. For example, two separate reviewers made similar comments regarding the Center's research portfolio:

In looking at the publications of NCETE and recent developments in technology education, it is clear that the Center and its publications have been instrumental in furthering the discussion and acceptance of engineering education within the technology education community. This has resulted in an ongoing conversation among technology educators, the recent change in name of the International Technology Education Association to the International Technology and Engineering Education Association, and an increase in publishing activity by a handful of the NCETE member faculty.

The work of this research portfolio has laid an important new research base within the field and assured that the findings and methods of this research are communicated in a broad context and to a large audience. Several of the publications focused on issues of diversity and seeking to learn to broaden opportunities, and enable the participation of underrepresented minorities in engineering and related fields. The overall impact on the scholarly production of the field as a whole has been greatly impacted by the productivity of the Center's participants. The knowledge generated within these manuscripts and conference proceedings will be referenced and used to build on for years to come.

Increased collaboration in research

A major accomplishment of NCETE's research efforts is that they have created a context for connecting professionals from different institutions and different fields (e.g. technology education from a variety of campuses, and technology and engineering educators from around the country). An external reviewer of the Center's research portfolio reported:

The center appears to be encouraging more collaboration in research and writing than has been evident in technology education historically. At least, advisors and students appear to be publishing together in a number of articles and there are two articles written by faculty teams of authors.

In an interview, a seed grant recipient commented on collaboration as well:

By having this opportunity, we have been able to build a better network. That is always my wish. It's not just meeting people once and saying 'Hi and Bye' but how can we collaborate to understand each other's interests?

And another of the external experts who reviewed the research portfolio wrote:

The dissertation committees reflect a broad range of faculty from education, technology education, and engineering. This intra and inter-disciplinary cooperation helps to build and strengthen a field of study.

These collaborations were often useful and productive, leading to additional funding, and have cultivated relationships that will be fruitful in the future as others try to infuse engineering design principles into technology education.

What the Center has been able to do by these universities working collaboratively is they have begun to re-energize the field in regards to moving forward with some very good pieces around the research agenda. Their strength is that they have been able to bring together a group of very good professionals that have collectively worked together to achieve a better goal than they could have achieved individually.

This "re-energizing" of the field through collaboration was noted by another expert from the field as an important element of NCETE's work:

The Center is also re-energizing and re-introducing young faculty into university programs. We were getting to a point that we were getting a little bit stale, because we didn't have a lot of younger people coming into the field to take over some of these university teaching positions and as people retired, there was just

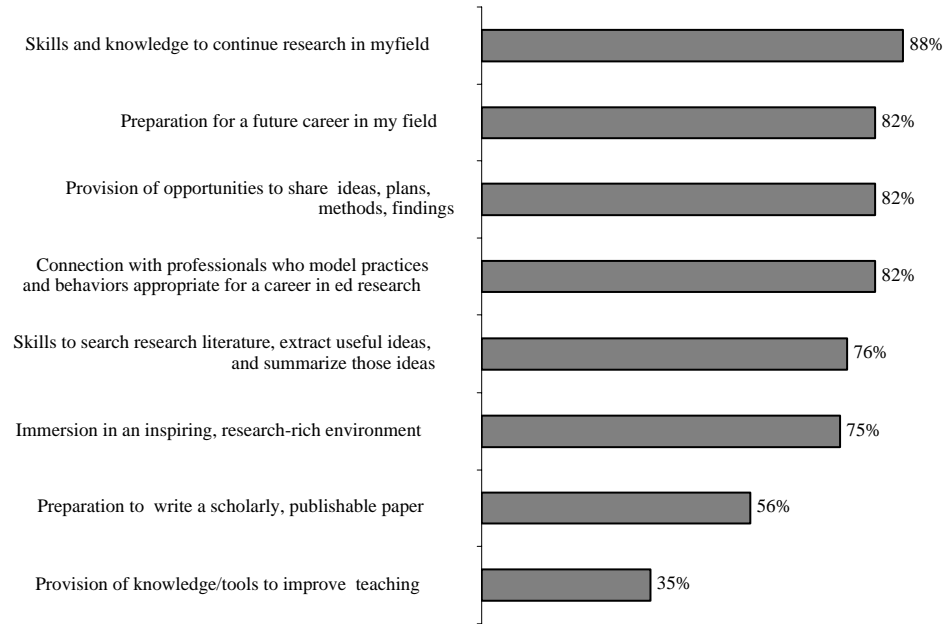
no one on the horizon to take the job. The Center has developed those people. All of that is good.

Increased capacity for research among doctoral students

Given the relatively low starting place for NCETE's research in technology education, it is undeniable that the Center increased the capacity of its faculty and students (and perhaps collaborators) to design and conduct research. While the products do not always live up to the standards set in other fields, they have moved substantially forward from where research in technology education has been. NCETE has built the *capacity* of the Center participants to do research but also the *potential* to secure a future vision for research in the field, creating momentum among individuals in research universities who are dedicated to refining and furthering the research agenda of the field.

As one example of how the Center has increased the capacity of its students to design and conduct research, in March of 2009, Inverness conducted a survey of all NCETE doctoral students from both cohorts. With regard to the extent that their research experiences in the NCETE doctoral program was preparing them for continuing as researchers in the field, the majority (88%) of students said that the Center was equipping them with the necessary skills and knowledge to continue to conduct research in their field.

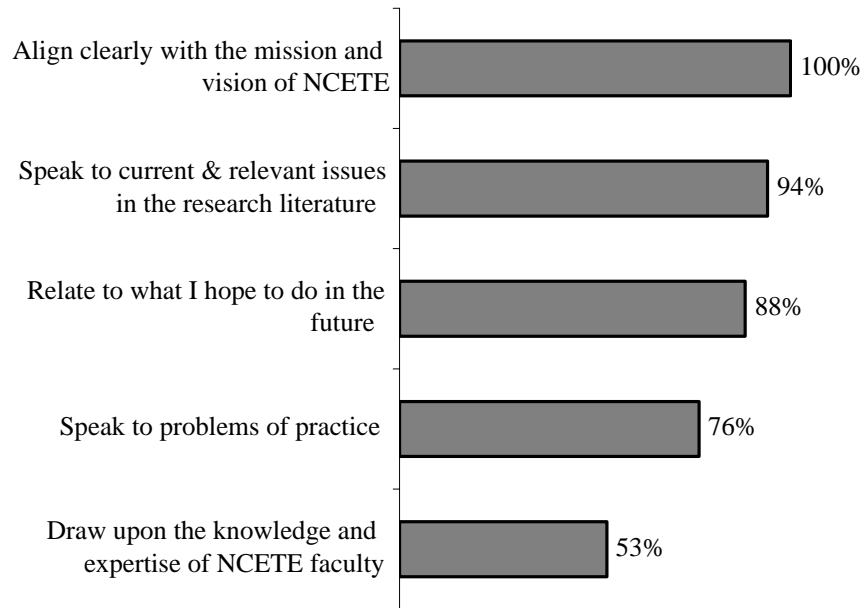
Percentage of NCETE doctoral fellows who report that the doctoral program is achieving positive outcomes related to their preparation to conduct research



Percentages represent ratings of 4 or 5 on a 5-point scale, where 1 = "disagree strongly" and 5 = "agree strongly."

Also in 2009, NCETE doctoral students had been pressed to consider how their dissertation research fit within the needs and knowledge of the Center and the field at large, and how it might help them in the future. All of the survey respondents replied that their dissertation research aligned clearly with the mission of the Center and the vast majority (94%) believed that their research would speak to the current and relevant issues in the research literature.

Percentage of NCETE doctoral fellows who think that their dissertation research will have positive outcomes



Percentages represent ratings of 4 or 5 on a 5-point scale, where 1 = "disagree strongly" and 5 = "agree strongly."

Again in spring 2010, a second (shorter) survey was sent to 17 NCETE doctoral fellows, both graduates and fellows still in the program. The purpose of the survey was to gather fellows' summative reflections on the program, and their sense of the extent to which the program prepared them to work in the engineering and technology education field. Of the 17 fellows, 13 completed the survey.

We asked the NCETE doctoral fellows to rate the extent to which a series of research components was available to them, and to rate the quality of those components. The majority of fellows believe that there were high-quality opportunities for them to learn about research, and felt supported to do so. Fewer (but still the majority) felt that they were prepared to conduct research on their own once they graduated from the program.

| | Extent to which this component was available to me % (n=13) | | | Quality of this component % (n=13) | | |
|---|--|----------------|-------------------------|---------------------------------------|--------------|----------------|
| | Not at all/to a limited extent | To some extent | To a large/great extent | Very poor/poor | Mixed/medium | Good/excellent |
| Opportunity to learn about and conduct research | 8 | 0 | 92 | 0 | 15 | 84 |
| Support for conducting your own research while in the program | 15 | 0 | 85 | 8 | 8 | 84 |
| Preparation for conducting independent research once you graduated from the program (i.e. in your current role) | 8 | 15 | 77 | 8 | 31 | 61 |

The doctoral fellows were also generally satisfied with the research component of the NCETE program. Of the 13 respondents, 85% reported that they were satisfied or very satisfied. The remaining 15% were “somewhat satisfied.” The fellows had the following comments about the research component:

We had/have extraordinary opportunities to meet and work with some of the most influential and best researchers in the field.

Seed grants and the opportunity to apply for dissertation funding have provided many fellows with a solid research foundation.

Now from the vantage point of being an assistant professor at a research-intensive university, I am grateful for all of the preparation in research provided via NCETE and my doctoral program.

The Center exposed us to the various areas in engineering and technology education where more research is necessary to build the capacity of engineering and technology educators to teach design.

One event that was particularly useful for the doctoral fellows was the research symposium. The Center organized and held a doctoral student conference at the University of Minnesota on May 22, 2008. The theme of the student conference was “Research in Engineering and Technology Education.” NCETE Fellows as well as doctoral students and their faculty advisors from Tufts, Ohio State, Virginia Tech, Colorado State, and Purdue were invited and presented papers. After reviewing the proceedings from that research symposium, specifically those from the Conference on Graduate Student Research in Engineering and Technology Education, one external expert reviewer wrote:

This conference, organized by the Center to highlight and bring together graduate students from around the country to report on their research progress is notable. Many of the conference participants have completed and published their dissertations. This is an excellent metric to see; when work-in-progress support yields young professionals who complete their doctoral degree and enter the profession.

Increased capacity for research among NCETE faculty

NCETE created and increased the capacity of students across the Center for designing and conducting research, yet it also increased the capacity of faculty to design and conduct research.

Three Center faculty members who received seed grants said of their experience:

I was always... not afraid of the unknown, but the unknown was unknown and so I didn't even know how to get started with the research proposal and I think my experience with NCETE did help me understand what the process was like, even though the learning curve is still huge. I think it helped me gain the confidence to try this research proposal that I am sending in.

The seed grant taught me a lot about how to write a proposal.

I think the approach that the Center took—going out and getting external reviews, even on the seed grants—it really added gravitas to the research. These could have been treated in a way where the leadership gets together and just kind of processes the paperwork and doles out the money. Instead, there was a degree of professionalism and seriousness to it—these weren't just handed out. You had

to compete for them and they expected quality and they were heavy-duty reviews and to come out of that with really positive reviews, is how it should be. It was a little more like NSF's process than it was just carving up a little bit of money out to the Center. I thought that was good.

Perspectives on NCETE Research—Challenges

Along with the positive outcomes and accomplishments achieved through NCETE's research initiative, there were also mixed reviews, particularly from the external experts in the field who we asked to review the Center's research portfolio. We argue that the variable nature of external experts' opinions on the quality of NCETE's research portfolio is in part attributable to its nascent status as a field that engages in rigorous research. In other words, they have made huge strides given where the field was six years ago. However, many reviewers do not believe the research within technology education is yet on par with that of science education or mathematics education.

In *Engineering and Technology Education* (2008), Johnson, Berghardt, & Daugherty recall Shavelson and Towne's 2002 statement that "to be ethically conducted and produce valid results, scientific efforts must be guided by fundamental principles that are agreed upon by the community of researchers within a discipline". According to the authors, the guiding principles that should underlie all scientific inquiry, including educational research consist of:

- Posing significant questions that can be investigated empirically
- Linking research to relevant theory
- Using methods that permit direct investigation of the question
- Providing a coherent and explicit chain of reasoning
- Replicating and generalizing across studies, and
- Disclosing research to encourage professional scrutiny and critique

(Shavelson & Towne, pg. 52 in Johnson et al, 2008).

As standards that have long-been accepted in science and mathematics education research, these were also the standards several external expert reviewers had in mind while reviewing the NCETE research portfolio.

In addition, we asked reviewers to comment on the contents of the research efforts along four key dimensions, which we will use to summarize their feedback in this section: 1) quality of the research; 2) relevance or importance of the research questions; 3) soundness of the conclusions and interpretations (analysis that led to the interpretations); and 4) coherence of the overall research agenda and coherence of the studies.

Quality of the research

While one reviewer thought the quality of the research portfolio overall was “sound and acceptably met methodological standards for social science research,” the majority of reviewers had concerns regarding the quality of research products they reviewed:

In terms of quality of the research, I find the portfolio somewhat uneven. For example, several of the methodological weaknesses in the research on K-12 engineering education documented in the 2009 Academies report are apparent in the portfolio (e.g., small sample sizes that make it difficult to generalize results, reliance on self-reported, as opposed to observed behavior, and a mismatch between the assessment tool and behavior being assessed). The use of Delphi panels was sometimes not appropriate, in my opinion.

Two reviewers commented on the literature reviews of some of the studies, particularly the doctoral dissertations:

The literature reviews of all studies are fairly extensive and of varied quality. What is not as clear in some of the studies is how the literature review has shaped the design of the research or the instruments.

The literature reviews in some of these theses are quite interesting, even in some of the theses that I think were very weak. However, most lit reviews are all over the place—everything the student knows about some topic but without leading readers to know why the research question is important and where it fits into the general scheme of what we need to know to promote learning from design experiences.

While in some of the reports, theoretical frameworks are included as part of the literature search, it is often not clear how these frameworks have informed the design of the study or how the results of the study further inform or challenge the framework. In general, the documents provide much more of a description than set forth a new way of looking at a problem space.

Finally, a reviewer questioned the overall ability of NCETE participants to conduct quality research:

My overall impression of the research portfolio is that the NCETE leadership has had great difficulty moving themselves and their students towards carrying out deep and meaningful research that will result in substantial progress in technology education. I see confusion about what makes for an interesting research question, approaches to carrying out research, and, what a high-quality research endeavor entails. The theses, journal articles, and reports show me a leadership that wants to be doing high quality, productive, and important research but that hasn't yet made the transition into knowing how to do that.

Relevance of research questions

One reviewer articulated that what makes for quality research goes beyond the relevance or importance of the research questions being addressed:

I conclude that the research questions addressed in the NCETE portfolio do address some important and relevant issues along the technology education—engineering education continuum. However, simply addressing issues that are important and relevant is not the same as conducting quality research. Factors for judging quality research might include such things as the importance of the research question but also how the research takes account of and builds on what is already known, the appropriateness of the study methodology, and the investigator's skill at executing the methodology and making sense of the results.

Another reviewer felt that the research questions were not relevant or current enough to influence future research and practice—that they were not the most important questions for the field right now:

Many of the research questions are about topics that have been bantered about for years. After reading this complement of articles, it's difficult to think of one study that informs how I would do my work. There simply are not data or studies that are situated where the action is occurring.

One reviewer suggested looking to other disciplines for methods and tools and using some of the knowledge generated by these other disciplines, in order to push the boundaries of what is known in technology education:

Related to this, the articles and community seem to be fairly insular. This is a community that cites each other's work. Rarely does the literature, or theoretical framework, or studies reach beyond the technology education community to learn from or borrow methods or other interesting research tools from other disciplines. There is little precedent of looking toward the outside (to science education, to

math education, to sociology, to science studies etc.) and using the knowledge generated by these other disciplines to suggest new areas of research to push the boundaries of what is currently known.

Similarly, one reviewer wishes to see more innovative and current research questions and rigorous mixed-method studies:

Perceptions and thoughts are not adequate to ground a discipline. What is desperately needed are well-designed actual studies in real classrooms. This is a glaring need in the field—at present the field seems to be a very small number of people hypothesizing and reflecting about theoretical ideas. It's time to get down and dirty—get into the classrooms, ask really interesting and difficult questions, gather a lot of data from teachers and students, and undertake very detailed and careful analysis, using a number of highly respected qualitative and quantitative techniques.

Soundness of the methods, analysis, interpretations, and conclusions

Again, referring to the lack of a solid research tradition in technology education, one reviewer commented that while most of the methods were still descriptive, the portfolio did include more quasi-experimental designs than have been typically observed in technology education research:

The research based manuscripts often used descriptive and qualitative methods, however it is obvious that within the Center's journal publication portfolio, the number of quantitative quasi-experimental designs reported was proportionally higher than normally found in journals within this field.

Other reviewers were not so willing to overlook weaknesses in the research methods and analyses (across research products), simply because of the history of the field:

Perhaps the biggest challenges in the Center's dissertation research are the methods that are used—they are limited and generally weak. Descriptive or "theoretical" studies are in the majority. The sample sizes and analytic techniques used for these studies are often very rudimentary so it's hard to see a clear evidentiary trail between data and result. Very, very rarely does a study triangulate a finding or use more than one source of data and there are almost no mixed methods studies.

No one tried to observe engineers in practice as a qualitative researcher would have done or ask engineers about their work as the vocational and career educators would have done.

Reviewers called into question the soundness of some conclusions, given the methodologies as described:

Across the seed grant study reports, the analysis and reporting of results needs to be more carefully constructed. The methods used in the studies are often underreported. In general, more detailed methods could bolster the findings from the studies. Much more description about what was done, and many more steps that prove to the reader that very careful analysis of the data, resulting in codes, that were analyzed is needed. The reader should be able to see how the findings come from the raw data. Overall, perhaps because of the nature of the funding, the samples of students and of data collection are small. Deeper studies will help to generate stronger claims. Finally, the findings and language in some cases need to be more tentative and more carefully worded.

The comparison studies are, in general, disappointing as they tend to simply be evaluations of results without the analysis needed for us to learn what is responsible for the differences (which is essential in making decisions about new directions).

Coherence of the overall research agenda and coherence of the studies

Two external expert reviewers felt that the portfolio as a whole was coherent and balanced:

A good representative balance of theoretical, conceptual, professional, and research related manuscripts are contained within the journal and conference proceedings publication portfolio.

The Center's journal publications were clearly focused on the study of engineering design as it relates to curriculum, defining the core content of engineering design, assessment, professional development, and thinking and reasoning in engineering design. The importance of these topics is critical to the field of engineering and technology education as it evolves from a curriculum of human productive practice towards a more disciplined and analytical field of engineering. The issues raised and studies conducted represent a coherent and articulate base from which to build on within the field.

Other reviewers felt that as a whole, the portfolio's coherence and cohesiveness—and overall impact—was not clear:

I could not determine on my own if the Center's work was guided by a vision or strategy that influenced the choice of research questions, the selection of fellows, and the overall plan for research. I am sure there was such a vision laid out in the original proposal (and I did read the proposal abstract available at the NSF website), but it was not apparent from my review of the published research or from looking at the center's own website.

Unfortunately, given the small number of published articles available, as a group they are no more than paint splatters on a canvas, as they are not coordinated in any way. The studies leave a lot of disconnected white space in between forays into what engineering design might be. The researchers have sought either previous curriculum work or expert opinion and have not attempted to get into the field and observe and study what it is that engineers do and how that might help them to construct a body of knowledge for engineering education curriculum.

Doctoral fellows also questioned the extent to which the Center created a cohesive research agenda. On our spring 2009 survey, one commented:

I think the idea of a cohesive research agenda was a great one; however each of the doctoral advisors varied in their ability to have their students adhere to developing dissertations that targeted aspects of the Center's research agenda. In addition, across the partner institutions the quality and quantity of research varied greatly. Meetings could have been geared more toward enhancing individuals' research skills. It is apparent that this is something our field is weak in, and talking about it over and over does nothing; but developing specific skills can perhaps.

Contributions: Reaching new audiences and broadening dialog?

There is some concern across the external expert reviewers and the doctoral students that the Center may not be broadening the dialog regarding integrating engineering design principles into technology education, by including individuals outside of the field of technology education. One reviewer noticed some positive examples of the Center's efforts in broadening its audience:

Some work of the Center, related to understanding professional development of teachers of K-12 engineering and identifying the core concepts of secondary K-12 engineering, has informed both the recent Academies report on K-12 engineering as well as a more recent study at the National Academy of Engineering.

But this same reviewer also commented that most of NCETE's publications stay within the technology education field:

Is there evidence NCETE is speaking only to “the choir,” or is there evidence of trying to reach new audiences and broaden dialog about issues that cut across STEM disciplines? What is the evidence for reaching out to the K-12 mathematics and science education communities? This issue of broadening communication and collaboration to other parts of the STEM community would seem to be an important objective for a national center devoted to subjects that are only marginally part of the “core” of K-12. It appears, however, that a significant majority of the published articles in the portfolio are in journals that target the technology education community.

Another reviewer commented similarly:

The NCETE group has published in a fairly narrow range of journals that are almost exclusively targeted at the technology education community. Very rarely have they produced work that might be of interest to other closely related STEM fields (like engineering education, or science education). Thus, if the goal is to create a larger awareness of and linkages between science and technology education, these do not yet seem to be present.

And again:

Most were published as either book chapters in a Council for Technology Teacher Education Yearbook edited by two Center members, journals within the field of technology education, and practitioner level journals within the same field. Few were published outside the field in related engineering education, educational journals, or journals that help inform the greater science, technology, engineering, and mathematics (STEM) community.

Of concern to this reviewer is the breadth of dissemination of this work to external audiences. Few, if any of the Center’s scholarly publications and conference proceedings were directed towards science and mathematics educational partners. Little evidence is provided that the Center went outside the technology education community to share its results. It is important that future work involve collaboration with other STEM fields and build even stronger cooperation with the K-12 engineering community which would help to form a larger accessible base with both political and educational synergy.

Out of the 17 articles I read, one is in a science education journal and two are in engineering education publications. The dissertations are in a general education database, but with their titles and descriptors there is little hope that the dissertations will be identified by educators outside of technology and engineering education. The web reports could suffer the same fate. In addition, the book that they have published is primarily circulated within the technology teacher education community, so that it might not move its view of engineering education into the greater educational community. Having offered a different discussion of what the content for engineering education might be it may go

nowhere unless the information gets into mainstream educational publications and specifically science and math publications.

One doctoral fellow described his concern regarding the Center's dissemination efforts during our interviews in late 2009. He is concerned that too few doctoral fellows are publishing at all:

I was kind of blown away when I was trying to make the point that I thought that our impact with our Center was going to be forthcoming because a lot of the dissertation work and a lot of research hadn't been published yet. I said, 'Raise your hand if you have something in press'. I was amazed at how few people had something in press. So, that concerns me. It is one thing to do the research, it is another to disseminate the information. That is critical in an R-1 institution, but even in these regional institutions, you do need to publish.

A different doctoral fellow commented on a survey we administered in March of 2009 that he would like to see the Center's research efforts be packaged appropriately and disseminated to decision-makers:

I believe the NCETE environment is research-rich and knowledge is being created and distributed, though not as effectively as possible. I don't entirely fault the NCETE for this as I feel a much larger initiative would be needed to create and disseminate knowledge to a broad audience outside the Center and even the field of Technology Education. Important research is getting done but is not relevant/digestible by decision makers such as politicians at the state and federal level, school superintendents, principals and teachers who could eventually make the technology education field irrelevant.

Inverness' Perspective on the Research of NCETE

Some of the challenges described above are not surprising—they have been apparent since Inverness was contracted to serve as the external evaluators for NCETE in October of 2006. In March of 2007, we presented findings from our preliminary work of observing meetings and conducting in-depth interviews with all of the cohort 1 doctoral students. At that time, we reported our concern that the doctoral fellows did not seem to be solid in their understanding of and commitment to the domain that the Center was created to improve:

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.

At that time, we expressed the challenges as: Students have a range of understandings of the “intellectual landscape of the field.”

- Some students perceive they have experienced inequitable opportunities to participate in research that would help them understand 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

Later that year, in September of 2007, we made suggestions regarding sharing conceptual frameworks across the center and from other fields, in addition to hosting one or more research seminars or workshops that might help clarify the intellectual landscape of the field for those who would eventually be conducting research (as well as those faculty who were currently conducting research):

We wonder also whether the conceptual frameworks, instruments, findings, etc. that are developed for conducting the landscape studies can be made available to Center participants. These “deliverables” are important as they build the capacity of those in the field who are currently or will in the future conduct research. In the final two years of the Center, an investment in one or two seminars or workshops where research plans and findings are shared, discussed, critiqued, and refined could both enhance the quality of the work itself and provide an opportunity to continue to build community among Center participants. These meetings could also include practitioners—teachers and professional developers, for example, who are engaged in the research work or who are knowledgeable about the challenges the field faces. In addition, these meetings could involve leaders from outside of the field but related to it—math, engineering, science—to provide expert perspectives on the emerging theories and findings.

In June of 2008, we recognized again the fact that NCETE was trying to build a hybrid field while simultaneously researching it:

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 into technology education... 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.

Again in 2009, we wrote:

It is not obvious that the Center will have a thorough understanding of the landscape of the field by the end of the grant period. By "landscape," we mean the policies, instructional practices, research, improvement strategies, professional development practices, and curricula that are associated with this domain. While some of the graduate students' dissertations and the seed grant studies will shed some light on a few aspects of the landscape, it is not clear that the Center will have a full picture of what is happening in field, though they will have made progress to be sure.

We are still not certain to what extent the Center's research portfolio addressed the intellectual landscape of the field. Early on, what seemed to constrain the limits of their imaginations was that they were still struggling with the purpose of infusing engineering design principles into technology education. Was it to increase the pipeline of engineering students or was it to encourage technological literacy for all?

In addition, we're not sure that Center faculty and students ever really settled on a definition of engineering design principles, much less what it means to infuse them into technology education. In point of fact, one NCETE faculty member admitted (in September of 2009):

When we talk about engineering, bringing engineering into technology education... I think this question still is not answered: what does that really mean?

These issues seemed to be interpreted differently across the Center and this was evident in the core courses, the professional development work, and the research. All of these issues contributed to the delay of pulling together a coherent research agenda. Liles, Johnson, Meade, & Underdown (1995) described a research agenda as:

The framework that determines the boundaries for scientific inquiry that addresses the fundamental questions of a discipline. It provides the means of grounding theory with practice... An effective research agenda is one that stands the test of time as researchers and practitioners exchange problems and research results to move the discipline forward (in Johnson et al, 2008).

To date, technology education has not agreed upon such a framework.

However, it must be said that the Center leadership has made great efforts to address the challenges they knew were present, as well as those that others identified. They sought to articulate a research agenda and mission that doctoral fellows' dissertations must address. They organized and hosted a research symposium that received excellent reviews for its attempts to bring in researchers from other disciplines. They provided "seed grant" opportunities for researchers within the Center to hone their research skills and address aspects of the research agenda that had not yet been addressed. All of these were substantial and positive responses.

As we have seen and heard, progress has been made, particularly in building the capacity for individual students and faculty to do research. It will be interesting to observe the course of events at Purdue University, where three NCETE doctoral fellows are now part of the professoriate and are focused on integrated STEM. One of these fellows told us:

We want to become the leader in graduate technology education with a focus on STEM—that clearly is a goal of everybody that is in our program and that is what we are shooting for. We are trying to recruit more masters' students and specifically we are trying to target Ph.D.s because Minnesota is no longer graduating Ph.D.s in that particular field and we feel there is opportunity there. We know that some of the other faculty members are getting ready to retire and programs are phasing out. We have a great opportunity, but we need to start carving out a research agenda that has a wider scope than just what traditional technology education and engineering design allows you.

As we have stated throughout this report, NCETE was building a hybrid field while researching it, and the two fields brought together through the Center did not have solid research traditions of their own to begin with. The nature, quality, and depth of research a CLT can produce is in part, inherently a function of the research history of the disciplines it is working within. Furthermore, NCETE, like other CLTs, were not initially funded to conduct research and were therefore unclear regarding the nature and extent of the research they were meant to conduct—much less how to foster and support that research.

While the Center was solid in its goal to develop a supportive doctoral program, the entire vision for creating a research-rich milieu was unclear. Also, the faculty involved with the Center did not have a uniform or typical approach to engaging in and conducting research; therefore, there were not strong existing research groups that could subsume and mentor NCETE doctoral fellows. It may have helped the

Center's research efforts to encourage and support research and writing groups across or even within the campuses. Of course, NCETE's widely distributed nature posed a challenge to this sort of effort as well.

In a sense, NCETE can be described as a bootstrapping effort. That is, it had to *build* itself upon a foundation that it had to first create for itself—there was not an existing foundation for this work. Do we believe that the Center made progress in creating a stronger foundation for the field to continue to develop itself? Yes.

Closing

In summary, NCETE's research efforts resulted in some strong accomplishments and revealed (and in some cases, reinforced long-standing) challenges facing researchers in the technology education field. Both of these should be considered powerful learning opportunities.

Several reviewers noted the impressive progress NCETE has made, given the short time it has been in existence:

I recognize how short a time five years is to grow a meaningful research effort, especially on a set of topics that have been largely outside the mainstream of education research. I believe it is premature to try to determine the impact of NCETE's research. The time scale for meaningful education change of any significance is probably best measured in decades, not years.

This presentation, poster session, and workshop portfolio when examined very carefully contains some of the most in-depth study, work, and dissemination of scholarship and research in the field of technology education. Never in the recent history of this young field of study has so much been written and disseminated.

The overall intellectual merit of the journal and conference proceeding publications in this cross-sectional review is excellent for the time the Center has been in existence. The writing, discovery, and discourse within the breadth of the journal portfolio are of high quality and have raised the standards within the field.

The Center increased the capacity of faculty and doctoral fellows to conduct research to begin with, and the research portfolio consists of strong evidence of increased collaboration among faculty from different universities and even some between technology educators and engineering educators. While challenges continue to face NCETE, in terms of its research agenda, this review has identified some clear

recommendations for future research efforts, which is extremely valuable. The Center has created momentum within and outside of the field to improve research in STEM.

In addition, now that the International Technology Education Association (ITEA) has changed its name to the International Technology and Engineering Educators Association (ITEEA), it is time to further the work of the Center in a modified “NCETE 2.0”. How is ITEEA defining “engineering education” and its relationship with technology education? What will this look like in practice? What are the implications of the name change for future research agendas? Inverness suggests that a small task force group of individuals (who will think deeply and hard) form out of the original NCETE, to first take stock of the work the Center has accomplished to date and next to solicit in-depth input from researchers in the rest of the STEM fields—the science, math, and engineering education fields—as well as experts in methodological approaches (even outside of the STEM fields) regarding a future research agenda and approach. We suggest a working meeting where sub-groups could identify appropriate, relevant, and current research questions, as well as vet rigorous appropriate methodologies. Such a workshop would, in a sense, replicate the work that our external expert reviewers completed—identify strengths and weaknesses in the work to date, identify areas to fruitfully build upon, identify future directions, and brainstorm project ideas, and funding and dissemination opportunities.

Recommendations for future research efforts:

- Research questions should be current and not a rehashing or simple reformulation of previous research questions
- Attempt to identify appropriate content for engineering and technology education, K-12
- Methods should move away from descriptive studies that rely on self-report instead of observable data, to involve more mixed-method, empirical studies
- Attention should be paid to all guidelines for quality research:
 - Posing significant questions that can be investigated empirically
 - Linking research to relevant theory
 - Using methods that permit direct investigation of the question

- Providing a coherent and explicit chain of reasoning
- Replicating and generalizing across studies, and
- Disclosing research to encourage professional scrutiny and critique
- Employ larger samples sizes
- Identify clear pathways from data to interpretation to conclusions
- Include more engineering educators, along with math and science educators and education researchers
- Disseminate the Center's research at conferences and in peer-reviewed journals in engineering education, math education, and science education (i.e. outside of the technology education field)
- Package and disseminate research to decision-makers

While our external expert reviewers had many critiques of the work they reviewed in NCETE's research portfolio, all of them had summary comments that were appreciative of the Center's efforts to date and optimistic about the future of research in technology education. We end with a sampling of those comments:

They have laid a lot of groundwork that will lead to a lot of innovative things.

In a field that lacks solid leadership, the Center must be commended for not only showing research and scholarship leadership, but also for communicating new knowledge and direction for the field in general.

Although most of their publications have been descriptive of the landscape and descriptive in nature, more recent publications have begun to focus on trying to identify the content of engineering education, a step that had been identified as essential via several conferences and studies that have been conducted. These efforts at identification of content are in the initial stages and there does not appear to be enough work on this topic to generate agreement on content among the center participants. However, this is important work that needs to be continued because this group may include the only professionals who are actively seeking to provide engineering education information to the academic community.

NCETE efforts to promote engineering education have been noted by the larger community and they are making inroads in the teacher educator and ITEA communities regarding engineering design, as evidenced by the association name change.

Over the past two decades, no effort within the field of technology education has yielded such a robust unified body of knowledge focused on infusing engineering into the K-12 classroom. The work of this Center has important implications for the movement of the field of technology education into incorporating the strengths of engineering in its curriculum. This work is aligning with national goals for education and in particular STEM education.

In the end, the Center has provided a significant service to technology education by bringing teacher educators together and influencing their beliefs, by adding to the need to change the name of the professional association, by identifying the landscape of K-12 engineering education in the United States, by radically altering the discussion of science and mathematics as the appropriate content for engineering education, and by pointing to the need to identify an engineering education curriculum.

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Appendices

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A. Doctoral Fellow interview protocol

NCETE Doctoral Student Structured Interview Protocol March 2007

Hello, my name is _____. I am calling from Inverness Research Associates on behalf of NCETE. As you know, we are the external evaluators for this NSF Center.

We are conducting phone interviews with all of the doctoral students, following up on our January focus group interview, to learn more about your experiences and perspectives as an NCETE doc student. Our purpose for collecting this information is to gain a deeper understanding of your experiences, to inform and guide the Center's future work, and to inform and build the capacity of the field. Your feedback will be invaluable for guiding NCETE's work with Cohort 2.

We will use information from these interviews in our reports anonymously – that is, your name and other identifying information will not be directly attributed to any statement you make.

*We would also like to compensate you for your time today with a gift certificate at Amazon.com for **\$75.00**.*

| | |
|-------------|---------------------|
| Name: | Interview Date: |
| University: | Year in program: |
| Phone #: | Date began program: |
| Address: | Interviewer: |

For a rough overview, first I'm going to ask you questions about your coursework, then about your experiences with your advisor(s). Third I'll ask a set of questions about research, and finally we'll talk about your sense of NCETE overall.

I. COURSES

Since there are several studies of the core courses underway, we will only ask you some general questions at this time about courses.

1. How well do you feel your coursework so far has **prepared you for a career in your field?**

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Not at all somewhat very well

Comments:

2. How well do you feel your coursework so far has **prepared you for conducting independent research?**

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Not at all somewhat very well

Comments:

3. To what extent do you feel your coursework so far **supports/connects to the larger mission of NCETE?**

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
not connected somewhat very
at all connected connected

Comments:

4. What, if anything, is **missing** from your course of study?

5. Is there anything you would like to add about your coursework?

II. ADVISING/ADVISORS

Now I'd like to ask you some questions about your advisor and your experiences with advising in your program.

6. Who is your **primary advisor**?

Has this person always been your advisor? Yes _____ No _____

If no, from whom did you switch, and why?

7. Have you been seeking advice from anyone else? Yes _____ No _____

Who?

What is their relationship to NCETE?

8. How often do you “**meet**” with your advisor?

- never
- rarely
- once/month
- once week/more

How do you meet?

- in person
- by phone
- email
- other

Comments:

9. What kinds of things do you **discuss with your advisor**?

- logistics
- courses
- research
- internships
- comprehensive exams
- other

Comments:

10. To what extent does your advisor give you **feedback on your written work**?

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Not at all some a great deal

Coursework?

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Not at all some a great deal

Research?

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Not at all some a great deal

Comments:

11. How **useful is the feedback** you receive?

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
not somewhat very
useful useful useful

Comments:

12. To what extent do you believe your advisor is engaged in the work of the Center

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Not at all some a great deal

Comments:

13. Overall, **how well supported** do you feel by your advisor?

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Not at all somewhat very

14. In what **ways, if any, do you feel supported**?

15. In what **ways do you wish you had more support**?

16. Do you have **other committee members** in mind for your dissertation research? Yes _____ No _____

If yes, **who** are they, **where** are they, and **why** have you chosen them?

17. Have you had significant **contact with any other faculty** (inside or outside of NCETE)? Yes_____ No _____

If Yes, who, and what is the context and content of your contact?

18. Is there anything you would like to add about advising in your program?

III. KNOWLEDGE

Now I'd like to ask you a few questions about your experience with the knowledge production and sharing within the Center

19. First, we want you to describe **your perspective on the intellectual landscape of the field**. By this we mean the key research, critical questions, findings, efforts facing the field. (If needed, prompt about technology education's relationship to engineering design.)

20. Please rate **your confidence level** in terms of the extent to which you believe your perspective is shared across the Center.

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
low medium high

What about your advisor, specifically?

Comments:

21. Are you engaged in ANY kind of **research project** right now?

Yes_____ No_____

If yes, please **describe the project** (who is the lead, how is it supported, what are the questions, methods, etc.)

22. How well would you say the **research relates to the larger mission** of NCETE?

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
Does not somewhat Relates
Relate at all related very well

23. In what **ways/how is it related**?

24. What are your **current ideas for your own dissertation research**? (probe for questions, general domain, methods, sites, what they know about existing research in this domain, what they hope to learn from it, timeline, etc.)

25. How does your **research idea build on your experience**, either inside or before your program?

26. Does your research **interest connect with the interests of your faculty/committee**? In what ways?

27. To what extent do you think your **research interests connect with the concerns and issues of practitioners**?

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
not at all somewhat A lot

Comments:

28. Becoming a researcher is a process that may involve **apprenticeship**. Apprenticeship entails the opportunity to work along side master craftspeople, with increasing responsibilities and appropriate guidance. Do you feel that you have had/will have a well-designed apprenticeship experience?

29. **Sink or swim**? This phrase refers to an approach of learning to swim where the child is simply thrown in the water and has to learn to swim. Would you characterize your own experience this way? Why or why not?

30. Who do you think you will **learn from**? Who do you think you will be **influencing** in your career?

31. To what extent do you feel you have a **realistic understanding of future opportunities** available in the field?

1 _____ 2 _____ 3 _____ 4 _____ 5 _____
not at all somewhat A great extent

- If rating is high: What are some examples of opportunities?
- If rating is low: Why is that? Do you feel unprepared for future opportunities, or do you feel you do not have a firm understanding of future opportunities?

32. Is there anything you'd like to add about **research**?

IV. NCETE COMMUNITY

In this section, I will ask you questions about your connection with the larger CLT project, etc.

33. Overall how **connected do you feel to a scholarly community through NCETE?**

| | | | | |
|--------------|---|-----------|---|-----------|
| 1 | 2 | 3 | 4 | 5 |
| very | | somewhat | | very |
| disconnected | | connected | | connected |

Comments:

34. What, if anything, does your **advisor do to bring you in/make you feel part of a scholarly community** (e.g. encourage participation in conferences, introduce to colleagues/researchers, invite student to co-author papers, etc.)?

35. How **connected do you feel to a “doctoral program”** at your university?

| | | | | |
|--------------|---|-----------|---|-----------|
| 1 | 2 | 3 | 4 | 5 |
| very | | somewhat | | very |
| disconnected | | connected | | connected |

If somewhat or very, what are some of the **things that help you feel connected?** (meeting with other students, sharing papers, sharing reading for courses, going to conferences together, co-authoring papers, etc.)

If very disconnected or poorly connected, **what is missing** that would help you feel connected?

36. Some NCETE fellows are in departments like human resources. How do you think your program fits into the larger university? How do you think it is viewed or received by the larger university community?

37. How **connected do you feel to other NCETE doctoral students?**

| | | | | |
|--------------|---|-----------|---|-----------|
| 1 | 2 | 3 | 4 | 5 |
| very | | somewhat | | very |
| disconnected | | connected | | connected |

Comments:

38. What kinds of **work/activities are you involved in that support your connection to the field?** (eg. RAsip, TAsip, internship, etc.)

39. How **satisfied** are you with the work/activities you are involved in?

1 2 3 4 5
very somewhat very
satisfied satisfied satisfied

Comments:

40. To what extent is the Center providing you **shared experiences** outside of the core courses?

1 2 3 4 5
not at all somewhat A great extent

41. What **professional organizations** do you belong to? Please describe the **nature of your activities** related to these organizations.

42. What **research conferences** have you attended since becoming a doctoral student? What has been the **nature of your role** at these research conferences?

43. What other **strands of work within NCETE** are you involved in?

TTE_____

Research_____

Other_____

Describe the **ways you have connected** with these other strands.

44. Have you **offered feedback to the project leaders** about any aspect of your experience so far? Yes_____ No_____

If yes, what **kind of feedback** have you offered?

45. How would you rate the **overall quality of your own communication** with the leaders of your program?

1 2 3 4 5
poor adequate excellent

Comments:

46. How would you rate the **overall quality of communication** among the leaders of the Center?

1 2 3 4 5
poor adequate excellent

47. How would you rate your overall satisfaction with how **finances** have been handled in your program?

1 2 3 4 5
not at all somewhat Very satisfied
satisfied satisfied

Comments:

48. How would you rate your overall satisfaction with how **logistical issues** have been handled in your program?

1 2 3 4 5
not at all somewhat Very satisfied
satisfied satisfied

Comments:

49. How would you rate your **overall satisfaction** with your program?

1 2 3 4 5
not at all somewhat Very satisfied
satisfied satisfied

Comments:

50. What would you say are the **greatest strengths** of your program?

51. What would you say are the **biggest issues/concerns** of your program?

52. Is there anything you would like to add about NCETE?

THANK YOU!!!

B. Faculty interview protocol

BACKGROUND and GENERAL CLT

1. What is your university or department **involvement** in NCETE? What is the particular role or specialty of your institution within NCETE?
2. What is your **current role** in the NCETE? How much time and effort do you spend on NCETE work? Do you play any leadership roles in the Center or in tech ed in general?
3. What are the **incentives for your participation** in NCETE? What are the **barriers** to participation? What are the **institutional messages** (overt and implicit) that you as a faculty member are getting from administrators and other faculty vis-à-vis the importance of NCETE and the advisability of your own involvement in the work of the Center?
4. Are you engaged in **research** related to the NCETE? What is important about the NCETE for research in this domain? Where are the opportunities for research in this domain?
5. Outside of teaching and research, in what **other ways are you involved** with NCETE? In what ways would you like to be more involved?

GRADUATE STUDENTS

6. How well **do you know** the NCETE doctoral students in Cohort 1 and 2? What is your **impression of them**? How do they **compare** to past students you have known/advised/taught who were not a part of NCETE?
7. How **are you working with graduate students at your institution in general**? (different roles: teaching, advising, committee work, leadership, etc.) What about NCETE doctoral students specifically?

Master's Advisors:

- a. How many master's students have you advised in Tech Ed?
- b. To what extent and in what ways have masters students you have advised participated in NCETE?
- c. How well prepared do you feel the masters students are for assuming leadership positions in this field? Explain why.
- d. What role do you envision masters students playing in the field in the future (eg. are they in schools, districts, at universities, other leadership roles – we want to determine if they see masters students as leaders in the field)

PROFESSIONAL DEVELOPMENT

8. Have you been or are you now involved in any of the professional development efforts of the Center? What is your role?
9. What is your impression of the evolution of this work?
10. What contribution do you envision this strand could make to the Center? To the field at large?
11. How, if at all, is developing high school teachers related to developing leaders in the field?
12. What remains to be done in professional development in tech ed?
13. What are the major challenges facing this strand of work for the Center? For the field?

TEACHING

14. If you are currently or have recently taught a **course** for NCETE doctoral or masters students:
 - **Describe** the course(s)
 - What are your **goals** for the students in the course?
 - How does the course **fit in with the overall doctoral/masters experience**?
 - How do you see the course **fitting in with the overall Center mission**?
 - In what ways, if at all, did the course prepare students to become leaders in the field?
 - How does the course **fit into the rest of your teaching/research agenda**?
15. How, if at all, has teaching in **influenced your teaching** of other courses?
16. What **advice** would you give to another instructor teaching a course for the graduate students in NCETE?
17. How, if at all, has teaching in NCETE **influenced your ideas for future research or scholarship**?

RESEARCH

18. What do you know about the **research agenda** of the CENTER? Is there a **synergy** of efforts?
19. Who are the Center's **critical competitors** in the research arena?

20. To what extent do you feel the Center's research:
- a. **Builds on past work** in the field; **adds value** to both the field and researcher's current work
 - b. Encompasses **new and important questions** of the field
 - c. Addresses issues of **practice**
 - d. Brings **new energy** to the field, is generative
 - e. Is of **high quality**

21. Are you planning on participating in the **Research Conference** in May? In what capacity?

SUMMARY

22. How, if at all, has participating in NCETE **affected you** professionally? **Added value** to your work? Has anything happened that would **otherwise not have happened** without the Center? What **new work** are you better prepared to engage in as a result of your involvement with NCETE?

23. What are some ways you feel you have **contributed to** NCETE?

24. At this point in time, what would you say the legacy of NCETE will be?

25. When the NSF funding comes to a close, do you anticipate continuing any center-related work?

26. If you had the resources you needed to continue some center-related work, what aspect, if any, would you choose to continue and why?

27. Do you have any **closing or final thoughts** that would be helpful to the leaders of the CENTER or for funders considering the impacts of the CENTER?

THANK YOU!!!

C. Seed grant recipient interview protocol

Intro: We are interested in hearing more about the seed grant program: what the process was like, how the recipients experienced the program; and how, if at all, the program influenced the capacity of people to do research in the field of technology education.

As always, this interview is confidential and your comments will remain anonymous in any reports we write. Do you have any questions before we start?

- 1) How did you first learn about the seed grant opportunity (general announcement or one-on-one communication)?
- 2) Why did you choose to pursue a seed grant? What were you hoping to get out of the experience?
- 3) How would you describe your confidence to conduct research, prior to applying for the seed grant?
- 4) How, if at all, did the Center prepare you for the process of applying for the seed grant?
- 5) How, if at all, did the Center support you during the process of applying for the seed grant?
- 6) Did you collaborate with anyone on writing the proposal or conducting the research for your seed grant? If so, tell us a little about what that collaboration looked like and how the Center supported or did not support that collaboration.
- 7) How would you describe your confidence to conduct research, after having gone through the seed grant experience? How, if at all, did the process influence your capacity to conduct research?
- 8) What did you learn as a result of the entire seed grant proposal writing process and the research process that was of most value to you?
- 9) Are you aware of what research other seed grant recipients conducted? How familiar, if at all, are you with others' methodology and findings?
- 10) How, if at all, do you think the seed grant opportunity and process impacted the Center as a whole?
- 11) How effective does you think the seed grant process was as a strategy to influence the field of technology education at large? What might have been done differently?

THANK YOU!!!

D. Experts in the field interview protocol

NCETE External Expert Interview Protocol September 2009

You've been recommended as a reference for NCETE. The reason you've been recommended is you have a broad knowledge in the field in which NCETE is working, and you also have some familiarity with the Center.

Key focal points for the conversation include:

The Domain NCETE Has Chosen

One of the premises of Centers is that they've identified a sub-domain of STEM education that needs investment for its improvement. So, for example, with engineering and technology education, there is an assumption that by studying and addressing issues related to infusing engineering design into technology education, we can make progress toward addressing or improving significant problems or situations in education. In other words, it's worthy of investment. This is a question of the importance of the domain.

1. Is this an important domain NCETE has chosen to focus on (ETE)? What are the issues that matter to practitioners? To researchers?
2. Was this Center well-positioned in that domain to make progress? In what ways? (probe for people involved, reputation, university partners, etc)
3. What are the critical areas of need in the domain, going forward? Has the Center addressed those needs at all?

Knowledge Generation and Knowledge Utilization (a Center is supposed to do both):

4. From what you understand of the kinds of research projects that the Center is engaged in and the kind of research they're promoting, is this Center likely to be significant in contributing to the knowledge base in the field?
5. To what extent and how has the Center succeeded in collecting, disseminating and consuming research? Of all the research in the field, has this Center played a role in helping to digest, translate and make the Center useful to researchers, practitioners, policy makers and others?
6. To what extent and how does the Center have the potential to make progress in this field, vis-à-vis, important questions, knowledge generation and utilization, that would address important issues that are faced by policy makers, practitioners and researchers?
7. Anything else you would like to add about the Center's research focus?

Leadership – Generation and Support of *Leadership*

8. I'd like you to now talk about the need for leadership or expertise in this domain and the degree to which you think the Center made progress in generating leadership among faculty members, researchers, graduate students, post docs, and practitioners. To what degree do you think the Center has produced people with expertise, knowledge, and leadership skills that will be important to this domain?
9. To what extent and how do you think the Center has made progress in empowering or enhancing existing leaders? Has the center drawn upon the skills of existing leaders in the field, put them to use, connect them? Examples.

Summary Questions

10. Overall, how has the Center performed in terms of building/contributing to the improvement of the domain of tech ed? How has the Center positioned itself to be a significant player, and to add value to the work of this field?
11. What are this Center's strengths?
12. What are this Center's weaknesses?
13. Major concerns?
14. Other summary thoughts?

THANK YOU!!!

E. Email invitation for expert review of research

Dear Colleague,

My name is -- and I am a researcher with Inverness Research. Our group is serving as the external evaluators for the National Center for Engineering and Technology Education (NCETE), an NSF-funded Center for Learning and Teaching.

As part of our summative evaluation of the Center, we are seeking your help as an expert in the field of engineering and/or technology education. We would like to offer you an opportunity to review NCETE-supported research products, in exchange for a small honorarium. We are hoping to complete these reviews by mid-April. We offer a range of options for you to choose from. Below is a description of each level of task.

Portfolio Review (\$2000 honorarium): This task entails reviewing the entire selection of research products in the NCETE portfolio, reading several pieces, and writing a 3-4 page summary that considers (at least) the following:

- Your overall impression of the portfolio as a whole
- Importance/relevance of the research questions being addressed
- Originality of the research topics/foci
- Quality of the writing
- Overall potential contribution to the field
- What it suggests to you for the future

Dissertation Review (\$1500 honorarium): This task entails reviewing at least three dissertations that interest you and summarizing your reflections in 3-4 pages with the following in mind:

- Your overall impression of the dissertations
- Importance/relevance of the research question being addressed
- Originality of the research topic/focus
- Soundness/appropriateness of the research design/methods
- Strength of the interpretations/data supports conclusions
- Quality of the writing
- Overall potential contribution to the field

Journal Article Review (\$1000 honorarium): This task involves choosing and reading 6 NCETE-supported articles that interest you and summarizing your reflections in 3-4 pages with the following in mind:

- Your overall impression of the journal articles
- Importance/relevance of the research questions being addressed
- Originality of the research topic/foci
- Soundness/appropriateness of the research design/methods
- Strength of the interpretations/data supports conclusions
- Quality of the writing
- Overall potential contribution to the field

Papers of Your Choice Review (\$800 honorarium): Here we are asking you to choose any 3 NCETE research products (from the website) that interest you, and reviewing them for quality and contribution to the field, and writing up 1-2 pages of your reflections.

For any task that you choose, we are hoping that you can apply your expertise and experience in reviewing the quality and value of this work. To make sure we have at least one person performing each level of task, please indicate how (if at all) you are interested in participating, by giving each option a rating from 1-4.

1 = I would very much like to do this

2 = I would like to do this

3 = I am willing to do this

4 = I do not want to do this

Options:

Portfolio Review (\$2000). Your rating:

Dissertation Review (\$1500). Your rating:

Journal Article Review (\$1000). Your rating:

Review 2-3 articles of interest (\$800). Your rating:

If you agree to participate, we will send you the documents (or links to the documents). Please reply to this email and indicate whether or not you would like to participate. If you would prefer to be interviewed over the phone in lieu of writing your reflections, we can arrange this.

Many thanks,

Michelle Phillips and Jenifer Helms for the Inverness Research NCETE evaluation team