

Utah State University

DigitalCommons@USU

Reports to NSF

National Center for Engineering and Technology
Education

6-2010

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

NCETE Faculty

Follow this and additional works at: https://digitalcommons.usu.edu/ncete_reports

 Part of the [Engineering Education Commons](#)

Recommended Citation

Faculty, NCETE, "Year Six Annual Report: Activities, Findings and Evaluators' Reports" (2010). *Reports to NSF*. Paper 4.

https://digitalcommons.usu.edu/ncete_reports/4

This Report is brought to you for free and open access by the National Center for Engineering and Technology Education at DigitalCommons@USU. It has been accepted for inclusion in Reports to NSF by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.





Year Six Annual Report

Activities, Findings and Evaluators' Reports

2009 - 2010



nceteTM

National Center for Engineering
and Technology Education

www.ncete.org



The material is based on work supported by the National
Science Foundation under Grant No. ESI-0426421

National Center for Engineering and Technology Education

Activities Report Year Six: 2009-2010

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.

The goals of the Center are:

1. To conduct research to:
 - a) define the current status of engineering design experiences in engineering and technology education in grades 9-12;
 - b) define an NCETE model for professional development by examining the design and delivery of effective professional development with a focus on selected engineering design concepts for high school technology education;
 - c) Identify guidelines for the development, implementation, and evaluation of engineering design in technology education.
2. To build leadership capacity by developing a collaborative network of scholars who work to improve understanding of the process of learning and teaching of engineering design in technology education.
3. To establish and maintain a communication program to inform all stakeholder groups of NCETE activities and accomplishments.

NCETE was granted a no-cost extension for a sixth year of work. Significant activities of year six include: completion of doctoral dissertations; postdoctoral studies; internally supported research by Center partners; conference presentations; and publications related to Center work. The Center research continues to be refocused to align with NSF research priorities in learning and teaching. Some researchers have now been supported by the Center in series of two or three studies. Also, individuals affiliated with the Center have increased their pursuit of external funding by submitting proposals to outside groups.

Goal One Activities: Research Studies

Ongoing and Pending Dissertation Studies

Nine NCETE doctoral fellows have completed their doctoral programs. Their dissertation titles are listed below. Complete copies of their dissertations are available on the NCETE website (www.ncete.org). Most of the doctoral fellows have submitted manuscripts for publications in peer-reviewed journal articles based on their dissertation studies. Daugherty, Denson, Kelley, and Mentzer had articles appear in 2009-2010 based on their doctoral research. Austin, Daugherty, Denson, Kelley and Mentzer have been involved in the preparation of proposals to NSF and Mentzer is a Co-PI on a funded NSF project. NCETE anticipates Austin, Daugherty, and Denson may be Co-PIs on NSF funded projects soon.

1. 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.
2. 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.
3. Daugherty, J. L. (2008). Engineering-oriented professional development for secondary level teachers: A multiple case study analysis. Unpublished doctoral dissertation, University of Illinois.
4. 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.
5. Franske, B. (2009). Engineering problem finding in high school students. Unpublished doctoral dissertation, University of Minnesota.
6. Kelley, T. (2008). Examination of engineering design in curriculum content and assessment practices of secondary technology education. Unpublished doctoral dissertation, University of Georgia.
7. 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.
8. Stricker, D. (2008). Perceptions of creativity in art, music and technology education. Unpublished doctoral dissertation, University of Minnesota.
9. Walrath, D. (2008). Complex systems in engineering and technology education: The role software simulations serve in student learning. Unpublished doctoral dissertation, Utah State University.

Internal Research Awards

In year five, NCETE invited Center partners to prepare proposals for research to further the research mission of the Center. The internal grants were intended to support intensive

scholarly endeavors over a period of 6 to 12 months during the period ending August 31, 2009. Funding for individual grants ranged from \$10,000 to \$45,000 for total direct and indirect costs, including released time or summer salaries for faculty, support for graduate students, travel, equipment, and supplies. A 10% cost-share was required. Nine internal proposals were submitted for review. The proposals were externally reviewed by a panel of three experienced reviewers. Final reports describing the research studies and results were submitted to NCETE during year six. This section includes descriptions of the findings of the six internally-funded studies. Complete research reports are posted on the NCETE website. Five of the internally-funded studies contributed to the development of formal proposals to NSF programs during 2010.

Custer, R. L., Daugherty, J., & Meyer, J. (2009). Formulating the conceptual base for secondary level engineering education: A review and synthesis.

The purpose of the study was to identify and refine a conceptual foundation for secondary school engineering education. Specifically, this study sought to address the following research questions:

- What engineering concepts are present in literature related to the nature and philosophy of engineering?
- What engineering concepts are embedded in secondary level science, technology, engineering, and mathematics standards?
- What engineering concepts are embedded in secondary level engineering-oriented curriculum?
- What engineering concepts have been identified in the related research literature?
- What engineering concepts are deemed core for secondary level education by practicing engineers and engineering educators?

Key input activities included conducting a review and synthesis of extant educational materials focused primarily on standards, curriculum materials, and various research studies. In addition to these materials, literature from the history and philosophy of engineering was also reviewed and included in the analysis. Also included in the process was a series of focus group sessions conducted with selected engineering educators and practicing engineers to identify and classify their recommendations of concepts appropriate for secondary level engineering. As a final phase of the process, a reaction panel of engineering and technology education experts was convened.

The study found thirteen core engineering concepts appropriate for secondary level engineering: analysis, constraints, design, efficiency, experimentation, functionality, innovation, modeling, optimization, prototyping, systems, trade-offs, and visualization. The researchers reported a pervasive difference of opinion about whether the concepts identified in the study are appropriate and important for both pre-engineering and for general technological literacy. Neither conceptualization was given precedence over the other in the analysis because the pursuit of “core” concepts was deemed appropriate for either approach. However, the researchers noted that the pedagogical implications of implementing these concepts may differ

between the orientation toward general technological literacy and the preparation of students for postsecondary engineering education. This project provided experiences and outcomes that were incorporated into a proposal to the 2010 DR K-12 Program.

Lawanto, O., & Stewardson, G. (2009). Engineering design activity: Understanding how different design activities influence students' motivation in grades 9-12.

The objective of this study was to evaluate the motivation of high school students engaged in two different engineering design projects from Project Lead The Way (PLTW): the marble-sorter and bridge designs. The motivation components measured in this study were students' intrinsic goal orientation (IGO) and extrinsic goal orientation (EGO), task value (TV), self-efficacy for learning and performance (SELP), and control belief (CB). After finishing each project, students were asked to complete an Engineering Design Questionnaire (EDQ) survey instrument, consisting of 26 items modified from the Motivated Strategies for Learning Questionnaire (MSLQ), five demographic items, and two open-ended questions exploring students' most and least motivating aspects of their design challenges. The sample was comprised of 123 students from five PLTW high schools in Indiana, Missouri, and Utah. A total of 104 students completed the EDQ for the marble-sorter design and 53 students completed the EDQ for bridge design. Students at only two schools successfully completed both marble-sorter and bridge design activities; consequently only 34 students completed both EDQ surveys.

The results showed a significant difference on students' IGO during marble-sorter and bridge design activities. Students' intrinsic goal orientation was significantly higher on bridge design than on the marble-sorter design. Students who planned to major in engineering or technology education were significantly more motivated by working on the two design activities than were those students who planned majors in other areas. Students' EGO was not significantly correlated to their IGO, TV, SELP, and CB. Common themes associated with student motivation in the activities are presented in this report. This project provided experiences and outcomes that were incorporated into a proposal to the 2010 DR K-12 Program.

Shumway, S., & Wright, G. (2009). A case study of the implementation of an engineering program into a high school technology education classroom.

A case study format was employed to: a) determine what criteria the teachers and districts use when selecting engineering design experiences for infusion into high school classes and which of these criteria are most effective; and b) determine what issues, opportunities, and constraints teachers confront as they change their approach to teaching to infuse engineering concepts into technology education. The case study participant was a Utah high school teacher who had been teaching technology education classes for over 12 years, held bachelor's and master's degrees in technology education, and who had participated in an NCETE-sponsored professional development program. The teacher was evolving his technology education program to include more engineering.

The findings from the interview and observations provide a broader understanding of the complexity of the transition from a traditional technology education program to a focused contemporary technology and engineering education program. Although this was not the initial research objective, the investigators felt this is an important finding because many schools with technology programs are either considering adopting new curricula to ensure that their programs stay current and relevant, or are cutting technology programs. The findings of the study suggest that teachers who are in transition from teaching traditional technology education to teaching contemporary technology and engineering focused education classes will need professional development to help familiarize them with the current technology and engineering learning objectives, standards, trends, issues, and curriculum. Additionally they will need administrative support from both site and district administrators for training, equipment, and supplies. In light of these findings, the national efforts of ITEEA and other organizations need to be better promoted in order to educate teachers about the current trends, issues, standards, and possible grants in the technology and engineering. This project provided experiences and outcomes that were incorporated into a proposal to the 2010 DR K-12 Program.

Wicklein, R., & Mativo, J. (2009). Learning effects and attitudes of design strategies on high school students.

The purpose of this research project was to use an experimental research design to compare learning and attitudinal effects of two different design instructional strategies on randomly selected and assigned 11th and 12th grade students. Through the use of a common technologically-based problem, students were guided through a design sequence that utilized two different instructional approaches (a) predictive analysis and (b) trial and error. At the completion of a five-day (15 hour) learning activity, a standardized engineering design test was administered to the students to evaluate differences in engineering design capabilities. Additionally, students completed an inventory related to their perceived confidence in solving technological problems and their beliefs about technological problem solving.

The outcomes of this research were measured by the Engineering Design Test (developed by Wicklein for this study). There was no significant difference between the participants in the design groups as measured by their scores on the Engineering Design Test, in their confidence in solving technological problems, or in their beliefs about technological problem solving. The researchers hypothesized that several factors may have contributed to the neutral effects of the two different design strategies. First, the amount of time dedicated to the instruction program was very short and limited.. Second, the engineering design process should be integrated within normal learning experiences of students in order for students to have a more established understanding of solving technological problems using this methodology. Without a formal preparation in the engineering design process utilizing predictive analysis, students defaulted to trial and error practices. Third, the small numbers of student participants available for assignment to each group may have been a contributing factor. This project provided

experiences and outcomes that were incorporated into a proposal to the 2010 DR K-12 Program.

In addition to the internal grants described above, NCETE provided start-up grants to two former NCETE fellows who had completed their Ph.D.s and were in their first year as faculty members. A summary of their research studies is provided below.

Kelley, T., Brenner, D. C., and Pieper, J. T. (2010). PLTW and Epics-High: Curriculum comparisons to support problem solving in the context of engineering design.

A comparative study was conducted to compare two approaches to engineering design curriculum between different schools (inter-school) and between two curricular approaches, *Project Lead the Way* (PLTW) and *Engineering Projects in Community Service* (EPIC High) (inter-curricular). The researchers collected curriculum materials, including handouts, lesson plans, guides, presentation files, design descriptions, problem statements, and support guides. The researchers conducted observations in the classrooms to collect qualitative indicators of engineering and technology reasoning, collect data on the nature of students' questions, how students define problems, and operate within the constraints of a design problem. Observational studies were conducted with students participating in *Project Lead the Way* and with students participating in *Engineering Projects in Community Service* (EPICS). Study participants were asked to work through an ill-defined problem, in this case the problem of creating a new playground for an elementary school. The data from these protocols were analyzed using a coding process; a list of universal technical mental processes and a computer program, OPTEMP, to record frequency and time of each mental process employed by the students. The data were used to identify common cognitive strategies employed by the students and to determine where students placed greatest emphasis during the observation period.

Findings indicated that participants in the *EPICS-High* program were in general more solution-driven problem solvers, while the *Project Lead the Way* participants were generally problem-driven as defined by Kruger & Cross (2006). Although the participants in both groups had completed advanced courses in mathematics; mathematics was rarely employed (less than 3%) to describe constraints of the problem or predict results of proposed solutions. Over half of the students became fixated at some point on the generic artist's view of a school site and based their solutions on that illustration. This study provides important insights about how students solve ill-defined problems and useful information for technology education as it seeks to implement engineering design. This project provided experiences and outcomes that were incorporated into a proposal to the MSP Program.

Stricker, D. (2010). A case study: Teaching engineering concepts in science.

This study describes a teacher-developed high school engineering course, teaching strategies used in delivering math and science literacy through this course, challenges and constraints encountered during its development and delivery, and strategies used to overcome those

obstacles. The case study utilized semi-structured interviews with the engineering instructor in Minnesota. In addition, the researcher conducted classroom observations and reviewed instructional materials, teacher lesson plans, and teacher journals.

The researcher noted the importance of the conceptual base in the delivery of instruction, the role of trial and error in curriculum innovation, the values of science and engineering competitions as bases for learning activities, the importance of project based learning and teaching in the innovative course, the emphasis on creative thought and work, and the teacher's role as a guide to learning rather than the sole "sage." The challenges and constraints that occurred during the development and delivery of this engineering course included the assessment of student learning and reporting on the discomfort of various stakeholder groups with the new pedagogy. Strategies used to overcome these obstacles included strengthening financial and instructional support through business partnerships and enhanced administrative support.

Survey Instrument Development

Development and testing of a survey instrument to understand students' engineering self-efficacy, interest, and perceptions was initiated during spring 2010, with postdoctoral research associates Chandra Austin and Cameron Denson as leads. The survey instrument should have broad application to high school students involved in engineering experiences. Initially, the survey instrument will be used to further understanding of the influence Mathematics, Engineering, Science Achievement (MESA) club activities have on students' engineering self-efficacy, interest in engineering, and perceptions of engineering. MESA is an academic preparation program that supports educationally disadvantaged students by providing pathways for them to succeed in science, mathematics and engineering disciplines.

The survey was administered to MESA participants in three schools in Utah and three schools in California: East High School, West High School and Highland High School in Salt Lake City; and Morningside High school in Inglewood, CA, Godinez Fundamental High School in Santa Ana, CA, and Savanna High School in Anaheim, CA. The MESA advisors at each of the six schools volunteered their programs for this preliminary study. From these schools, 175 MESA students completed the draft survey. Of the completed surveys, 62% of the students were female and 38% were male. The ethnic breakdown of the students is 14% African American, 9% Pacific Islander, 1% American Indian, 12% White, 10% Asian, 48% Hispanic, and 2% Filipino, and 2% Other.

Austin and Denson also conducted two focus groups, one at West High School in Salt Lake City and one at Morningside High School in Inglewood, CA. The participating students were chosen at random by the MESA club advisor from the pool of volunteers at the schools. The groups included similar numbers of males and females and reflected the ethnic representation of the clubs. The primary purpose of the focus groups was to improve our understanding of the activities that the MESA participants found important.

To continue to build their understanding of MESA, Austin and Denson also volunteered to work with the local Mountain Crest High School MESA chapter. They developed an engineering design challenge for the local club and introduced it to the MESA participants. They also assisted in the Utah-wide MESA engineering design competition event at Lagoon near Salt Lake City.

The survey data were collected during May and have not been analyzed in sufficient detail to comment on findings. NCETE has recently engaged Karen Peterman, a Senior Consultant with Goodman Research Group, Inc., and Frances Lawrenz, Associate Vice President for Research at the University of Minnesota, to provide independent reviews of the instrument and the focus group protocol and to offer suggestions for revisions to improve the usefulness of the instrument in the research program of the Center.

Team Approaches to Engineering Design

A case study was designed to pilot techniques used for measuring design thinking of high school engineering teams during the summer of 2009. Atman, Adams, Cardella, Turns, Mosberg & Saleem's playground design problem was presented to three pairs of high school students and a single high-school student. Participants were provided a maximum of three-hours to develop a solution to the problem while thinking aloud. Audio and video recordings were made of the sessions. The students also participated in reflective interviews at the conclusion of the design challenge. The audio data were coded into these nine categories developed by Atman, et al. Mentzer and Becker used the lessons they learned from this pilot study to improve the data gathering techniques for their DR K-12 project.

NAE/NCETE Collaborative K-12 Curriculum Study

In September 2009, the National Academy of Engineering (NAE) held a Symposium on K-12 Engineering Education and introduced the report *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*. With funding from both NAE and NCETE, Ken Welty conducted an extensive analysis of K-12 engineering education that substantially informed the committee's work. He gathered and presented information about the approaches used to introduce the study of engineering in K-12 settings. The study examined the mission, goals, content, and learning activities of prominent curricula to characterize their treatment of engineering concepts such as design, analysis, modeling, systems, and constraints; and the inclusion of mathematics, science, and technology. The results of Welty's study are presented in the publication as Appendix B: Curriculum Projects – Descriptive Summaries and Appendix C: Curriculum Projects – Detailed Analyses (reproduced in a CD in the back of the book).

Movement Towards an Exemplary Professional Development Program

A year-long professional development (PD) program was developed, based on the experiences of earlier PD activities within the Center and the current body of research. The NCETE PD

Model consists of: a long-term effort involving (teams of) STEM teachers; spring Saturday sessions and summer on-campus workshops providing experiences in working with engineering design; challenges and opportunities for the development of engineering design challenges suitable for each teacher's high school classes; classroom implementation of the design challenges during the subsequent academic year; and classroom visitations by members of the PD teams.

Teachers were introduced to the NCETE Definition of the Engineering Design Process which was adapted from a model used at Dartmouth. The design steps include:

1. Identification of need
2. Definition of the problem and formulation of specifications
3. Search for existing designs
4. Develop designs to meet criteria
5. Analysis of alternative designs, including simulations
6. Decision (may use a decision matrix)
7. Test prototype and verify the solution (provide iteration as needed)
8. Communicate results

Two sites were selected to pilot the NCETE PD model: CSULA and NCA&T. Both sites had positive involvement from engineering faculty as content experts on the professional development teams and access to diverse teacher and student populations. CSULA had access to STEM academies through Long Beach Unified Schools and NCA&T had access both to STEM academies and to traditional science, technology, engineering, and mathematics programs. Most of the professional development work worked occurred during year five (2008-2009). NCETE internal evaluators, James Dorward and Jodi Cullum, evaluated the year five professional development and prepared a report, *Final Internal Evaluation Report for the 2008-09 NCETE Professional Development Program*, which was included with the NCETE Year Five annual report. Their report offers evidence that the teachers who participated in the workshops increased their content knowledge in engineering design, were well served by the teams of professional developers, were quite pleased by the organization and conduct of the workshops, and were positive about the potential of engineering design activities to increase student motivation and learning in their high school science, technology, engineering, and mathematics courses.

In year six, the professional development team at NCA&T and CSULA observed teachers in the classroom as they implemented the PD design challenges. They also provided feedback to the teachers on their instruction. Nine teachers at NCA&T were followed in year six and five teachers at CSULA. All of the teachers indicated that they had used part of the Engineering Design process in their classes. Many expressed concerns about the time required to fully implement one of the design challenges, student mathematics and science capabilities, and the fit with their current curricula. Six teachers indicated that they planned to continue using elements of the engineering design challenges in their classes and would like to add additional units.

The PD team at NCA&T and CSULA observed that some of the teachers were challenged because of weaknesses in pedagogy or content knowledge. The mathematics teachers were challenged by the pedagogical issues related to students working in groups and moving around the room while the technology education teachers were challenged by weaknesses in mathematics. The use of a team of STEM teachers helped compensate for the individual teacher weaknesses. Upon reflection about the PD experience, the team of developers felt they may have placed too much emphasis on strict adherence to the predictive analysis model. While this is clearly a hallmark of engineering design, the PD team felt they overemphasized this facet rather than broadening the use of the model with an understanding that engineering design may sometimes rely on intuitive mechanical design.

One investigation of the PD program was a qualitative case study to describe the engineering design process lesson planning that teachers generated during professional development. Complete study results were published in Denson, C., Mentzer, N., & Cullum, J. (2009). This study was guided by the following research question: How do high school STEM teachers plan to implement engineering design in their classrooms? Researcher understanding of teachers' planned implementation emerged through the triangulation of data which included teacher generated lesson plan documents and lesson presentations during the professional development. The sample of 17 teachers participated in the study representing science, mathematics, and technology education teachers who work under the constraints of standard-based curriculums. Data considered in this study were limited to professional development experiences and did not include observations of teaching behaviors their classrooms.

Data were collected on 17 high school teachers from California, North Carolina, and Virginia. The participants represented a variety of racial and ethnic backgrounds including ten Caucasian, three Latino/Latina, two Asian, one African American, and one Native American. The majority of participants were male (59%). The majority of teachers indicated majoring in science, math, technology, or education as undergraduates. Nearly 60% of teachers had certification in mathematics education; 12% of teachers were certified in science education; and 47% held certification in technology education. Seventy-six percent of the participants had obtained, or were actively pursuing, graduate degrees. All of the teachers reported experience in teaching students in grades 10-12. The average number of years teaching was eleven with a range of one to thirty-two years. Participant teaching assignments for the academic year following the start of the professional development program included math (59%), science (12%), and technology education (47%).

The investigators concluded that most teachers (14 of 17) who completed the professional development created lesson plans which involved the engineering design process. Teachers planned for a general shift in responsibilities as students progressed through the design process. In the early stages of the design process, teachers had the majority of responsibility for identifying the need and defining the problem. This may be attributed to the difficulty novice learners encountered by attempting to define the problem. Teachers planned to do most of the research and develop a limited set of designs with which the students might work. Student

responsibilities increased as they began with a limited solution set and conducted analysis planned by the teacher. Students made a decision based on the analysis and tested their predicted results with experiments planned by the teacher. It was solely the students' responsibility to communicate their results, often in a mock presentation, sharing their findings and justifying their decisions with data.

Goal Two Activities: Capacity Building

Doctoral Student Status

Nine NCETE doctoral fellows have completed their doctoral programs, including one white female, one African American female, two African American males and five white males.

- Chandra Austin completed her doctoral program at the University of Minnesota and is a post-doctoral research associate for NCETE at Utah State University.
- Zanj Avery completed his doctoral program at Utah State University and is an adjunct faculty member at California State University, Los Angeles.
- Jenny Daugherty completed her doctoral program at the University of Illinois at Urbana-Champaign and is an assistant professor in the School of Technology at Purdue University.
- Cameron Denson completed his doctoral program at the University of Georgia and is a post-doctoral research associate for NCETE at Utah State University.
- Ben Franske completed his doctoral program at the University of Minnesota and owns Frankse Consulting, LLC, a full service technical consulting company.
- Todd Kelley completed his doctoral program at the University of Georgia and is an assistant professor in the School of Technology at Purdue University.
- Nathan Mentzer completed his doctoral program at Utah State University and is an assistant professor in the School of Technology at Purdue University.
- David Stricker completed his doctoral program at the University of Minnesota and is an assistant professor in the School of Education at the University of Wisconsin-Stout.
- Doug Walrath completed his doctoral program at Utah State University is the Director of the Northwestern Alaska Career and Technical Center.

Five NCETE doctoral fellows have their dissertation proposals approved and are in various stages of completion. Their dissertation titles are listed below.

- Dixon, R. (2010). Experts and novices: Differences in their use of mental representation and metacognition in engineering design. Unpublished doctoral dissertation proposal. University of Illinois at Urbana-Champaign.
- Lammi, M. (2010). Characterizing high school students' systems, cognitive processes, and strategies in engineering design challenges using the F-B-S framework. Unpublished doctoral dissertation proposal. Utah State University.

- Meyer, J. (2010). Mental rotation and mechanical reasoning in the performance of a mechanical assembly task. Unpublished doctoral dissertation proposal. University of Illinois at Urbana-Champaign.
- Nehring, M. (2010). The role of alternative categorization in reducing functional fixedness in problem solving activities in children pre-k to 9th grade. Unpublished doctoral dissertation proposal. University of Minnesota.
- Roue, L. (2010). Divergent thinking skills: Influence of gender and grade level. Unpublished doctoral dissertation proposal. University of Minnesota.

Two NCETE doctoral fellows have passed their comprehensive examinations and are in the process of preparing their dissertation proposals.

- Katrina Cox, Utah State University
- Yong Zeng, University of Illinois at Urbana-Champaign

One NCETE doctoral Fellow is finishing course work.

- Scott Wetter, University of Illinois at Urbana-Champaign.

Other doctoral students who received support from NCETE include:

- Paul Asunda, who received support for an early research project, completed his doctorate at the University of Georgia and is presently on the faculty at Southern Illinois University.
- Jodi Cullum, who worked on the internal evaluation of NCETE while completing her doctorate in psychology at Utah State University and is presently an evaluator in private practice in Canada.
- Oenardi Lawanto, who received support for an early research project, completed his doctorate at the University of Illinois at Urbana-Champaign and is presently on the faculty at Utah State University.
- Rod Flanigan, a recently-enrolled doctoral student at Utah State University.

NCETE doctoral fellows who completed some course work and then left the program:

- Wendy Knapp (UM). Wendy and Randy Knapp are a married couple with a blended family. They had full-time jobs off of campus and were trying to carry a full-time load as first-year doctoral students. They were struggling to meet all of their obligations and opted to leave the doctoral program.
- Randy Knapp (UM).
- Edward Locke (UGA). Edward was coached out of the PhD program at University of Georgia. He did graduate with an Educational Specialist degree from UGA.

- Marty Westrick (UIUC). Marty's wife took a position in another state and for one semester; they tried to live separately without much success. Marty left UIUC and joined his wife.
- Deborah Williams (UGA). Following the birth of her first child, Deborah decided to delay her doctoral studies.
- Dan Wixted (USU). Was granted a medical leave of absence from USU; left Utah to live with his family in another state. He has not indicated when he plans to return to USU.

Postdoctoral Research Mentoring

Over the past year, NCETE has supported two post-doctoral research associates: Cameron Denson and Chandra Austin. Cameron Denson was an NCETE fellow at the University of Georgia and is in his second year of post-doctoral work. Chandra Austin was an NCETE fellow at the University of Minnesota and is in her first year of post-doctoral work.

Mentoring activities for the post-docs included assistance with the development and delivery of formal presentations for meetings of professional organizations. NCETE provided support for Cameron Denson to attend the Design and Principles Conference in Chicago, Illinois, the International Technology and Engineering Educators Association Conference in Charlotte, North Carolina, and the American Society for Engineering Education Conference in Louisville, Kentucky. He made presentations at each of these meetings based on his year-one post-doctoral work. Chandra Austin attended the International Technology and Engineering Educators Association Conference in Charlotte, North Carolina, and the American Society for Engineering Education Conference in Louisville, Kentucky, where she made presentations based on her dissertation work.

The post-docs also attended meetings of other professional societies where they were not expected to give a paper. Participation in these meetings was encouraged so they could further develop their research agendas and to provide opportunities for networking with other professionals. Cameron Denson and Chandra Austin attended the Mississippi Valley Technology Teacher Education Conference in Nashville. Chandra Austin also attended the American Educational Research Association meeting in Denver. (Cameron attended this meeting in his first year as a post-doctoral research associate).

Additional research-related activities of the post-doctoral research associates include the preparation and submission of scholarly manuscripts. In 2009 Cameron Denson published two journal articles based on research conducted while he was an NCETE doctoral fellow at the University of Georgia. He also revised a manuscript based on his dissertation which is expected to appear later in 2010. Chandra Austin collaborated with her doctoral advisor, Theodore Lewis, in the preparation and submission of a manuscript based on her dissertation research. That manuscript was recently declined, so they are now revising the material for submission to another journal.

The post-doctoral research associates also participated in a number of NCETE research and capacity building activities described in more detail later in this document. In particular, they helped develop a research seminar and deliver it via distance education technology; conducted preliminary investigations into the development of a survey instrument to measure students' self-efficacy, interest, and perceptions of engineering; and studied the approaches of teams of high school student confronted by engineering design challenges.

Online Research Seminar - Spring 2010

During Spring Semester 2010, NCETE sponsored a seminar series that featured researchers in the field of Engineering and Technology Education. The purpose of the seminar was to expose graduate students to current research on engineering and technology education at the secondary and postsecondary levels, and to create a networking opportunity for faculty and graduate students at selected doctoral granting institutions. Participating universities included: Colorado State University, Purdue University, University of Georgia, University of Illinois at Urbana-Champaign, Utah State University, and Virginia Tech.

The seminar met for 2 hours every other week during the semester. Presentations lasted approximately 30 to 60 minutes with the remaining time for open discussion. Handout materials were made available to the participants prior to each seminar.

Seminar Presenters and Dates:

DATE	PRESENTER	AFFILIATION
January 12, 2010	Introduction	All sites
January 26, 2010	Oenardi Lawanto	Utah State University
February 9, 2010	Gary Benenson	City College of New York
February 23, 2010	John Mativo	University of Georgia
March 9, 2010	Cameron Denson	Utah State University
March 23, 2010	Donnie Coleman	Virginia Tech
April 6, 2010	David Stricker	University of Wisconsin-Stout
April, 20, 2010	Todd Fantz	Colorado State University

Strategic Alliance of Doctoral Programs

NCETE is developing a plan for a strategic alliance of doctoral programs. The alliance would include institutions interested in sharing a series of doctoral courses focused on K-12 engineering education. The courses would introduce doctoral students to contemporary research in this emerging area and require research experiences in each course. The long term goal of the strategic alliance is to continue to build research capacity in engineering and technology education.

The proposed strategic alliance will build upon the experiences gained by faculty members affiliated with the National Center for Engineering and Technology Education as they collaborated to build capacity through the preparation of doctoral students who would become the next generation of leaders in engineering and technology education. NCETE developed a community of doctoral fellows who resided at four partner institutions and who enrolled in a common core of courses on-line at each of the four institutions: University of Georgia, University of Minnesota, University of Illinois at Urbana-Champaign, and Utah State University. Each partner institution developed one of four common core courses and provided the instructional team for the course, often bringing in visiting lecturers to supplement the expertise of their faculty members.

The report of the NCETE external evaluator, Inverness Research Associates, provided substantial evidence of the effectiveness of the common core of instruction to supplement the existing doctoral programs at the respective institutions. The evaluative comments from the doctoral fellows about the strategic alliance were highly positive. Early publications and presentations by the doctoral fellows provided additional supporting evidence of the role the common core courses played in building the leadership cadre in the emerging area of engineering education.

To build upon the success of common core of instruction, NCETE hosted an exploratory Strategic Alliance Focus Group April 30, 2010. Participants were:

Utah State University

Christine Hailey, Senior Associate Dean, College of Engineering and NCETE PI
Kurt Becker, Engineering and Technology Education Department Head and NCETE Co-PI
Jim Dorward, Associate Dean for Research, College of Education and Human Services

Colorado State University

Michael DeMiranda, Professor, School of Education and Department of Electrical and Computer Engineering
Thomas Siller, Associate Dean for Instruction, College of Engineering

Purdue University

Gary Bertoline, Associate Dean for Graduate Programs, College of Technology
Krishna Madhavan, Assistant Professor, Engineering Education

University of Illinois, Urban-Champaign

Scott Johnson, Associate Dean for Online Learning, College of Education
Ty Newell, Professor Emeritus, Mechanical Engineering

University of Georgia

Bob Wicklein, Professor, Workforce Leadership & Social Fund
John Mativo, Assistant Professor, Workforce Leadership & Social Fund

Virginia Tech

John Wells, Associate Professor, School of Education

Participants were asked for their input on the following topics:

1. a description of a successful alliance,

2. possible benefits of an alliance,
3. challenges of an alliance,
4. important topics for graduate course work in an alliance (advantages for your graduate students and institution), and
5. how an alliance might be organized.

Participants of the April 30 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.

Cohort Two Meeting in Washington, DC

Doctoral fellows participated in the NCETE Fellows Leadership Seminar in Washington, DC, on July 12-14, 2009. Gerhard Salinger, Program Director at the National Science Foundation, provided a historical perspective of the National Science Foundation's interest in and support of engineering and technology education. Greg Pearson, Program Director at the National Academy of Engineering, hosted the fellows for the Monday July 13 meeting at the NAE Keck Center. He introduced the fellows to the National Academies and their purposes: to address critical national issues and to give advice to the federal government and to the public. He also reviewed current projects within the NAE that focus on engineering education, both K-12 and higher education. Patti Curtis, Managing Director for Washington Office of the Museum of Science, provided the fellows with an overview of the legislative appropriations process and the importance of advocating for engineering and technology education with legislators. Julia Ross, PI of the INSPIRES Curriculum project at the University of Maryland Baltimore County, led the fellows in a lively discussion about current research with high school technology education teachers, professional development models, and engineering design. On Tuesday, July 14, the fellows also had an opportunity to meet with NSF program officers at the NSF building and to learn more about the funding opportunities. David Ucko, Elizabeth VanderPutten, Sylvia James, and Susan Kemnitzer provided overviews of programs for which they are responsible and gave well-founded advice to the fellows about successful approaches to the preparation of proposals, establishing relationships with programs and personnel at NSF, and the management of their personal research agendas as they begin their careers.

Goal Three Activities: Communications

Communications initiatives designed to reach external audiences include the NCETE web site as well as conference presentations, poster sessions, and publications in the scholarly and professional journals. Internal communication relies heavily upon e-mail messages and conference telephone calls, in addition to the distance delivery of instruction to the fellows at the four doctoral sites. The NCETE web site, <http://www.ncete.org> was reorganized to present the expanded content effectively and a program of continuous updating was initiated. It is

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

National Center for Engineering and Technology Education
Year Six Findings Report

Major NCETE Findings: 2009-2010

Significant outcomes of the year feature strengthened research activity including: completion of doctoral dissertations; postdoctoral studies; internally supported research by faculty, graduate students, and collaborators; conference presentations; and publications related to Center work.

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 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.

Additional evidence that NCETE is building capacity within the K-12 engineering and technology education field is provided by the number of journal articles and conference presentations made by NCETE collaborators since the inception of the Center in 2004. The section, *NCETE Capacity Building*, provides a listing of each Center collaborator's scholarly work. The internal grant process designed to support intensive scholarly endeavors was a successful capacity-building endeavor. Five of the internally-funded studies contributed to the development of formal proposals to NSF programs during 2010. Several investigators are in various stages of preparing manuscripts for submission to journals in the field.

Linkages with the engineering education community continue to grow. NCETE partners have been invited to present findings to the National Academy of Engineering Committee on K-12 Engineering as part of their two-year study entitled *Understanding and Improving K-12 Engineering Education in the United States*. In addition, Ken Welty's complete review of K-12 engineering curricula is included in a CD attached to the final report. An increasing number of NCETE personnel are actively involved in ASEE, particularly its K-12 Division. There is also an increase in collaboration between engineering educators and technology teacher educators on several of the NCETE campuses.

This year the professional development effort focused on participant follow up to determine the classroom implementation of the year five professional development effort where teams of science, technology and mathematics teachers were recruited and introduced to engineering design. Teachers planned for a general shift in responsibilities as students progressed through a design challenge. In the early stages of the design process, teachers had the majority of responsibility for identifying the need

and defining the problem. Student responsibilities increased as they conducted analysis planned by the teachers.

One of the significant outcomes of the NCETE work with professional development is the difficulty teachers and PD leaders face in finding, adapting, or creating authentic engineering design challenges. Student background, teacher background, classroom resources, fit within a particular curriculum, and assessment of learning outcomes are challenges teachers face as they include engineering design challenges in their classrooms.

The report of the NCETE external evaluator at the conclusion of year five provided substantial evidence of the effectiveness of the common core of instruction to supplement the existing doctoral programs at the respective institutions. NCETE is building upon the success of the common core of instruction by hosting an exploratory meeting to examine the feasibility of developing a strategic alliance of doctoral-granting institutions interested in sharing courses. The initial response from five institutions was positive with general agreement that small doctoral programs can leverage resources and expertise through the formation of an alliance.

Report on Evaluation Activities for Year Six of the National Center for Engineering Technology Education

Submitted to NCETE Management Team by
Jim Dorward, Evaluation Consultant

May, 2010

Abstract: The internal evaluation activities during Year Six of the NCETE project consisted of an examination into the effectiveness of the seed grant program, an assessment of the influence of Center activities on partner institutions, and an ongoing review of the management team's responsiveness to changing conditions in the field and feedback from stakeholders. Evaluation methods included a content analysis of seed grant proposals and reports, formal interviews with seed grant recipients and project leaders, and observations of management team meetings. Findings suggest that the seed grant program was successful in stimulating innovation and continuation of valued Center activities. There is also evidence that the Center continues to be responsive to changing conditions in the field. However, there was some concern expressed by leaders at partner institutions that Year Six Center activities were not as timely or inclusive as in previous years. Lastly, there was evidence that the Center has had some influence on structure and programming at partner institutions, although further substantiation of this finding is recommended. Additional recommendations include continuation of the doctoral and seed grant programs to the extent possible.

BACKGROUND AND METHODS

Evaluation of National Center for Engineering Technology Education activities is intended to provide information to the management team for program improvement. Major project components of Year Six included a seed grant program intended to expand influence of the Center beyond the funding period, continuation of the second doctoral fellowship program cohort, ongoing dissemination of project activities, and development of a self-sustaining alliance of engineering education doctoral granting institutions.

The internal evaluator coordinated Year Six evaluation objectives, questions, and activities with representatives of Inverness Research, the external evaluation agency. The evaluation plan, identified at the beginning of Year Six, is outlined in Table 1.

Internal Evaluation Questions and Methods

The questions that guided the NCETE Year Six internal evaluation were:

1. To what degree has the seed grant opportunity stimulated innovation within and beyond the Center? In order to answer this question, the internal evaluator conducted a content analysis of the seed grant request for proposals, the original proposal submissions, and final reports for funded projects. The content analysis focused on determining the degree of alignment between the proposal and the project, and use of evidence-based approaches to assess project outcomes.

Table 1: NCETE Year 6 Internal Evaluation Plan

Research Question	Outputs	Evaluation Strategies	Timeline
To what degree has the seed grant opportunity stimulated innovation within and beyond the Center?	Description of seed grant program, awards, and outcomes from the perspective of partners and evaluator.	Mini-case studies of a representative sample of seed grant awardees.	Interviews conducted Fall, 2009 and Winter, 2010. Report due in early April, 2010.
To what degree has the Center been effective in adapting to changing expectations; modifying its mission, goals, and program of work; and its capacity to reposition goals and activities for making valued contributions? How have activities influenced concern about the future of the profession?	Timeline of major center activities and publications and alignment of evaluation findings with major decision points.	Analysis and interpretation of center archives and interviews with leadership team members.	Analysis of center records and development of timeline in Summer and Fall, 2009. Dissemination of timeline in December, 2009. Interviews conducted Fall, 2009 and Winter, 2010.
How have NCETE activities influenced change at partner institutions? How have activities influenced ETE teacher preparation?	Descriptive comparison of ETE activities before, and since, NCETE inception.	Interviews with leadership team members and selected academic leaders at partner institutions.	Interviews conducted Summer and Fall 2009.
To what degree has the Center's organizational structure reflected prevailing perspectives on organizational theory?	Interpretation of alignment between Center structure and organizational theory.	Review and interpretation by panel of experts on organizational theory.	Panel review conducted in Fall 2009.
How has the NCETE Doctoral Program contributed to the development and maintenance of an appropriate balance between research and practice?	Interpretation of the NCETE doctoral student program as part of IRA's evaluation plan.	Mixed method, longitudinal analysis conducted by IRA.	Report due Spring, 2010.

Formal interviews were conducted with representatives of the funded seed grant projects in order to further assess implications of the project.

2. To what degree has the Center been effective in adapting to changing expectations; modifying its mission, goals, and program of work; and its capacity to reposition goals and activities for making valued contributions? How have activities influenced concern about the future of the profession? Information used by evaluators to answer these questions was obtained through observation of weekly management team meetings, and follow-up interviews with six engineering education leaders from partner institutions and stakeholder groups.
3. How have NCETE activities influenced change at partner institutions? How have activities influenced ETE teacher preparation? Answers to these questions were obtained from information gathered from formal and informal interviews with leaders at the partner institutions.

FINDINGS

The first evaluation question assessed the degree to which the internal seed grant program stimulated innovation within and beyond the Center. The purpose of the seed grant program was to support projects that would lead directly to submission of one or more major proposals for research aligned with the mission and goals of NCETE. (See Appendix A for Seed Program proposal request). Six seed grant projects were funded by the Center in the summer of 2009 (Custer, Kelley, Lawanto, Shumway, Stricker, Wicklein). The following table lists the proposed purpose and methods for each project.

Table 2: 2009-10 Seed Grant Studies Supported by NCETE

Investigators	Purpose	Methods
Rodney Custer, Jenny Daugherty, Joe Meyer.	To identify and refine a conceptual foundation for secondary level engineering education.	A literature review and a set of structured focus group sessions with engineering educators and practicing engineers.
Todd Kelley, Daniel C. Brenner, Jon T. Pieper	To better understand the current status of engineering-focused curriculum programs at the high school level and their impact on student learning	Mixed methods including content analysis, observations, a survey, and performance assessments.
Oenardi Lawanto, Gary Stewardson,	To better understand how different approaches to solving an engineering design problem impact students' motivation.	Program evaluation using pre-, post-survey research.
Steven Shumway, Geoff Wright	To identify criteria teachers and districts use when selecting engineering design experiences for infusion into high school classes, which of these criteria are most effective, and constraints to infusing engineering concepts into technology education.	Case study using interviews and classroom observations
David Stricker	To examine a program to teach science and math concepts via problem solving and engineering	Case study using semi-structured interviews with the engineering instructor

Robert Wicklein, John Mativo	To compare learning and attitudinal effects on two engineering design instructional strategies.	Experimental study using randomly selected 11 th and 12 th grade students.
---------------------------------	---	--

Each of the resulting seed grant projects were well-aligned with the purpose and methods as described in the proposals. This was due, in part, to revisions requested by the management team prior to funding the proposed projects.

Findings from the seed grant projects were appropriately documented and, in most cases, had implications for either engineering education practice or future research. Table 3 provides a brief summary of the findings and implications. Final reports for each of the seed grant projects can be found at: http://ncete.org/flash/publications_rete.php

Table 3: 2009-10 Seed Grant Findings and Anticipated Outcomes

Investigators	Findings	Outcomes or Implications
Rodney Custer, Jenny Daugherty, Joe Meyer.	Conceptual consistency was observed across the study's five major inputs. Ten of the thirteen concepts were represented in all five inputs and two additional concepts were represented in four of the five inputs. Collectively, this represents strong cohesion across the materials reviewed. It is also clear that considerable conceptual overlap and interaction exists among the concepts. For example, many, if not most, of the concepts represent elements or aspects of the engineering design process. This conceptual overlap makes sense given the interconnected nature of engineering design. Also, functionality and efficiency are key engineering constraints.	Contextual issues can significantly impact educational policy at the pre-collegiate and post-secondary level given growing calls for reform in engineering education. Additional areas that warrant investigation include the possible need for K-12 engineering standards, curriculum, and teacher pre-service and professional development. The central premise of this study is that these issues are best addressed after the conceptual foundation has been carefully and thoughtfully developed.
Todd Kelley, Daniel C. Brenner, Jon T. Pieper	Participants in the <i>EPICS-High</i> program were more solution-driven problem solvers, while the <i>Project Lead the Way</i> participants were generally problem-driven. Although the participants in both groups had completed advanced courses in mathematics; mathematics was rarely employed to describe constraints of the problem or predict results of proposed solutions. Over half of the students became fixated at some point on the provided picture.	This study provides important insight about how students solve ill-defined problems, providing vital information for technology education as it seeks to implement engineering design.
Oenardi Lawanto, Gary Stewardson,	Students' intrinsic goal orientation was significantly higher on bridge design than marble-sorter design. Students who planned to major in engineering or technology education were more motivated when working on the two design activities than those whose majors were in other areas. Students' extrinsic goal orientation did not appear to be correlated to their IGO, task value, self-efficacy for learning and performance, or control belief.	Potential topics for future research include answering a general question like: How does student motivation influence the cognitive processes during engineering design activities? This question may lead to several more specific questions, including what meta-cognitive and task process are employed when addressing design goals.

Steven Shumway, Geoff Wright	It is imperative that teachers have a passion for technology beyond subject expertise and be willing to include contemporary techniques, tools, processes, and issues courses. Teachers need to help administrators understand the need to have contemporary technology education programs focused on engineering. Teachers need to be aware of contemporary technology and engineering education issues, trends, processes, techniques, standards, and tools. There will be obstacles when making the transition to technology and engineering programs, however, they are limited to issues of facilities, administrative concerns, teacher training, and pedagogical issues.	Findings suggest that teachers who are in the transition from traditional technology education to teaching contemporary technology and engineering focused education classes will need professional development to help familiarize them with the current technology and engineering learning objectives, standards, trends, issues, and curriculum. Additionally they will need administrative support from both site and district administrators for training, equipment, and supplies. In light of these findings, national efforts of ITEA and other organizations need to be better promoted in order to educate teachers about current trends, issues, standards, and possible grants in technology and engineering.
David Stricker	Teachers need to have firm conceptual understanding of the content they aspire to deliver, need to “think big”, and need to be at ease with the creative process and the ambiguity involved in learning new content and contemporary technology. Administrative support for program development relies as much on the teacher’s record of solid instruction and demonstrated student learning as upon available financing.	Teachers interested in creating and delivering deliver engineering need to begin the process with clear thinking relative to a conceptual framework they would deliver to students. Obstacles to successfully developing and implementing a naturalistically developed engineering curriculum can be addressed by establishing administrative support and gaining business and industry instructional and financial support
Robert Wicklein, John Mativo	The amount of time dedicated to the instruction program was very limited, but findings from this research indicated no difference between groups on scores as measured by the Engineering Design Test.	Application for presentation from this research has been submitted to CTTE and has been accepted for the 2010 ITEA conference in Charlotte, NC.

Respondents who received seed grant funding made the following comments when asked about how the support stimulated innovation within and across their institutions:

Our work will have an impact on the field because it pulled together a lot of foundational materials and provides a concise ontological framework. It can be used as a springboard for development or how to teach engineering.

Doing the seed grant project has been a great opportunity to address a high interest research objective that wouldn’t necessarily be something that I could do otherwise. It was a really good thing for me personally.

We are submitting a proposal to CCLI that builds on our seed grant findings. We now have data that we can use in the study that we will be proposing. There isn’t a lot of research in this area, so we have a pretty good opportunity for funding.

I am in the process of submitting my report for publication. I have plans for three articles that have implications for engineering education nationwide. There are a lot of contradictory studies, so what we have done will be really interesting.

I've put together an MSP proposal with people in science education using results from this work as evidence of my experience with specific methodologies. I feel that we have a very good chance with that proposal.

This was a huge opportunity to interact with ETE colleagues and disseminate results to the broader community. This award helped me to learn about how to put a proposal together, the IRB process, and the submission processes.

In summary, **the seed grant program has positively influenced innovation at both individual and institutional levels.** Every seed grant recipient identified implications of supported research for future and pending externally funded proposals, journal articles, and presentations at national conferences.

The second evaluation question examined Center effectiveness in adapting to changing expectations; modifying its mission, goals, and program of work; and success in repositioning goals and activities in order to make valued contributions. An additional question *examined how Center activities have mitigated widespread concern about the future of Engineering Education.*

Project activities in 2009-10 reflected modifications to Center mission and goals from 2006. During the summer and fall of 2006, the National Center for Engineering and Technology Education (NCETE) developed a new mission and goals statement in response to suggestions from the staff, the evaluators, and the reverse site visit at the National Science Foundation. The revised mission was to build capacity in technology education and increase research on the learning and teaching of high school students and teachers on engineering design processes. The modified goals of the Center were:

1. To conduct research to:
 - a. define the current status of engineering design experiences in engineering and technology education in grades 9-12;
 - b. define an NCETE model for professional development by examining the design and delivery of effective professional development with a focus on selected engineering design concepts for high school technology education;
 - c. identify guidelines for the development, implementation, and evaluation of engineering design in technology education.
2. To build leadership capacity by developing a collaborative network of scholars who work to improve understanding of the process of learning and teaching of engineering design in technology education.
3. To establish and maintain a communication program to inform all stakeholder groups of NCETE activities and accomplishments

These revised goals focused on developing a collaborative network of scholars with the knowledge and skills and to advance technology and engineering education by creating and fostering a research-rich environment. In essence, the revised goals de-emphasized building capacity in pre-service and in-service education, and emphasized knowledge generation within engineering education.

Center activities related to the three goals that were undertaken during Year 6 included:

Goal 1: Research activities:

- Ongoing and pending dissertation studies
- Postdoctoral research associate activities included a study of team approaches to engineering design (Denson, Mentzer, Park, Lammi), and development and pilot testing of an instrument to assess self-efficacy and interest in engineering (Austin, Denson).
- Internal research awards – Custer, Kelley, Lawanto, Shumway, Stricker, Wicklein
- Professional development follow-up studies – Childress/Lipton; Avery; Daugherty
- Becker/Mentzer DR K-12 project activities
- Engineering design challenges for high school students
- Release of NAE Study and NCETE's role in the study: (Welty, Custer, Daugherty, Householder)
- Publications (best year since NCETE inception)
- Development of NCETE-MAE research team

Goal 2: Leadership Capacity building activities:

- Placement of Ph.D. graduates and Postdoctoral Research Associate
- Postdoctoral Research Associates: Austin; Denson
- Cohort Two Washington DC Meeting

Goal 3: Communication and Dissemination activities:

- Weekly staff meetings
- NCETE web site upgrading and updating
- Publication support in preparation and revision of manuscripts
- Presentations at ITEA, ASEE, other conferences
- Conference participation including NCETE booth at ITEA
- Interactions with MESA
- Spring Seminar for graduate students at multiple universities
- April 30 Focus Group and Planning Session

Among evidence of Center responsiveness and adaptation during 2009-10 is an associated DRK-12 exploratory project addressing the program challenge of assuring that all students have the opportunity to learn significant STEM content. This project, entitled *Exploring Engineering Design Knowing and Thinking as an Innovation in STEM Learning* was funded by the National Science Foundation in 2009. The goal of this project is to clarify engineering design as a construct and perform empirical preparatory research on engineering design as a STEM learning experience for high school students. This goal clearly falls within the NCETE mission of building capacity to infuse engineering analytical methods and design content into 9-12 schools through technology

education. The project activities seek to understand how high school student engineering design thinking compares to that of experts in terms of engineering design performance and knowledge with respect to:

1. Time allocation across essential elements in the design process,
2. Transitions between elements in the design process,
3. Generation of alternative solutions,
4. Prioritization of design activities, and
5. Congruence between prioritization and practical application.

Findings from this study will situate high school learners on a continuum from novice to expert utilizing the learning sciences as participants demonstrate their understanding of the engineering design process. This positioning will inform developers of instructional materials and curricula, teachers when planning classroom strategies, and designers of initiatives in formal education.

A second proposed project, targeting NSF's ITEST program, is *Energy, Water, and Air Engineering Design Challenges in Cache County Utah*. In this Strategies Project, faculty from College of Engineering at Utah State University (USU) will work with Cache Valley Mathematics, Engineering, Science Achievement (MESA) chapters to introduce secondary students to engineering activities and engineering design challenges related to local environmental issues. If funded this project will extend recent NCETE research efforts by investigating the development of appropriate engineering design challenges and studying the introduction of engineering design experiences in a setting that bridges formal and informal education experiences. Projects and challenges developed within the scope of this project would be disseminated on the NCETE website.

A third proposed project building on NCETE research and development targets NSF's DRK-12 program and is entitled *The Influence of MESA Activities on Underrepresented Students*. If funded, this exploratory research project will examine the effect of student-oriented MESA activities (e.g., field trips, guest lecturers, design competitions, hands-on activities, and student career and academic advisement) on career interests in engineering.

Additional evidence of repositioning for prospective future contributions included a Spring 2010 offering of a Research Seminar designed to expose graduate students to current research surrounding engineering and technology education and create a network for faculty and graduate students. Students from Colorado State, the University of Georgia, the University of Illinois, Virginia Tech, and Utah State participated in the seminar. The seminar has, in part, stimulated an interest in seeking a new strategic alliance of Institutions of Higher Education focused on a possible doctoral level curricular joint venture.

The Center subsequently sponsored a meeting on April 30, 2010 of engineering education leaders charged with considering the benefits and challenges associated with a doctoral level curricular joint venture. This venture would develop and sustain a collaborative doctoral program, which would build on the model implemented by NCETE. The

meeting resulted in a set of goals, assumptions, benefits, challenges, structures, and outcomes of a potential alliance. There was widespread support for this venture and a high level of commitment among the attending leaders. The NCETE management team will be submitting a proposal to NSF that will seek support to further develop and initiate this venture.

Respondents to interviews (See protocol in Appendix B) had the following comments with respect to the influence that the Center has had in positioning itself for positive contributions to the field, and mitigating concerns about engineering education:

The management team was responsive to changing expectations. We were a little slow in recognizing problems and not as firm as we needed to be in order to get what we needed out of some of the institutions. Some institutions were just taking the money and not contributing as much as they could have.

NCETE helped to revitalize our program. It has brought a couple of the faculty into the engineering education fold. It has provided other research opportunities for some of the faculty and brought in some additional graduate students. It has provided closer connections with some key faculty in engineering.

The five teacher education institutions got off to a good start. The problem there was they did their own thing and never agreed on a common model, which I think hurt us. I think we lost quite a lot from those five institutions and what we could have learned from the professional development. We never came out with a national PD model that we had hoped to when we got started.

The continuation year is a little disappointing because there is little going on with the Center. They are running a doctoral seminar, but there are no conference calls. We've got continuation for students, but no support for faculty.

I'm not sure that I see a direct impact of NCETE nationwide. While there is a Center, I do not see specific outcomes that have been implemented nationwide. One great thing was the doctoral student program, and it is good to see them out there. I hope that they become teacher educators as well as good researchers. It was productive for us to interact with colleagues across the country.

The Center has a lot of influence on fundamental core issues that no one else has addressed. How kids learn about engineering, why it's important, and what kids should learn about engineering; and they've developed these courses around some of these ideas. I think there is a mindset around a theoretical perspective in our area that there wasn't as much before the Center.

As I look back on the five years, the first two were very useful. Being part of the center brought us some recognition and validated the work that we've done. The next two years were frustrating for us, as it didn't seem that we made any progress on professional development. The last year with the seed grants has been a positive influence. We have done some things with schools that have been productive.

I did not have direct interaction with NCETE until 2006, but I have a closer relationship with the Center now. The most valuable moment was when we participated in regular

Center meetings. We do not have them now – I don't know why – but in 2008-09, we had several meetings that were very fruitful. We got a chance to meet people and get to know them, but we brainstormed and learned a lot about proposals and how to write good proposals. This interaction among faculty within the Center was probably the most important value.

In summary, there is evidence that the Center has adapted to changing expectations; modified its mission, goals, and program of work; and been involved in activities that re-position itself for future contributions to field. At the same time, there were some respondents who believe that the Center has not fully realized its potential for influence within the field of engineering education. During Year 6, the Center was involved in many activities directly aligned with modified goals. These included the support of post-doctoral researchers, continued support of the second doctoral student cohort, development of several grant proposals that built on important Center research activities, and ongoing dissemination efforts. Several of those who were interviewed expressed dissatisfaction about the pace at which the Center responded to changing expectations from the funding agency, lack of timely consensus building among the teacher education partners in previous years, and the apparent discontinuation of regular communication across partner institutions.

*The third evaluation question **addressed** a more summative approach regarding **the influence that NCETE activities have had on change in Engineering Education at partner institutions.*** The following comments from leaders at partner institutions reflect an initial examination into this question. The external evaluator is also pursuing related questions and will present related findings at a later date. Respondents had the following comments when asked how NCETE activities have influenced structure and programming at partner institutions:

I don't think NCETE has had a great influence at our institution because we don't have an undergraduate teacher education or technology education focus. We don't train future technical education teachers, so that wouldn't impact us that much. I think people in STEM would be interested in seeing what they came up with because people do want a little more agreement on what the implications are for engineering education.

Things have changed over the five years. We've brought in two good groups of graduate students and they've done some good things. They have all been well prepared and have added to our credibility as a program within our institution.

The NCETE model for doctoral programming is sustainable if the individual institutions can support the students. It is just great having a team of students working on similar projects.

I think the biggest impact of the Center is the number and quality of the doctoral students. It has had a great impact in our program and will continue to have a great impact down the road.

I think the cross-institutional core course component was important. We had exposure to broader expertise, developed relationships with students at other institutions. It was nice

because there aren't very many graduate students in engineering education across the country.

I usually have a couple of publications a year, but I have not done a major research proposal in 17 years. But, being involved in NCETE has given me the interest to pursue a proposal. I'm not sure how it will be received, but at least I'm going through the process.

It has been very productive for us to be involved with colleagues at other institutions. I don't know that we've gained super prestige from our involvement in NCETE from our own university, but it validated us in the eyes of my colleagues within the college.

The impact of Center involvement at our institution has been good. It has brought our program some recognition and validated our programming.

NCETE has had a direct impact on our institution and programs. We have examined both our curriculum and our facilities. I have used this information as I prepare students in our technology education program.

I think places that have undergraduate teacher education or technology education would more likely see the impact of the Center. We don't train future technology education teachers, so that wouldn't impact us that much.

While the interviews provided **some evidence that Center activities have had a positive influence on structure and programming at the partner institutions**, much more needs to be done to substantiate this finding.

RECOMMENDATIONS

Based on findings from ongoing internal evaluation, the NCETE Management team should consider the following recommendations:

- 1) Further investigate and substantiate the influence of Center structure and activities on innovation and change within the field of Engineering Education. There is some empirical and anecdotal evidence to suggest that Center activities have had a direct influence on positive change within the field. A future report on this issue will be forthcoming from the external evaluator.
- 2) Continue support for seed grant program to the extent possible. This program has produced relevant research of importance to engineering education, and stimulated innovation. Clearly, careful oversight of the proposal development, implementation, and reporting has contributed to the success of this program.
- 3) Continue support for the second doctoral cohort program to the extent possible. This program component is widely recognized as a strength of the Center and there is strong interest in developing and sustaining an associated curricular joint venture.

APPENDIX A: 2008-2009 NCETE Seed Grant Program
Request for Proposals

The National Center for Engineering and Technology Education (NCETE) invites proposals for research to further the research mission of the Center. The NCETE mission and goals are available at <http://ncete.org/flash/about.php>

The program of work to be supported by each proposed project should lead directly to the submission of one or more major proposals under NCETE auspices with the intent of obtaining long-range support for a significant area of research within the mission and goals of NCETE.

Seed grants are intended to support intensive scholarly endeavors over a period of 6 to 12 months during the period ending August 31, 2009.

Funding for individual seed grants is expected to range from \$10,000 to \$45,000 for total direct and indirect costs, including released time or summer salaries for faculty, support for graduate students, travel, equipment, and supplies. A 10% cost-share is required.

Proposals for seed grants will be accepted from NCETE fellows, including recent graduates; individual faculty members at NCETE institutions; or teams of faculty members, which may include collaborators from institutions outside NCETE.

Proposals are due to NCETE September 10, 2008.

The ten-page description of the proposed project should:

- Specify the objectives of the proposed research.
- Describe the significance of the research area to the NCETE mission and goals.
- Summarize the current body of knowledge and practice in the area under investigation.
- Specify the theoretical foundations for the work.
- Identify the participant(s) to be supported by the proposed seed grant.
- Synthesize any relevant completed preliminary work.
- Identify the funding agencies and programs to be targeted by the major proposal(s) as a result of the seed grant.
- Estimate the cost and duration of the major research effort(s) to be proposed by the recipient(s) of the seed grant.
- Describe pilot studies or preliminary research to be undertaken under the auspices of the seed grant.
- Include a timeline listing major steps involved in the preparation of the major proposal(s) and the relevant submission deadline(s).

In addition, the proposal should:

- Identify senior personnel to be invited to participate in the major proposal(s) and indicate their specific qualifications for the anticipated assignments using the

attached two-page format for biographical sketches (Attachment 3). A sample biographical sketch is also included (Attachment 4) to provide a model for format consistency as these documents are prepared.

- Provide a budget request for the proposed seed grant using the budget template (Attachment 5), which is based on the NSF approach to budgeting.
- Provide a one-page budget justification linking the expenditures to accomplishment of the objectives of the project.

Reviews

Seed grant proposals will be reviewed by experienced researchers from outside NCETE, who will be asked to base their comments on these criteria:

- Clarity of the purpose of the proposed research
- Theoretical base for the study
- Adequacy of the literature review
- Realism of the plan of work
- Overall quality of the proposed study
- Contribution of the programmatic research toward the NCETE research goals
- Cost effectiveness and realism of the proposed budget.
- Estimated likelihood of obtaining major funding based on the work accomplished under the seed grant.
- Probable contribution of a successfully funded major research effort to the national role of the Center.

Recommendations of the reviewers will guide the award decisions to be made by the Management Team and announced October 15, 2008.

NCETE personnel who are considering the submission of a proposal should participate in the informational teleconference to be held August 15, 2008. Teleconference participants will have an opportunity to raise questions and seek clarifications at that time. To participate in the teleconference, call in at 10:00 a.m. MDT August 15, 2008:

Dial 1- (866) 258-0959

Room Number *3047224* (The asterisk must be entered before and after the number.)

APPENDIX B: Internal Evaluation Interview Protocol

Sampling: Seed grant recipients, Partners, Stakeholders, on-site Leaders

To what degree has the seed grant opportunity stimulated innovation within and across the Center?

Tell me about your seed project.

How do your activities build on prior research?

How do you see your seed project informing ETE nationwide?

What plans do you have for dissemination and/or follow-up to your seed project?

How has your seed grant contributed to advancements in engineering design?

Contact information for knowledgeable seed project stakeholders:

How has the (seed project) influenced you and/or your organization?

To what degree has the Center been effective in adapting to changing expectations; modifying its mission, goals, and program of work; and its success in repositioning for prospective future contributions? How have activities influenced the concern about the future of the profession?

Describe your initial expectations for the NCETE Management Team.

How has the NCETE Management Team met those expectations?

How have expectations for the NCETE Management Team changed over the lifespan of the project?

Describe the future of ETE at your institution. Nationwide.

How have NCETE activities influenced change at partner institutions? How have activities influenced ETE teacher preparation?

Describe changes in ETE at your institution over the last five years.

How has NCETE affiliation influenced those changes?

What has been the NCETE Management Team's role in building and sustaining viable doctoral programs at partner institutions?

Inverness Research
Update on Summative Evaluation
National Center for Engineering and Technology Education
August 2010

Inverness Research has evaluated three NSF-funded Centers for Learning and Teaching. 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.

As of this writing, Inverness is in the process of writing two reports reviewing the work of the Center over its history, along two key dimensions. One report focuses on the efforts of the Center in terms of *Leadership Development* and the other report focused on the contributions the Center has made in terms of *Knowledge Generation and Flow* (i.e. developing, conducting, and communicating research). Drafts of both of these reports will be available in August of 2010.

What follows is a brief description of each report, to provide an overview of the evaluation work that has been done to date and the nature of the findings that will be reported.

1) Research (Knowledge Generation and Flow) report

Introduction

The primary audiences for this document are: Center leadership, 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. Here, Inverness highlights the important features of the NCETE research initiative. We provide an overview of the Center’s various research initiatives, as well as present a variety of perspectives on the efficacy of those initiatives.

Data sources and methods

Our data sources and collection methods for this report were:

- 1) Interviews (three) and surveys (two) of doctoral students, regarding their research experiences

- 2) Observations of research symposia and meetings
- 3) Interviews with Center leadership about the history of research in the field
- 4) Interviews of faculty members in '08 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 field experts to comment on their perspectives on the contribution of the center to the field, including research
- 8) 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.

Goals for research strand

We begin this report by presenting the goals for the NCETE research strand (as identified by the leaders of the Center):

- 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.

Research initiatives of NCETE

The Center designed its research work around several components: the funding of the research, the support of doing it, and then disseminating and sharing it. We review the four different research initiatives that the Center undertook.

Doctoral program. NCETE provided funding for doctoral students to complete their dissertations, once their committees had approved of the topic area and research plans. University of Minnesota, University of Illinois at Champaign-Urbana, Utah State University, and University of Georgia.

Internal grant program. 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 have been completed.

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 conference. Each year, prior to the annual meeting of the International Technology Education Association (ITEA, now called ITEE for International Technology and Engineering Education Association), NCETE hosted a meeting for those students and faculty involved in the Center’s research and professional development efforts.

Perspectives on the research

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, it is likely that 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.

The bulk of this report will consist of perspectives on the research efforts of NCETE, including all of our data sources described above. We will present perspectives on NCETE’s research efforts, along four key dimensions: 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.

The strengths of the NCETE research efforts include that the Center has contributed a substantial number of research products, some of which external reviewers felt “laid an important new research base within the field and assured that the findings and methods are communicated in a broad context and to a large audience.... The knowledge generated within these manuscripts and conference proceedings will be referenced and used to build on for years to come.”

The research initiatives of the Center also created a context for connecting professionals from different institutions within different fields (e.g. technology education from a variety of campuses, and technology and engineering

educators from around the country). These collaborations were often useful and productive, often 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.

NCETE created and increased the capacity of individuals across the Center for designing and conducting research. While some external reviewers suggest that the methodologies and analyses might still not be on par with those found in science education or math education research, they agree that the Center has built the capacity of the field to do more rigorous research in the future.

This report will conclude with Inverness' perspectives on the research contributions of the Center and potential implications for future work and funding.

2) Leadership Report

Introduction

The primary audience for this document is Center leadership and funders of future leadership development projects. In this report, Inverness reviews NCETE's approaches to and activities for developing leadership among its students, faculty, and community.

Data sources and methods

Our data sources and collection methods for this report were:

- 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

The final report will include the following sections, supported by multiple data sources, types, and analyses.

Leadership development initiatives of NCETE

The Doctoral Program. Doctoral students were admitted to 4 universities participating in the Center: University of Minnesota, University of Georgia, Utah State University, and University of Illinois, Champaign-Urbana. Each university offered different programs for eligible students.

- [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.

A key component of the doctoral program for the Center was the creation of four core courses. These courses were meant to provide a unifying learning experience for the Fellows, fill gaps of university programs, reinforce the NCETE mission and message, and provide exposure to Center faculty. The core courses received mixed reviews from the students over the years. Faculty teaching and overseeing the courses responded to student input and attempted multiple improvements.

The Cohort model 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 addition to the core courses and cohort model, there were many other doctoral program experiences that were intended to build leadership, such as NSF 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 confidence and skills in leadership.

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.

Faculty Leadership. There was a range of faculty involved in the Center, and they participated in different ways and capacities (research, professional development leaders, graduate advising, etc.). Interviews with faculty and field experts external to the Center provide evidence of the ways NCETE added value to their professional trajectory and provided new opportunities for them to make contributions to the field.

Progress and challenges

Here, Inverness will reflect on the progress made by NCETE to develop leadership through a variety of means. We also discuss the challenges the Center faced, in terms of developing leadership among its students and faculty. There are renewed efforts in the field to address engineering as a central aspect of technology education (e.g. 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. There is some evidence that suggests the Center made some headway in developing leaders, and provided one high profile university program in particular – Purdue – with new faculty that are committed to the vision.

Finally, we will present Inverness' perspectives on the leadership development efforts of this particular CLT and discuss potential implications for future work and funding.