6-2009

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

NCETE Faculty

Year Five Annual Report

Activities, Findings and Evaluators' Reports

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National Center for Engineering and Technology Education

Activities Report
Year Five: 2008-2009

Activities Outline

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

I Background

The National Center for Engineering and Technology Education (NCETE) received funding from the National Science Foundation on September 15, 2004. Originally NCETE proposed the following goals for the Center:

- To build capacity in graduate education and develop a new cadre of leaders who are engaged in research, teacher preparation, and professional development with the knowledge and skill to integrate engineering into technology education
- To conduct research in how students learn engineering and technological concepts; how students learn design and problem solving, assessment and evaluation strategies; and how best to prepare technology teachers
- To refocus technology teacher education (TTE) to prepare increasing numbers of new teachers, representing the diversity of the nation, who can infuse engineering principles, predictive analytical methods, and design into the K-12 schools
- To design and deliver professional development for practicing K-12 teachers and TTE faculty to enhance their knowledge and skills so they can infuse engineering principles, predictive analytical methods, and design into the curriculum, thereby enhancing problem solving abilities in students.
- To develop methods for encouraging a diverse array of K-12 students to choose science, technology engineering and mathematics careers.

The Reverse Site Visit (RSV) presentation by the Center team at NSF May 1, 2006 generated a generally positive response from the CLT program officer, who noted our success in incorporating engineering into technology education, the progress of the cohort of Fellows toward becoming a leadership cadre in the field, and the research emphasis accomplished in the doctoral program. We were, however, asked to focus and prioritize our mission and goals, to align the research framework more closely with the revised Center goals, and to strengthen the plans and protocols for the evaluation of the work of the Center.

The Center submitted its RSV response to NSF on October 30, 2006. Included in our response was a revised NCETE mission and goal statement, stated below. The mission and goal statement has guided our work since the RSV and provides the framework for this report.

a) NCETE Mission

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

b) NCETE Goals

The goals of the Center are:

1. To conduct research to:

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

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

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

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

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

II The Shift to Research

The original NCETE goal pattern assigned primary responsibility for research to the graduate students, with only minor interest in supporting small internal awards to faculty members as well. That early vision anticipated that the dissertations of the doctoral fellows would provide the majority of the scholarly research output over the life of the Center. Following the RSV, the Center worked to increase the priority assigned to research.

One of the major research efforts to define the current status of K-12 engineering education involved the preparation of a commissioned paper for the National Academy of Engineering committee working on DR-K12 Award 0733584. NCETE provided part of the support for the work of Kenneth Welty, who reviewed existing K-12 engineering education curriculum materials and prepared a report that will be published as a CD-ROM in conjunction with the published committee report. Several of the doctoral fellows were also involved in the early stages of that research effort.

To further the research mission of the Center, we initiated an internal grant process. The internal grants were intended to support intensive scholarly endeavors over a period of 6 to 12 months. Center members were encouraged to submit proposals for research studies that aligned with the Center goals. Proposals were screened by Center management and the more promising proposals were reviewed by an external panel. Start-up grants were also provided to support the research of NCETE Ph.D. graduates as they began university faculty positions.

Another effort to achieve the NCETE research goals focused on hiring post-doctoral research associates. Two of the NCETE doctoral graduates were interested in a post-doctoral research experience and were hired by the Center for a two-year program. Nathan Mentzer, a doctoral fellow from Utah State University, and Cameron Denson, a doctoral fellow from the University of Georgia, began their post-doctoral work in August, 2008. They were offered a two-year commitment from NCETE. The post-doctoral research associates were mentored by Daniel Householder, Kurt Becker and Christine Hailey.

The University of Minnesota hosted the May 2008 NCETE meeting, which featured the on-going research activities of graduate students in the four doctoral institutions in the Center. Graduate students from Colorado State, Ohio State, Tufts, and Virginia Tech Universities were also invited to participate in the formal presentations of their research activities. The twenty presentations appear in the *Proceedings of the Conference on Graduate Student Research in Engineering and Technology Education,* available on the NCETE web site at http://ncete.org/flash/pdfs/RETE%20Proceedings.pdf.

The March 25, 2009 NCETE research seminar, which was held in Louisville, Kentucky prior to the ITEA Conference, provided a comprehensive look at Center-supported research in professional development. This session began with a retrospective synthesis of the published materials describing the two initial years of professional development, then reported on the 2008 professional development workshops from the perspectives of the professional developers, the teachers, and the internal evaluator. A multiple case study analysis of engineering-oriented professional development concluded the morning session. Informal updates were provided by the two recipients of start-up grants for doctoral graduates in faculty positions, followed by brief highlights of the four research efforts currently supported by the internal grant program. A panel comprised of the five doctoral graduates then offered suggestions for the direction of future NCETE research efforts.

Center personnel are actively pursuing additional NSF funding possibilities for a wide range of research opportunities. During the year, proposals were submitted to the DR-K12 program, the RET program, the EEC symposium program and the CCLI program.

The following sections provide detailed descriptions of the progress associated with each specific goal statement.

III Research Goal 1a: Status Studies

The first research goal was defined, in part, in response to feedback from the external evaluators, Inverness Research Associates. They suggested it might benefit engineering and technology education to focus some efforts on status studies to describe what is currently in place in grades 9-12. Research Goal 1a is **to define the current status of engineering design experiences in engineering and technology education in grades 9-12**.

One of the major research efforts associated with this research goal was a commissioned paper for the National Academy of Engineering committee working on DR-K12 Award 0733584. NCETE provided part of the support for the work of Kenneth Welty, who reviewed existing K-12 engineering education curriculum materials and prepared a report that will be published as a CD-ROM in conjunction with the published committee report. Several of the doctoral fellows were also involved in the early stages of that research effort. The study was conducted as part of a larger project being conducted by the National Academy of Engineering and the National Research Council. Among other factors, the analysis examined the mission and goals of the curricula; the presence of engineering concepts, such as analysis, modeling, systems, and constraints; and the use of mathematics, science, and technology (Welty, K., Katehi, L., Pearson, G., & Feder, M., 2008).

Todd Kelley's doctoral dissertation, *Examination of Engineering Design in Curriculum Content and Assessment Practices of Secondary Technology Education*, informed this research goal. He examined the current status of technology education teacher practices with respect to engineering design. ITEA members, who were also high school teachers, were surveyed about the extent to which engineering design concepts are incorporated into curriculum content and the assessment practices employed by secondary technology educators. The survey also identified challenges faced by technology educators when seeking to implement engineering design. Design thinking related to engineering design and engineering communications were greatly emphasized in secondary technology education programs. Engineering and human values, engineering sciences, and engineering analysis were the least emphasized categories in technology education curriculum content.

Another doctoral fellow, Jenny Daugherty, reviewed the status of professional development programs. In particular, her study consisted of multiple case studies of selected professional development programs designed to prepare secondary teachers to deliver engineering-oriented education. The focus was on understanding the professional development design, fundamental content knowledge, essential pedagogies, unique challenges, and effective practices involved in this type of professional development. Five professional development programs were examined, including: *Engineering the Future*, *Project Lead the Way*, *Mathematics Across the Middle School MST Curriculum*, *The Infinity Project*, and *INSPIRES*. Jenny and Rod Custer interviewed the leadership, instructors, and participating teachers; observed the in-person workshops; administered a survey to the teachers; and analyzed the project's documentation. The findings from the individual case studies were compared and summarized across the five research questions. Jenny's dissertation study was part of a larger study in progress, led by Rodney Custer, to develop a foundation of knowledge on which to ground a professional development model for engineering-oriented technology education.

IV Research Goal 1b: Professional Development

This research goal builds on experiences of the first two years of the Center where individual sites conducted professional development to infuse engineering design into high school classrooms. These early experiences lead to the following research goal: **to define an NCETE model for professional development by examining the design and delivery of effective professional development with a focus on selected engineering design concepts for high school** technology **education**. Research investigations are underway to achieve this research goal. In addition, one of the core courses taken by the doctoral fellows at the four doctoral-degree granting institutions helps support this goal.

a) Background

In the first two years of the Center, five sites developed and implemented professional development (PD), with university faculty members working with teachers to infuse engineering design into high school classrooms. These early experiences resulted in a series of reports and presentations including:

Asunda and Hill (2007), Becker & Custer (2005, 2006), Becker (2006, 2007), Merrill, Custer, Daugherty, Westrick & Zeng (2007), Shumway, Berrett, Swapp, Erekson & Terry (2007), Merrill, Childress, Rhodes & Custer (2006), and Tufenkjian, Maurizio & Lipton (2006).

Synthesis of first two years of professional development activities and the research studies to help the Center understand PD effectiveness provided guidance to the Center on essential features of effective PD, especially those learned from the mathematics and science communities. This work built on a spin-off project of the Center, the National Symposium to Develop an Effective Model for the Professional Development of K-12 Engineering and Technology Education Teachers (NSF Award 0533572). In addition, the Center held a series of meetings to attempt to synthesize the lessons learned from two years of PD pilot studies that were conducted at five of the partner sites. Partners from USU, BYU, NCAT, ISU and CSULA planned a PD review workshop. A culminating one-week workshop, held at Illinois State University, involved: NCETE professional development providers; exemplary teachers, who had experienced one of the NCETE site-specific PD programs; beginning teachers; high school students; and internal and external evaluators (Cullum, J., Hailey, C., Householder, D., Merrill, C., & Dorward, J., 2008).

b) <u>Movement Toward an Exemplary Professional Development Program</u>

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. This program represents the first-step in developing an exemplary PD program for infusing engineering design thinking into a variety of science, technology, engineering, and mathematics (STEM) classes.

The goals of the year long PD program were to enable high school teachers of STEM to:

- *Increase their subject matter knowledge in engineering design and strengthen their mastery of pedagogical content knowledge related to the infusion of design experiences into their courses.*
- *Apply principles and practices of engineering design as they work individually and in small groups to develop solutions to technical problems.*
- *Develop proficiency in introducing engineering design challenges to high school students as a part of standards-based instruction in science, technology, engineering and mathematics.*
- *Engage in reflective practice as members of the learning community by analyzing instructional effectiveness, modifying lessons, and revising materials in order to improve subsequent instruction.*
- *Identify and select design challenges and instructional materials that will motivate and enable their students to move efficiently through learning progressions in engineering design.*
- *Assess the effectiveness of student performance in completing open-ended engineering design challenges*
- *Infuse engineering design experiences in their science, technology, and mathematics on a regular, on-going basis so their students acquire key engineering concepts while exploring the STEM disciplines*

Two sites were selected to pilot the exemplary program: 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 technology education programs. Jim Dorward, Professor of Elementary Education at Utah State University served as the program evaluator. His evaluation efforts were supported by a doctoral student, Jodi Cullum.

<u>Foundation Program</u>: The initial phase of PD program was a series of spring workshops that included a range of activities, including presentations, teambuilding, hands-on cooperative learning experiences, and group activities. Specific topics and activities included engineering, the engineering design process, the role of the engineer, teambuilding, using science and mathematics for predictive analysis, infusing engineering design into science, mathematics and technology classes, developing engineering design challenges, participating in several engineering design challenges, and teacher reflection.

Since the teachers had varied STEM backgrounds; each teacher was asked to apply what he or she learned to develop an engineering design challenge that could facilitate infusion of engineering design into one of their actual high school classes. To do this successfully, the teachers needed a high level of understanding of the engineering design process itself. Furthermore, each teacher had to consider what would interest students and meet appropriate STEM standards, while working within the existing physical environments and time constraints in their classrooms.

At the conclusion of the Foundation Program, participants developed their initial concepts and proposals for their own engineering design challenges. They then received feedback from their teacher colleagues and the professional development facilitators.

<u>Summer Workshops</u>: The summer workshops provided significant time for the participants to work with the facilitators, other consultants, and their colleagues to further refine their engineering design challenges. During the initial three-day period, emphasis was placed on participants' refining and completing development of their engineering design challenges, constructing required apparatus for the hands-on component(s), refining the science and math for the predictive analysis components, refining the instructional design/lesson plans, pilot testing, and determining how student performance will be assessed. Activities of the remaining two days focused on sharing all engineering design challenges with the group, presenting selected elements, applying assessment rubrics and identifying what else must be done to infuse the engineering design challenges into their classes, and discussing additional steps.

<u>Classroom Implementation and Observation</u>: The 2008-2009 academic year provided opportunities for teachers to begin infusing engineering design into their classes using a variety of teaching and learning strategies. Teachers include elements of engineering design and predictive analysis as appropriate into their classes with observation, when possible, by professional development facilitators.

c) Evaluation of the Year Long Professional Development Program

The program evaluation employed multiple mixed-methods which included: observation of foundation and summer workshop professional development activities; pre- and post surveys of participant knowledge and skills related to engineering design; and post-implementation interviews with participants and professional development facilitators. The results of the program evaluation are included in the Findings Section of this Annual Report in a section entitled "Final Internal Evaluation Report for 2008-09 NCETE Professional Development Program." The report focuses on information generated from initial planning in Fall 2007, to classroom implementation of engineering design principles during Fall 2008 and Winter 2009. That report is also included in the Findings Section of this Annual Report.

d) Research Studies Associated with the Year-Long Professional Development Program

Two NCETE post-doctoral research associates and an NCETE internal evaluator conducted a case study to describe the lesson planning processes that teachers used during the year-long PD program to plan for the introduction of the engineering design process into their courses. This study was guided by the following research question: How do high school STEM teachers plan to implement engineering design in their classrooms? The 17 teachers participating in this study were science, mathematics, and technology education teachers who work under the constraints of standards-based curriculums. Data considered in this study were limited to the professional development experiences and did not include observations of teaching behaviors in teachers' classrooms. A multisite case study approach formed the methodology for this study, utilizing the coordinated professional development efforts of NCA&T and CSULA. (Denson, C., Mentzer, N., & Cullum, J., 2009)

Another study currently underway involves synthesizing the findings of five different observers who observed the PD sessions at NCA&T and CSULA. Two qualitative researchers observed each of the foundation and workshop sessions. Data analysis is underway.

e) Professional Development Workshop at ITEA

NCETE sponsored a pre-conference workshop March 25 as a part of the 71st annual International Technology Education Association Conference in Louisville, KY. The workshop was titled *Introducing Engineering Design Challenges into Your High School Classroom*. Faculty from NCA&T and CSULA led the workshop supported by two high school mathematics teachers, one from Long Beach Unified School District and one from Windsor, North Carolina. Both mathematics teachers had been participants in the year long professional development program.

V Research Goal 1c: Learning & Teaching

An important component of the first Center research goal is to conduct research **to identify guidelines for the development, implementation, and evaluation of engineering design in technology education**.

a) **<u>Dissertation Studies</u>**

A number of doctoral fellows have focused their research to align with this goal. In particular, Mentzer's dissertation, "Academic Performance as a Predictor of Student Growth in Achievement and Mental Motivation During an Engineering Design Challenge in Engineering and Technology Education," examined whether students' academic success was correlated with student change in achievement during an engineering design challenge, and student change in mental motivation toward solving problems and critical thinking during an engineering design challenge. Walrath's dissertation, "Complex Systems in Engineering and Technology Education: A Mixed Methods Study Investigating the Role Computer Simulations Serve in Student Learning," was conducted to determine if students receiving complex systems instruction in the form of software simulations recognize patterns and underlying elements of complex systems more effectively than students receiving traditional instruction. Franske's dissertation, "Engineering Problem Finding in High School Students," explored the engineering problem finding ability of high school students at three high schools in Minnesota. Students at each of the three schools had differing backgrounds, including pre-engineering coursework, traditional technology education coursework, and advanced science coursework.

Three doctoral students focused on underrepresented groups and the learning and teaching of engineering. Austin's dissertation, "Factors Influencing African American High School Students in Career Decision Self-efficacy and Engineering Related Goal Intentions," looked at a number of factors that may explain the lack of equity in the choice of engineering as a career. Denson's dissertation, "Impact of Mentorship Programs on African-American Male High School Students' Perceptions of Engineering," examined the impact of mentorship programs on African-American male high school students' perceptions of engineering. In his study, indicators of students' perceptions included students' perceptions of engineering, their self-efficacy in the area of math, and their self-efficacy in the area of science. Roue's dissertation, still in progress, looks at the influence of grade level and gender on divergent thinking skills.

b) **<u>Internal Grants</u>**

In year five, the 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 is required.

Nine internal proposals were submitted for review. Six of the proposals aligned with the research mission of the Center and were externally reviewed by a panel consisting of Christine Cunningham, Boston Museum of Science; Gene Martin, Texas State University; and Larry Genalo, Iowa State University. Based on the external reviews, four were funded. Below is a description of the funded work and progress to date.

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

The study was designed to identify and refine a conceptual foundation for secondary level engineering education. Over the past decade, the interest in engineering at the secondary level has grown dramatically. However, in spite of the increased interest, there is a lack of a coherent and well-defined articulation of concepts appropriate for secondary level engineering. As a result, curriculum and professional development tend to revolve around student and teacher engagement and the process dimensions of engineering. While these aspects are important, academic rigor demands that the conceptual foundations of engineering be established and clearly articulated.

The primary methodology for the study has been to review and synthesize key literature. Key input activities include conducting a review and synthesis of extant materials focusing primarily on standards and curriculum materials as well as selected literature from the history and philosophy of engineering and technology. The review also includes relevant findings obtained from the NSF-funded National Symposium on Engineering and Technology Professional Development and the NCETE-funded landscape study of engineering-oriented teacher professional development practices. In addition to document analysis, a series of focus groups sessions has been conducted with selected engineering educators and practicing engineers to identify and classify their recommendations of concepts appropriate for secondary level engineering. Subsequent to the review and synthesis, the study will also include a reaction process, which will be conducted as a final, refinement focus group. The purpose of this phase of the study will be to refine the list of concepts generated through the first phase of the study (i.e., the review and synthesis, and the focus groups).

The review and analysis of the philosophical and historical materials has been completed along with the development and application of an analysis procedure designed to classify the identified concepts as “core”, “engineering”, and “concepts.” Three focus groups have been conducted and analyzed. Current activity is concentrated on analyzing a body of secondary level, engineering-oriented curriculum materials. This phase of the process will be completed by mid-May. The final synthesis focus group will be conducted by the end of June. The final report will be submitted by the end of August 2009.

Wicklein, R. & Mativo, J. Learning effects and attitudes of design strategies on high school students.
Using experimental research methodology, of this study will 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 technological problem, students will be guided through a design sequence that will utilize 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 will be administered to the students to evaluate differences in engineering design capabilities. Additionally, students will complete an attitude inventory related to their perceived enjoyment and general value of the instructional group that they were assigned to. The following research questions guide this study.

i. Is there a significant difference in engineering design learning ability for students who participated in a predictive analysis based engineering activity when compared with a trial and error based engineering activity?
ii. Is there a significant difference in learning attitude for students who participated in a predictive analysis based engineering activity when compared with a trial and error based engineering activity?

The results of this research will help establish a quantitative base of knowledge pertaining to the role and focus of engineering related curriculum and instruction for the field of technology education. Currently, there is significant discussion and debate pertaining to the importance and value that an engineering based curriculum may have on the field of technology education. However, there are few quantitative data that can be generalized to the field that pertain directly to the learning effects of predictive analysis as a basis for teaching engineering design. This research will add significantly to this knowledge base.

The following project activities have been completed to date: a) identification of school partners; b) IRB approval; c) selection of instructional topic and preparation for instructor training; d) selection and training of instructors; and e) preparation of classroom and laboratory facilities**.** The following activities are still be done: a) selection of student participants; b) random assignment of participants; c) conducting of instructional programs, d) data collection and analysis; and e) dissemination of results.

Shumway, S., Wright, G., & Terry, R. A case study of the implementation of an engineering program into a high school technology education classroom.
Using a case study format, the study objective is to collect qualitative and quantitative data related to the NCETE research question: What issues, opportunities, and constraints do teachers confront as they change their approaches to teaching to infuse engineering concepts into technology education? Specifically, the investigators are collecting data that will allow them to investigate issues, constraints and opportunities experienced by a technology teacher who is in the first year of implementation of an engineering program at the high school level.

The teacher and district personnel were contacted during summer 2008 and permission was received to conduct the study. The teacher was interviewed before the start of the school year and interviews have been conducted at least monthly throughout the school year. In addition, the researchers have visited the class and observed the teacher and students as they participate in various engineering activities and reviews of lesson plans and activities are being conducted. Finally, a written survey was given to the teacher after the first semester and the findings of that survey were presented at the NCETE winter meeting in Louisville, KY. Since that time, the interviews and observations have continued. At the end of the school year the teacher will complete another written survey regarding the research questions. The findings from the various interviews, surveys, lesson and activity analysis and observations will be synthesized into a final report by August 31.

Lawanto, O. & Stewardson, G. Problem-solving in the engineering laboratory: Understanding how learning styles relate to motivation and learning strategies in grades 9-12.
The intent of this quantitative study is to improve understanding of the ways different approaches to solving an engineering design problem impact students' motivation. Approximately 80 students in grades 9-12 from several schools that implement Project Lead the Way (PLTW) curriculum are participating in the study. This study evaluates students' motivation while working on two distinct engineering design activities: a design challenge that relies on design analysis (i.e., Bridge Design) and a one that relies on a creative trial-and-error process (i.e., Marble Sorter). One research question was constructed to guide the study: How do analysis-focused and creative trial-and-error-focused design activities impact students' motivation? Two versions of Engineering Design Questionnaires (EDQ) are

used to assess students' motivation: EDQ-Bridge-Design (EDQ-BD) and EDQ-Marble-Sorter-Design (EDQ-MSD).

Four high schools have submitted part one of the survey (i.e., EDQ-MSD). Two schools are in Indiana and the other two schools are in Utah. Those four schools have provided 75 data sets for the first part of the survey. There is an indication that some schools may not complete the bridge design activity this academic year. Therefore, there is a possibility that an extension of time may be required in order to collect Survey part 1 (EDQ-MSD) and Survey part 2 (EDQ-BD) from those schools.

c) New Faculty Grants

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.

Kelley, T. & Strobel, J., *PLTW and Epics-High: Curriculum and inter-school comparisons of the effectiveness of the programs to support the development of problem solving in the context of design.* The goal of this study is to compare and contrast EPICS-High and PLTW, two different engineering – focused curriculum programs implemented at the 9-12 grade level in regard to their effectiveness in teaching higher order thinking, particularly in the areas of design and problem solving. An outcome of this research will be transferable results on the effectiveness of the two programs and a preliminary explanation of the results. In addition, the study seeks to define characteristics of the different design experiences embedded in PLTW and EPICS-High by examining the nature of problems utilized and the integration of math and science in the respective curricula. An outcome of the results of this research will be a list of core elements of engineering design problems appropriate for study at the high school level.

Stricker, D., A case study: Teaching engineering concepts in science.
This study seeks to understand how a particular high school engineering education program derived organically from a science and math emphasis approaches engineering concepts. Data will be collected through interviews, classroom observations, and collected curriculum documents in the classroom in a Minnesota high school. While 2008-2009 observations have been completed, the data have not yet been compiled and synthesized.

VI Goal 2: Building Capacity

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

In year five, the leadership development efforts focused on the doctoral and postdoctoral students to help them become future leaders in conducting research on STEM learning and teaching.

a) Doctoral Students

Consistent with the goal of the NSF Centers for Learning and Teaching, to renew and diversify the cadre of leaders in STEM education, the Center has worked to develop a community of doctoral fellows that will become leaders in engineering and technology education. The fellows reside at the four research partner institutions: University of Georgia (UGA), University of Minnesota (UMN), University of Illinois at Urbana-Champaign (UIUC), and Utah State University (USU). The NCETE doctoral fellows take core courses together and came together during annual workshops to share research results and strengthen their sense of community. The fellows and faculty experience the strengths of the four research partners rather than that of a single institution.

Technology education has historically been dominated by white males; consequently the Center is proud of the diversity that our doctoral fellows bring to the profession. Over 40% of the fellows are from underrepresented groups. The Center currently has eighteen doctoral fellows. Eight have graduated and ten are enrolled at one of the partner institutions. The demographics of the eighteen doctoral fellows include two African American males, one Jamaican male, one Asian male, ten white males, three white females and one African American female. Since its inception, the Center has lost four doctoral fellows, all early in their programs of study. Once the fellows have completed course work and passed qualifying examinations, the Center has been successful in retaining the students. Brief biographical sketches of the fellows can be found at http://ncete.org/flash/graduate_fellows.php .

Eight Center fellows have completed their doctoral programs. Of these eight, three will be in tenure-track positions at Purdue University, one is a research professor at the University of Wisconsin-Stout, one is a post-doctoral faculty member at Utah State University, and one is Director of the Northern Alaska Career and Technical Education Center. Two fellows recently defended their dissertations in May 2009 and have yet to announce their future plans.

The Center has initiated a new faculty grant program to support fellows as they develop their research agendas as faculty members. Todd Kelley at Purdue University and David Stricker at the University of Wisconsin-Stout have been the recipients of new faculty grants for the 2008-09 academic year. The Center also supports the fellows' dissertation research for amounts up to $10K for justified direct costs.

The Center views the NCETE doctoral fellows as a select group of doctoral students who share similar backgrounds because of the core course sequence and opportunities to gather and discuss research results. In addition to the NCETE fellows, the Center has funded doctoral students who have helped conduct the research of the Center. Paul Asunda and Cameron Smith have completed doctoral programs at UGA, Mauvalyn Bowen has completed a doctoral program at UMN, John Duncan and Oenardi Lawanto have completed doctoral programs at UIUC and Jodi Cullum completed her doctoral work at USU. Asunda, Smith, Duncan, and Lawanto have doctoral degrees in the area of technology education. Cullum completed her doctorate in psychology and Bowen in human resource development. The Center also funded Edward Locke at the University of Georgia who will complete a Specialist in Education degree in August.

b) **<u>Doctoral Core Courses</u>**

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

Cohort one fellows completed the core-course sequence in years two and three (2005-2007). Faculty and representatives from cohort-one fellows from USU, UIUC, UMN and UGA met in Chicago, Illinois on July 10, 2007, to review and refine the core courses and other aspects of the fellows' doctoral program. One significant outcome of the meeting was recognition of the need to provide an introduction to engineering design, including opportunities to engage in engineering-like design experiences, early in the doctoral experience. Another significant outcome of the meeting was the addition of more research experiences in the core course sequence.

Cohort Two fellows experienced an improved sequence of core courses. During fall semester 2007, a two -hour seminar originated at USU to orient cohort two fellows to engineering design and research opportunities within NCETE. Ty Newell, a mechanical engineer from UIUC, conducted four seminar sessions on the engineering profession and engineering design as seen through the eyes of an engineering educator. In addition, David Gattie, a biological engineer from UGA, conducted a session on systems thinking in engineering and Ted Lewis, UMN, conducted a session on selecting a dissertation research topic.

The first NCETE core course, The Role of Cognition in Engineering and Technology Education, was revised and taught for the second time during spring semester 2008 by Scott Johnson. The majority of the course readings described empirical studies of cognition that focused on technical learning and thinking. Each student was expected to analyze a research report and present the major concepts from the article to the class. The fellows were also expected to write and present a major paper that reviewed and synthesized the literature on a critical issue related to cognition in engineering and technology education. Each fellow was also expected to conduct an analysis of the development of expertise in a domain of his or her choice using the protocol analysis method. This method of research was introduced in class as a way to capture empirically the thought processes that are used as the research participant completes a task. The fellows designed and conducted the study and wrote a technical report that included a description of the problem being addressed, the methods used to collect and analyze data, and the results and conclusions. The fellows also made formal presentations of their studies to the class.

The second NCETE core course, Design Thinking in Engineering and Technology Education, was taught for the second time during summer semester 2008. Theodore Lewis was the lead teacher with an engineering perspective provided by Gary Benenson. The course explored the concept that design is the primary conceptual anchor for technology education, drawing the subject ever more tightly toward engineering. As the doctoral students reviewed contemporary literature in design thinking, they were asked to identify the conceptual framework against which the study was set, the quality of the research problem, the design/methodological approach of the study, the findings and recommendations, and study limitations. The students were expected to analyze a body of research and develop a journal-quality synthesis paper.

In the third NCETE core course, Engineering Design: Synthesis, Analysis and Systems Thinking, the fellows were exposed to engineering design techniques. This course was team taught by engineering and technology education faculty at the University of Georgia (David Gattie, Syd Thompson, Nadia Kellum, Robert Wicklein and RogerHill). The course provided the fellows with an academic experience that fostered critical questions and recognition and identification of potential issues associated with infusing engineering design into K-12. The course identified the drivers of engineering design and the challenges of appropriately modulating qualitative reflection, quantitative analysis, critical thinking, mathematics and science within an engineering design process for technology education teachers and K-12 students. Fellows were asked to develop a curriculum model that integrated engineering design concepts and activities into a technology education program.

The fourth NCETE core course, Engineering Design in STEM Ed, focused on the integration of engineering design principles via engineering design challenges through research, development, and evaluation in grades 9-12 engineering and technology education. It was team taught by Mark Tufenkjian, an engineering faculty member at CSULA, and technology education faculty members Kurt Becker at USU and Jenny Daugherty and Rodney Custer at Illinois State University (ISU). Concepts explored in the course included curriculum development; students as learners and teachers; and engineering problem solving, analysis, modeling, optimization, and design. The differences between the engineering and technology education approaches to design were discussed, and engineering learning modules were developed that were exemplars of the engineering approach. The course focused on development of various aspects of high-school-level engineering design challenges, and on ways that evaluation and assessment could be used to improve teaching and learning in engineering and technology education. Professional development methodologies to integrate engineering design were also explored.

c) **Research Leadership Development for Fellows**

Conference on Research in Engineering and Technology Education: NCETE hosted a graduate student conference at the University of Minnesota May 22-23, 2008. Doctoral student research in the field of engineering and technology education was the focus of the meeting. NCETE fellows were joined by doctoral students and their mentors from Tufts University, Virginia Tech, Colorado State University, Purdue University, and Ohio State University. They shared research interests and built professional networks.

A conference proceeding has been published by NCETE and is available on the Center website (http://ncete.org/flash/pdfs/RETE%20Proceedings.pdf). Theodore Lewis, conference host, summarized the major research themes presented by the doctoral students in the introductory section of the proceedings. Twenty student papers are assembled in the proceedings, representing a spectrum of scholarship ranging from research synthesis papers from their doctoral course work to reports of completed doctoral dissertations.

Pre-ITEA Research Seminar: NCETE hosted a research seminar for Center faculty and doctoral students on May 25, 2009 prior to the ITEA conference. The morning session focused on findings from the variety of professional development programs conducted by the Center over the past five years. The afternoon session focused on progress on research funded by an internal grant process. At the conclusion of the morning and afternoon sessions, the recently graduated doctoral fellows participated in a panel where they were asked to synthesize the day's presentations and then discuss implications for the future.

Cohort Two Leadership Development: In July, cohort two fellows will participate in an NCETE-sponsored workshop in Washington, DC. The tentative program includes: Greg Pearson from the National Academy of Engineering on the NAE and its Role in K-12 Engineering and Technology Education; Patty Curtis, Managing Director of the Washington Office of the Boston Museum of Science, speaking about Influencing Federal Policies in Engineering and Technology Education; recipients of NSF funding who will present overviews of their research programs; and NSF program officers discussing NSF programs, proposal writing and funding.

d) Twenty-first Century Leader Associates (TCLA)

The Council on Technology Teacher Education (CTTE) has set out to help early-career professionals begin to develop a stream of research and to develop skills necessary for negotiating promotion and tenure.

The idea for an initiative to help early-career professionals was developed in 2005, and was piloted in 2006 and 2007. Prior to 2007, the TCLA activities consisted of a series of on-line discussions about leadership. In 2007, as a pilot program, the National Center for Engineering and Technology Education provided resources so that the program could include some activities in Washington, DC. The TCLA experience was modeled after a leadership experience that NCETE had provided for the Cohort One fellows. In September, 2008 NCETE supported the travel of five TCLA professionals to attend a meeting in Washington, DC. Given the success of the 2007 and 2008 CTLA experiences in Washington, DC, both CTTE and ITEA are exploring ways to fund this activity in the future.

e) Postdoctoral Students

In additional to doctoral students, the leadership development effort focused on postdoctoral students to help them become future leaders in conducting research on STEM learning and teaching. Two NCETE doctoral fellows were selected for post-doctoral research associate positions at Utah State University. As part of their leadership development, they attended four professional conferences during their year at USU. They presented papers at both the International Technology Education Associate conference and the American Society for Engineering Education conference. They also attended the American Educational Research Association conference and the Seventh Annual Harvey Mudd Design Workshop. Attendance at the two latter meetings enabled the post-docs to network with important leaders in the STEM education field and acquainted them with the research challenges being addressed in the broad STEM community.

VII Goal 3: Communication

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

Communications initiatives designed to reach external audiences include the NCETE Web site, CLT Net, the NCETE Newsletter, 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. Center-wide meetings play an important role in internal communication; these gatherings of fellows and faculty were at the University of Minnesota in May 2008 and prior to ITEA in March 2009. The Conference on Research in Engineering and Technology Education in May included invited doctoral students and faculty members from Colorado State University, The Ohio State University, Purdue University, Tufts University, and Virginia Tech University.

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

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.

VIII Realignment of Center Budgets to Achieve Mission and Goals

As an outcome of the reverse site visit, NCETE was asked to refine our mission, refocus our goals, and tighten our research framework. In order to respond to the requests from NSF, we have shifted from teacher enhancement programs at five teacher educator sites to research on a professional development model. In addition, funds allocated for teacher enhancement in the original proposal budget have been redirected to funding dissertation research, the internal research program, the new faculty grant program and two post doctoral research associates. The Center continues to fund doctoral fellows including stipends, tuition and funds for travel and research.

National Center for Engineering and Technology Education
Year Five Findings Report

Major NCETE Findings: 2008-2009

Significant outcomes of the year include strengthened research activity on several fronts: completion of doctoral dissertations; postdoctoral studies; start-up research by doctoral graduates in new faculty positions; internally supported research by faculty, graduate students, and collaborators; conference presentations; and publications related to Center work. While the shift to a research focus has been somewhat stressful for many Center participants, there is a substantial shift toward alignment with NSF research priorities in learning and teaching. There is a limited but clear tendency for individuals who engage actively in formal research efforts to continue their work in other, frequently closely related areas of inquiry. 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.

Evidence continues to support the value of the cohort approach to doctoral study as implemented by NCETE. The report of the external evaluator cites substantial evidence of the effectiveness of the system that enabled research institutions to collaborate on a common core of instruction to supplement the existing doctoral programs at the respective institutions. The evaluative comments from the doctoral fellows seem more positive about the collaborative components of their programs than about several dimensions of their experiences on their home campuses.

The completed doctoral graduates, individually and collectively, provide the first major block of 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.

Linkages with the engineering education community have been markedly strengthened during the year. Kurt Becker was the PI on an NSF award entitled "A National Symposium to Develop and Present a Case for the Establishment of Engineering Education Academic Programs," EEC-0835997. The purpose of the symposium is to stimulate a national dialogue on establishing engineering education programs in colleges of engineering in the United States 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, the Ken Welty's complete review of K-12 engineering curricula will be 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.

Evaluations of the NCETE 2008-2009 professional development activities offer 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. Evidence was less clear on the degree to which the teachers were successful in developing engineering design challenges for their students – or modifying challenges from other sources – and implementing the challenges in their classrooms.

This year, the professional development group attempted to recruit and prepare teams of science, technology, and mathematics teachers from collaborating schools. The initiative was an attempt to align the professional development with national efforts to enhance the STEM disciplines and build the STEM presence in schools, and strengthen the preparation of a strong STEM workforce. This effort has met with limited success, however, in the face of the stringent limitations imposed on collaboration among subject matter teachers in secondary school settings.

Professional development teams involving technology educators, engineers, mathematics educators, and science educators have played important roles in the success of the professional development efforts. The success of these collaborative teams, particularly those at the two institutions engaged in professional development during the past year, may provide guidance to future efforts to design and deliver effective professional development.

There is an increasing awareness of the need for NCETE to address policy issues that limit the possibilities for the implementation of engineering design challenges in the secondary schools. While engineering design has been a central theme undergirding the work of the Center throughout its existence, relatively little attention has been directed toward gaining acceptance and support of that idea. Neither teachers, administrators, parents, curriculum developers, designers of standardized tests, professional organizations, local school boards, state departments of education, nor state and national legislators fully understand the potential contributions of engineering design to the education of all American youth. Consequently, there are few outspoken advocates for the innovation, and possibilities for widespread adoption are limited at best.

Final Internal Evaluation Report
for Year One of the NCETE Professional Development Program

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March, 2009

Abstract

In September, 2007 the NCETE management team commissioned university partners from North Caroline A&T and California State at Los Angeles to work collaboratively on development of a new professional development program with a focus on infusing engineering design into high school curriculum. The goals for this one year program were to:

- Increase teacher subject matter knowledge in engineering design and strengthen their mastery of pedagogical content knowledge related to the infusion of design experiences into their courses.
- Apply principles and practices of engineering design as they work individually and in small groups to develop solutions to technical problems.
- Develop proficiency in introducing engineering design challenges to high school students as a part of standards-based instruction in science, technology, engineering and mathematics.
- Engage in reflective practice as members of the learning community by analyzing instructional effectiveness, modifying lessons, and revising materials in order to improve subsequent instruction.
- Identify and select design challenges and instructional materials that will motivate and enable their students to move efficiently through learning progressions in engineering design.
- Assess the effectiveness of student performance in completing open-ended engineering design challenges
- Infuse engineering design experiences in their science, technology, and mathematics on a regular, on-going basis so their students acquire key engineering concepts while exploring the STEM disciplines

The professional development model included the following elements: selection of cross-disciplinary teacher teams, use of communication technologies to minimize participant travel and sustain training over several months, a closely monitored implementation phase, and a strong evaluation component.

The program evaluation employed multiple mixed-methods which included: observation of spring and summer professional development activities; pre- and post surveys of participant knowledge and skills related to engineering design, and post-implementation interviews with participants and professional development facilitators.

Major findings from the evaluation of the one-year NCETE professional development program were:

- All participants indicated that they have used some of the teaching strategies and steps in Engineering Design in one or more of their classes.
- Most participants indicated that they did not implement a complete Engineering Design challenge in their classes. Reasons for this finding included appropriateness of the content, the time required to fully implement a challenge, and lack of interest or feasibility with their current curriculum.
- All participants indicated students derived benefits from teaching strategies or elements of activities from the PD that they were able to implement. These

benefits included an increase in critical thinking, more student-centered focus, improved attitudes toward group work, increased interest in abstract subjects such as math.

- Most participants indicated value associated with working with other teachers (interdisciplinary teaming) on activity development and implementation.

The evaluators recommend the following for future professional development in infusing engineering design into secondary mathematics and science:

- Increase emphasis in the workshops on the value added to student knowledge, skills, and attitudes when participating in group problem solving activities.
- Increase the number of short-term projects taught by the developers during the workshop.
- Align engineering design challenges to current high school curriculum.
- Provide additional assistance to teachers in understanding and applying math formulas used in engineering.
- Extend the professional development model over two years.
- Cultivate and nurture support from school administrators and curriculum developers.

Background

In 2003, researchers from Utah State University, the University of Georgia, and Brigham Young University assembled a strong team of engineering educators and technology educators to propose the establishment of the National Center for Engineering and Technology Education (NCETE). The NCETE links technology educators with engineering educators in a partnership to build capacity and diversity in engineering and technology education at all levels. In addition, NCETE is designed to infuse engineering content, design, problem solving, and predictive analytical skills into K-12 schools through technology education.

A major activity of NCETE is technology teacher education (TTE). The TTE component for the first two years involved five university partners delivering five different professional development programs to public school teachers. The following six goals framed NCETE's initial teacher professional development efforts:

- Develop teachers' instructional decision making so that it focuses on the analytical nature of design and problem solving needed to deliver technological as well as engineering concepts.
- Facilitate teacher-initiated change in program design, curricular choices, programmatic and student assessment, and other areas that will impact on learning related to technology and engineering.
- Develop teachers' capabilities as learners so that they assume leadership for their professional development activities, including recruiting and mentoring their colleagues
- Create a pool of highly skilled cooperating teachers who will accept pre-service technology teachers into their classrooms and mentor the next generation of technology/engineering teachers to effectively teach students of diverse backgrounds.
- Develop engineering analysis and design skills in technology teachers, including strengthening their mathematics and science knowledge and skills.
- Develop curriculum integration and collaboration skills in practicing technology teachers so that they can effectively collaborate with mathematics and science teachers.

Responding from feedback on initial TTE efforts, the NCETE management team commissioned university partners from North Caroline A&T and California State at Los Angeles to work collaboratively on development of a new professional development program with a tighter focus on engineering design. The goals for this revised program are:

- Increase teacher subject matter knowledge in engineering design and strengthen their mastery of pedagogical content knowledge related to the infusion of design experiences into their courses.
- Apply principles and practices of engineering design as they work individually and in small groups to develop solutions to technical problems.

- Develop proficiency in introducing engineering design challenges to high school students as a part of standards-based instruction in science, technology, engineering and mathematics.
- Engage in reflective practice as members of the learning community by analyzing instructional effectiveness, modifying lessons, and revising materials in order to improve subsequent instruction.
- Identify and select design challenges and instructional materials that will motivate and enable their students to move efficiently through learning progressions in engineering design.
- Assess the effectiveness of student performance in completing open-ended engineering design challenges
- Infuse engineering design experiences in their science, technology, and mathematics on a regular, on-going basis so their students acquire key engineering concepts while exploring the STEM disciplines

The revised program includes several elements characteristic of effective professional development. These elements include selection of cross-disciplinary teacher teams, use of communication technologies to minimize participant travel and sustain training over several months, a closely monitored implementation phase, and a strong evaluation component.

Scope of this report

This final report includes contextual information addressing questions of program fidelity, the use of formative evaluation by program staff, and findings related to impact on participant knowledge and skills related to engineering design. This report focuses on information generated from initial planning in Fall, 2007, to classroom implementation of engineering design principles during Fall, 2008 and Winter, 2009.

Methods

This evaluation employed multiple mixed-methods which included: observation of spring and summer professional development activities; pre- and post surveys of participant knowledge and skills related to engineering design, and post-implementation interviews with participants and professional development facilitators. The research questions guiding program evaluation include:

1) To what degree has the project contributed to an increase in participant knowledge and skills in engineering design?
2) To what degree are teachers' able to apply engineering design principles in group problem solving?
3) How have the NCETE PD workshops influenced teacher's proficiency in introducing engineering design challenges to high school students?
4) To what degree do teachers identify and select and implement appropriate design challenges and instructional materials in their classrooms?
5) To what degree do participants assess the effectiveness of student performance in completing open-ended engineering design challenges?

Sample and selection

The population for the NCETE professional development program is all middle and high school level engineering technology education, mathematics, and science teachers. The convenience sample consisted of all applicants to the program (n=33), who were selected to participate (n=25), and who completed the summer workshops (n=17). Of the 17 workshop participants, 10 responded to multiple requests and completed post-implementation interviews.

Program Logic and Evaluation Methods

Multiple sources of information provided the data for this report. The following table identifies overall project evaluation activities (See Table 1). As noted, this preliminary report relies on information from the application survey through the summer workshop evaluation activities.

Table 1: Overview of Program Components and Evaluation Methods

Goal	Actions	Short-Term Outcomes	Evaluation	Long-Term Outcomes
Increase teacher subject matter knowledge in engineering design and strengthen their mastery of pedagogical content knowledge related to the infusion of design experiences into their courses.	Orientation on ED process Provide didactic lessons on engineering design Provide hands on engineering design activities	NCETE teachers will be able to describe the engineering design process to solve engineering/technological problems. NCETE teachers will use the engineering design process and the technological design process to solve technical problems	Teacher self-perceived proficiency Evidence of ED principles in lesson taught to HS students during PD. Demonstrated by teachers' modification of an existing lesson to include ED Evidence of reflection on ED in teacher's notebooks	Increase in frequency and quality of engineering design activities and principles in classroom instruction..
Apply principles and practices of engineering design as they work individually and in small groups to develop solutions to technical problems.	Teachers involved in hands on ED group activities	Teachers work in small groups to solve ED problems using the processes provided by NCETE	Observation of teachers' completing activities	Evidence that participating teachers use ED to solve technical problems
Develop proficiency in introducing engineering design challenges to high school students as a part of standards-based instruction in science, technology, engineering and mathematics.	Teachers provided with instruction and opportunities to practice engineering design activities	Teachers implement ED activities adapted from those shared or developed during PD	Pre and post survey on perceived proficiency in infusing ED into the classroom Interview teachers	Participating teachers attribute increased proficiency to participation in PD.

Engage in reflective practice as members of the learning community by analyzing instructional effectiveness, modifying lessons, and revising materials in order to improve subsequent instruction.	Time set aside at each PD meeting for teachers to reflect on the session in groups…	Teachers will demonstrate reflective skills through group discussions and reflective writing activities?	Observation of reflection sessions (i.e., time spent, questions posed, teacher feedback) Review design notebooks for reflective comments Review of short reflection papers Interview teachers on reflective practice	Evidence of improved instruction attributed to reflective practice.
Identify and select design challenges and instructional materials that will motivate and enable their students to move efficiently through learning progressions in engineering design.	Highlight and discuss existing curricular products through national and state-based resources	Program participants locate ED resources and adapt for use in their instructional settings.	Teacher survey on design challenges and curricular materials they are using to infuse with ED	Evidence that participating teachers adapt learning activities based on student characteristics.
Assess the effectiveness of student performance in completing open-ended engineering design challenges	Provide teachers with assessment rubrics for students	Teachers able to apply assessment rubrics in PD	Anecdotal comments from post-implementation lesson study critiques	Teachers apply scoring rubrics to own classrooms activities

Infuse engineering design experiences in their science, technology, and mathematics on a regular, on-going basis so their students acquire key engineering concepts while exploring the STEM disciplines	Teachers taught instructional design processes by NCETE to plan lessons	Teachers develop ED activities to fit within their curriculum	Review of lessons plans developed by teachers Pre-post assessment of ED infusion to assess for change in the infusion of ED into classrooms Interview teachers	Evidence that PD participants are resources and advocates for use of ED activities and principles in classroom instruction.

Data Analysis

Information analysis included measures of central tendency. Qualitatively-oriented responses to open-ended survey questions, and formal and informal interviews were themed according to categories derived from survey data, and questions posed by project leaders. The evaluators constantly compared emergent themes from the narrative data to project goals and evaluation questions. As part of the interpretation of interview data, preliminary findings were shared with the two program facilitators. These facilitators were asked whether the findings were expected and what implications the findings have for future professional development activities (See Appendix G).

Limitations

The unit of analysis in this study was the 2008 Professional Development program undertaken by the National Center for Engineering Technology Education. Some data related to this program is not included in this report. Observations of site-specific professional development activities at North Carolina A&T and Cal State LA were completed by Center Co-PI's, but that data was not made available for this report. Classroom observations by site facilitators have been ongoing during Fall 2008 and Winter 200. Information from those observations is not included in this report. Consequently, findings in this report were interpreted from a center-level perspective.

Findings

1) To what degree has the project contributed to an increase in participant knowledge and skills in engineering design?

There is evidence to conclude that participation in the spring and summer components of the professional development increased teacher knowledge, skills, and confidence in implementing engineering design principles. Of the participants that responded to a pre-workshop question about their preparation to use engineering design in their classes, only 4 (23%) were prepared. After the program, 15 (88%) indicated they were prepared (See Table 1).

Table 1: Preparation in Implementing Engineering Design

	Pre- Program		**Post- Program**	
	Yes	**No**	**Yes**	**No**
I am prepared to use ED in my class	6 (24%)	12 (48%)	15 (88.2%)	2 (11.8%)

This increase in teacher preparation to infuse engineering design principles appears to be a result of better understanding of theoretical and practical components of the professional development program (See Table 2).

Table 2: Post-survey Responses to Change as a Result of Professional Development

	Strongly Disagree	Disagree	Agree	Strongly Agree
Greater understanding of engineering theoretical foundations	0	0	4 23.5%	11 76.5%
Greater understanding of hands on applications of engineering concepts	0	1 5.9%	5 35.3%	10 58.8%
Greater understanding of what makes an activity/concept engineering design	0	1 5.9%	5 29.4%	10 64.7%
Greater understanding of math knowledge needed to understand engineering concepts	0	0	10 58.8%	7 41.2%
Greater understanding of science knowledge needed to understand engineering concepts	0	1 5.9%	7 41.2%	9 52.9%

In the post-workshop survey, participants also reported increased confidence in their abilities to infuse engineering design principles, support other teachers, and develop assessments for engineering design activities (See Table 3).

Table 3: Confidence with Engineering Design

	Not Confident	Confident	Very Confident
More confident in my ability to infuse engineering design into my classroom	0	1 5.9%	11 64.7%
More confident in my ability to support other teachers with infusing engineering design into their classes	0	2 11.9%	6 41.2%
More confident in my ability to develop assessments for engineering design activities	1 5.9%	1 5.9%	10 52.9%

During the post-implementation interviews, several participants indicated that they were utilizing what they learned about engineering design in their teaching. For example:

> *Currently, I'm working with a physics teacher here on campus and we're going to be re-writing a course that is going to be called principles of physics and engineering. So we're kind of applying some of the concepts that I learned. The class is going to be focused on five engineering design challenges.*
>
> *I learned more about what the engineering design looks like the steps to the process. And I learned how to take a project and how to actually make it fit that design.*
>
> *The way that they (students) think and the skills that they acquire from the interests that were brought out because of what they have done in the class – based on what I had taken out from the professional development and brought in the classroom. And it really did help out a lot what I did and what I learned in the professional development kind of boost up my confidence in doing more team work in the class. And to encourage kids to think more of the problems and how they can solve it as a team.*

2) To what degree are teachers' able to apply engineering design principles in group problem solving?

There is evidence to suggest a shift in participants perceptions about the relative value of group problem solving activities. In the pre-program survey, participants indicated that group or cooperative learning activities in engineering design were relatively infrequent in their classrooms (See Table 4).

Table 4: Pre-program Classroom Activities

	Daily	Weekly	Monthly	Rarely
Individual projects	2 8%	2 8%	8 32%	11 44%
Use engineering design for cooperative learning projects	1 4%	1 4%	10 40%	11 44%
Student group projects include engineering design	2 8%	2 8%	7 28%	14 56%
Students develop their own learning environment for engineering design	2 8%	1 4%	2 8%	20 80%

Findings from the Post-workshop survey indicate that participants place a higher value on the use of group or cooperative learning activities (See Table 5).

Table 5: Post-workshop Ranking of Best Approaches for Integrating Engineering Design into Learning

	Best Approach	Second Best Approach	Third Best Approach	Fourth Best Approach
Specialized group activities	15 (88.2%)	2 (11.9%)	0	0
Lecture	0	0	4 (23.5%)	13 (76.5%)
Individual Group Projects	1 (5.9%)	14 (82.4%)	2 (11.9%)	0
Involvement in Competitions	1 (5.9%)	1 (5.9%)	11 (64.7%)	4 (23.5%)

However, results from the summary interviews were mixed. While several participants indicated some success in applying engineering design principles in group problem-solving activities, most participants found classroom implementation problematic.

> *Beforehand I used to try using groupings and stuff and trying to make the kids think but it was always difficult to manage the kids in groups and make them think that they are trying to solve a problem. When I got into the professional development and I saw a structure that I could help the kids think along that line and I presented it to them and I kind of trained them that you have to think this way and follow these steps. And they've improved a lot and it basically became a part of the way the teams work.*

> *It's made me better able to ask questions and field questions related to application. I haven't used it to come up with a project at this point because working with some of the guys over the summer they knew what they wanted from an engineering design challenge. And what I'm doing would not be it.*

> *I am still trying to put into place my plans for using the bungee cord experiment which is one of the things I learned from the professional development. And I am actually thinking of bringing a team of kids because we have a symposium for all of the STEM school in Northern Carolina and I am thinking of bringing a team of kids and having them present what they would come up with the bungee cord experiment. The way that they think and the skills that they acquire from the interests that were brought out because of what they have done in the class – based on what I had taken out from the professional development and brought in the classroom.*

Barriers to full implementation of workshop-like activities in participants' classrooms included alignment of content with core curriculum, time necessary for implementation, and student capabilities.

> *As a classroom teacher we already have enough on our plate. For me to take a project like the ones they gave us and use that, after we tweak it a lot… I can't give that to my 10th- 11th graders- I would have to dumb it down. And that takes time. They gave us all this stuff, which was nice of them but it not being utilized. I can bet the other teachers are not using it either.*

> *Just time. You've got to prepare a lesson and to take it down to where we take a theory and then we test it and develop and build a model it is so time consuming. In high school teachers it's here comes another comes another class, here comes another subject and is it tough.*

> *The biggest problem I have, its frustrating to me, is the lack of base knowledge kids have when they get to HS. I have to go back further back then I would thing I would have to. I shouldn't have to teach a 10th grader how to read a ruler. That base knowledge that these HS kids are coming in with, is a huge barrier for this engineering design process.*

3) How have the NCETE PD workshops influenced teacher's proficiency in introducing engineering design challenges to high school students?

There is evidence to suggest that the professional development program resulted in greater proficiency in introducing engineering design challenges and some changes in teaching strategies. Prior to the workshops, more than half of the participants indicated they were not proficient at developing, implementing, or sharing engineering design challenges (See Table 6).

Table 6: Current Implementation of Engineering Design

	Yes	**No**
I am proficient at developing instructional activities that require students to understand engineering design components	6 (24%)	19 (76%)
I implement instructional activities that require students to demonstrate their knowledge of engineering design concepts	10 (40%)	15 (60%)
I share my engineering design approaches with other teachers	8 (32%)	17 (68%)
I introduce other teachers to engineering	4 (16%)	21 (84%)
I integrate community resources into classroom learning activities	9 (36%)	16 (64%)

Post-workshop findings indicate that all participants reported improved ability to prepare engineering design challenges for their students (See Table 7).

Table 7: Engineering Design Challenge Preparation

	Strongly Disagree	Disagree	Agree	Strongly Agree
Improved ability to prepare engineering design challenges for students	0	1 (5.9%)	8 (47.1%)	7 (41.1%)

Information from the summary interviews provided further clarification of how teaching strategies changed as a result of the professional development. Participants attribute some changes in their teaching strategies to the program. These changes include a tendency for some teachers to broaden their view of teaching to include problem posing and monitoring.

Just doing the project was a huge departure from what I normally do. But during the project itself there wasn't a lot teaching per se. I taught everything I normally teach then we would take a day and do the projects and it incorporated all the concepts that we had been doing for the last month or so. During the projects I would walk around and monitor, but I wasn't doing any teaching itself really.

I'm learning how important it is to work in teams and how important it is to think like an engineer and just trying to solve a problem. The kids – they're – and me as well, I don't up on the board as much. I'm passing on the responsibility of learning onto them.

I learned the 7-step process but I haven't really been able to apply it as much as I would like to. And I think that would take place when I do the projects when I would use it. Because otherwise I am a straight lecture sort of and it doesn't really lend itself to doing the actual engineering process.

Part of it is analysis – in engineering design find the problem, look for alternatives, and then come up with the solutions. Analyze and then come and check back which totally works out for math.

I keep looking for the applications and the project I put together for this thing is still sitting in my garage and I keep – it's made me less satisfied with standard teaching and so I tend to ask more questions. I'm looking.

4) To what degree do teachers identify and select and implement appropriate design challenges and instructional materials in their classrooms?

Findings from follow-up interviews suggest that the program increased teachers' abilities to identify and select appropriate design challenges and materials, but did not substantially increase the number of engineering design challenges that were implemented in their classrooms.

It's made me better able to ask questions and field questions related to application. I haven't used it to come up with a project at this point because working with some of the guys over the summer they knew what they wanted from an engineering design challenge.

I would have preferred to have projects already in place that I can apply directly to the curriculum that I have to teach. And the way the program was set it wasn't set that way. I had to come up with one project and it was really tough to do because we were supposed to come up with an extended project but with the pacing and curriculum that we have set in our district it really doesn't allow for that because we really don't have that kind of time.

These things have to stay in front of you because once you get into the classroom you tend to forget the cool stuff that you have learned and just going to start turning pages

5) To what degree do participants assess the effectiveness of student performance in completing open-ended engineering design challenges?

This question received little attention in the evaluation activities. To date, there has been limited implementation of complete engineering design challenges, and there was limited time spent in the professional development on measuring student performance. However, there was some evidence to suggest that the emphasis on backward design principles may have a positive influence on participants' knowledge and skill with respect to assessment of student learning.

I think I look a little deeper into what I'm doing. I don't know about opportunities in their school but for but for their experiences, yeah. I think it takes them a notch further in the depth that I teach. I think the application, the analysis and synthesis of what we're doing, is where I'm taking them a little bit farther.

Maybe application and a lecture on future careers – what they're interested in to study in college. Because a couple of people do voice that they'd like to be engineers.

Hopefully I can make my projects more realistic so I tend to ask more from the kids as they start getting involved in a project. Hopefully the old projects and new projects won't be so much step 1, step 2, step 3. Because the idea is for them to understand it and gain an appreciation for the work that they're doing.

Summary

Engineering education, science, and mathematics teachers who participated in the NCETE professional development program indicated that learning about engineering design is valuable and applicable to their disciplines. Mathematics teachers, in particular, were attracted to the possibility of being able to tie engineering design into math and other abstract concepts and applications. Other aspects of the professional development that attracted teachers to sign up were the introduction to projects to apply directly into their classrooms, course credit, and the stipend.

The internal evaluators identified four major findings attributable to implementation of the professional development model. These major findings are summarized below:

Finding 1: All participants indicated that they have used some of the teaching strategies and steps in Engineering Design in one or more of their classes.

While all participants recognized value in the program and implemented some aspects of engineering design in their classes, there was considerable variance in the degree to which participants used elements of engineering design. Implementation included use or one or more complete engineering design challenges into the classroom, presentation of the engineering design steps or a concept, providing information on the profession of engineering, using backward design in lesson planning, and utilization of engineering design notebooks.

Finding 2: Most participants indicated that they did not implement a complete Engineering Design challenge in their classes. Reasons for this finding included appropriateness of the content, the time required to fully implement a challenge, and lack of interest or feasibility with their current curriculum.

In cases where a full engineering design challenge was not viewed as feasible, teachers worked on incorporating some of the engineering design steps (e.g., considering alternatives to a problem). Few teachers reported incorporating their own engineering design challenge into their classroom. More teachers used a previously developed engineering design challenge in their classroom. The majority of teachers were unable to include a design challenge into their classrooms, however, they maintained an interest and intent in implementing a challenge in the future.

In addition to implementing new engineering design content and challenges, teachers noticed changes in their approaches to teaching as a result of the professional development. A common change among the teachers, regardless of their subject area, was the inclusion of more group work and the discussion of their group experience. There was a move away from more teacher centered, lecture styles of teaching to student centered. The professional development experience encouraged teachers to take a more hands on approach in their classes and aim for more application of concepts. In essence, *participants tended to place more value on what they learned about teaching processes or pedagogical strategies, then on development and implementation of specific engineering design challenges*.

All teachers who participated in post-implementation interviews expressed a great deal of appreciation for the commitment made by course instructors. The participants described instructors as “qualified,” “dedicated,” and “knowledgeable.” Teachers reported coming out of the workshop feeling personally enriched. The engineering design process as presented in the workshops was considered an excellent model to work with and teach.

There were numerous aspects to the overall program that teachers viewed favorably. The activities and demonstrations of how to incorporate more group work into a classroom were very well received. Additionally, teachers found the development of their own engineering design challenge to be a rewarding experience and they appreciated the flexibility of the developers when choosing a project. Smaller projects that were already developed were received positively. The Barbie Bungee in particular was considered a project that could easily be brought into a variety of classroom settings and potentially tied into existing curriculum.

Teachers reported obtaining support from various sources as they worked towards implementing engineering design into their classrooms. These enablers included the availability of experts in the field of math and engineering, support from other teachers or a principal, guidance by developers on where to locate additional material (e.g., websites), and excitement from students upon presenting engineering design material.

Finding 3: All participants indicated students derived benefits from teaching strategies or elements of activities from the PD that they were able to implement. These benefits included an increase in critical thinking, more student-centered focus, improved attitudes toward group work, increased interest in abstract subjects such as math.

All of the teachers viewed the infusion of engineering design and related teaching strategies into their classrooms as beneficial to students regardless of their level of implementation. Some of the benefits listed included providing students with a sense of accomplishment in seeing a project through, increasing understanding of engineering, increase in critical thinking, providing of a more student centered environment, improved attitudes to group work, and increasing student interest in more abstract subjects like math. Teachers have also found that their students like the integration of a project into a math class, and exposure to different apparatuses. Some teachers indicated that more of their students showed an interest in engineering as a career option as a result of participation in an engineering design related activity.

Finding 4: Most participants indicated value associated with working with other teachers (interdisciplinary teaming) on activity development and implementation.

The teachers appreciated the opportunity to work with other teachers with expertise in other subject areas. Working together with a more diverse group of colleagues was reported to be motivating. Some of the participants shared that they were actively forming relationships with teachers from different subject areas or that were working more closely with colleagues teaching the same subject areas. There was some ongoing communication between schools through email. Most teachers had shared their NCETE professional development experience with at least one other teacher in their school and were hopeful about opportunities for collaboration in the future.

Overall, teachers found the professional development to be meaningful. Some of the more meaningful aspects of the program were: interactions with university professors in an academic environment; relationship building with other teachers and the developers; increased awareness of education system beyond one’s school; the creation of unique projects; and learning about backwards design as a strategy for lesson planning.

Recommendations

The evaluators identified the following recommendation based on evidence through the summer 2008 workshop:

Participant feedback from post-workshop evaluation efforts suggest that *NCETE PD staff may want to consider increasing emphasis in the workshops on the value added to student knowledge, skills, and attitudes as a result of group problem solving activities* using engineering design principles. One method employed by other professional development programs is to provide teachers with opportunities to pilot activities with summer school students. This opportunity enables teachers to implement at least one evaluation and revision cycle prior to full implementation during the school year. Providing this trial opportunity also enables teachers to pilot assessment measures to assess student understanding. It may also strengthen perceptions among participants that students will benefit from the activities.

The evaluators identified the following recommendations based on evidence collected throughout the year-long implementation:

Teachers identified a number of areas requiring improvement for future cohorts. Although the opportunity to create their own engineering design challenge was a highlight of the program for many, there was a desire to have *more short-term projects taught by the developers during the workshop*. The development of larger classroom challenges was viewed as very time and labor intensive.

Additionally, there was an expressed need *to align challenges to current high school curriculum*. The majority of teachers interviewed shared their concern with attempting to implement challenges in their classrooms without first going through the curriculum and finding units that could be matched with an engineering design challenge.

The teachers were forthcoming in reporting their struggles with some of the content taught. In particular, teachers without a math background suggested *additional assistance to gain more confidence in applying different math formulas*. The teachers own difficulties with some of the content more generally led to some apprehension in taking the content and applying it at a lower level in their own classrooms. Numerous teachers shared the belief that some of the content appeared to be beyond the level of most high school students as it was presented and would require significant planning on the teachers part to make it accessible to their students.

Additional concerns expressed by the teachers were time constraints due to seemingly rigid curriculum guides, lack of additional time to properly prepare challenges to bring into the classroom, a loss of reminders after the professional development to implement engineering design challenges and related content, and lack of resources within the school. One of the facilitators suggested that several of the concerns could be addressed by *extending the professional development model over two years*.

For the most part, participants reported having little awareness of any changes in formal partnerships or agreements between schools and the university, however they did acknowledge improved relationships between teachers and university faculty. To date, there have been no significant changes made to program offerings as a result of the teachers participation in the professional development. Participants generally believe that they are not in a position to suggest or work towards creating new courses or curriculum. One teacher that was in the midst of developing a new engineering course in his school with another teacher did credit NCETE for providing him with knowledge and ideas to bring into the new course. Teachers did mention that there were improved communication lines with developers and content experts. This suggests that additional attention be directed toward pre-implementation phases. In particular, professional development facilitators should *cultivate and nurture support from school administrators and curriculum developers*.

APPENDIX A: Spring Meeting Notes

NCETE Spring Meeting
May 22-23rd, 2008

Student presentations that occurred on the Thursday of the conference highlighted the diversity of student research interests. It was evident however, that some NCETE members and outside observers were concerned with lack of cohesiveness across student presentations. It was unclear if there was an attempt to group particular presentations together based on similarities. A different approach to grouping the presentations may have illuminated where common research interests lie. It was noted on Friday that there was a focus on teachers rather than student learning across the students' studies. This leads to the question of how can NCETE assist students in conducting research that is more in line with the interests and needs of NSF among other funding bodies. Additionally, it appeared as though student committees require more diversity that entails including members from different departments. This will provide students with a solid knowledge base when developing and conducting research projects.

The audience appeared visibly fatigued as a result of the lengthy presentation day on Thursday. Future workshops with an emphasis on student research may consider taking an approach similar to a full conference where poster presentations can assist in reducing the number of paper presentations and provide students with an additional presentation option.

It was difficult to ascertain what NCETE's program goals are based on the student research or whether or not there was a desire for student research to line up with the program goals. If the goal is to align student research with NCETE's goals then more direct means of communicating this may be considered.

The student panels that addressed under-representation and the role of engineering in faculty in professional development allowed students to voice their opinions and led to some lively debates. However, it may have been a little unclear what prompted NCETE to focus on these two issues over others. Thus, more background information on the importance of these topics would have been helpful to the audience.

Overall the meeting was very informative and provided a wonderful opportunity for students to present and receive feedback on their research interests. The showcase of student interests illuminated the difficulty that the Center has experienced in moving forward with a more cohesive research agenda. With an increased awareness of the state of affairs for Center research fruitful discussions on the importance of moving towards a more cohesive research agenda ensued. Additionally, research areas that are most likely to provide an impact in the field were discussed. While there was general agreement at the end of the workshop that shifts in direction were needed there was not adequate time to actually develop an action plan for how to go about making changes in the Center's approach to research.

APPENDIX B: NCETE Summer PD Agenda/Schedule

Monday, July 14, 2008

8:00 While we wait on folks to arrive, establish a locker in the lab for yourself.

Welcome

Form STEM teams: When you need to work in groups, here are the group memberships.
Team 1: Anne, John, Tyler
Team 2: Brandon, Richard, Kenneth
Team 3: Tim, Kezia, Renferd

What were the advantages and disadvantages of the online portion of the spring professional development?

Goals for Summer PD:

Continued from Spring:

1. Work as a team of science, technology, engineering and mathematics teachers in order to make good decisions.
2. Apply mathematical principles and analysis in design; Apply scientific principles and analysis in design; Design within constraints; Apply the engineering design process
3. Teachers review the content knowledge of the engineering design process in order to transfer that knowledge to the design of their own EDCs.

Summer:

4. Prepare teachers to analyze performance of individual students and student groups on design challenges.
5. Examine and critique curriculum and instructional materials for infusing design into standards-based STEM instruction; propose motivating lessons for STEM classrooms.
6. Teachers become refreshed on the procedures for instructional design as learned in the spring.
7. Create motivating lessons for STEM classrooms.
8. Practice implementing design in the classroom; practice assessing student performance.
9. Give teachers an understanding what we hope to accomplish during the school year.

What is on your CD.

8:30 The Bungee Cord - Engineering Design Challenge
This will be led by Ali. He will walk us through the steps of solving this challenge, and teachers will follow along.

1. Work as a team of science, technology, engineering and mathematics teachers in order to make good decisions.
2. Apply mathematical principles and analysis in design; Apply scientific principles and analysis in design; Design within constraints; Apply the engineering design process
3. Teachers review the content knowledge of the engineering design process in order to transfer that knowledge to the design of their own EDCs.

Opening challenge related questions:

- How complete is your engineering notebook from the Food for the World Challenge?
- What is the main thing that the engineering notebook has taught you regarding how you will manage your students?

1. Vincent will administer the Bungee Cord pretest.

9:00 Bungee Cord Activity

2. Ali will show us how to make preliminary measurements.
3. Teachers will make preliminary measurements
4. Barbara will walk us, step-by-step through the construction of a predictive analysis, using a spreadsheet that will help us design bungee cords. Teachers construct spreadsheets as she does this. Barbara shows a step. Teachers implement the step on their spreadsheets…

10:00 Break 15 minutes

12:00 Lunch

1:00 Bungee Cord continues

5. Ali will show us how to manufacture and test and verify our bungee cords, designed based on the spreadsheet predictions.
6. Teachers will construct their engineering notebooks (your choice of hardcopy or electronic), but use the Childress engineering notebook as a guide.

3:00 Break 15 minutes

4:00 Discussion

- How or how not does the Bungee Cord EDC meet the criteria for an activity that infuses engineering design?
- How does it or how does it not address any of the learning outcomes or standards that you have to teach your students?
- Feasibility; how could it be modified by you to teach to your students?
- In terms of mathematics, science, and engineering, what did you learn from the activity?
- How complete is your engineering notebook?

4:45 Clean-up

5:00 Dismissal

Tuesday, July 15, 2008

8:00 Complete your engineering notebooks from the Bungee Cord EDC.

1. Prepare teachers to analyze performance of individual students and student groups on design challenges.

9:00 Vincent administers Bungee Cord posttest.

10:15 Switch engineering notebooks with another group.
Apply the Bungee Cord rubric to the assessment of the teacher whose notebook you receive. Mark the rubric cells and write comments on the rubric.

Criteria for a Well Designed Written Test
You all seemed to understand what is required to develop a rubric based on your responses to the spring online discussion, but what does it take to design a good written test?

Validity: Does the test measure what it is supposed to measure in terms of content?
Reliability: Does the test measure consistently over time?
Objectivity: Would the student score the same grade if two different teachers graded the test independently? Multiple choice tests tend to be more objective than variable response items such as essays.

A common threat to validity is that you don't start the instructional design with content standards and decide what assessments will be appropriate before designing the learning activity.
A common threat to validity is a test that is too wordy with items that are not clearly written. You end up testing reading skill instead of the content under examination.
A common threat to reliability is designing a test that is too short. A test with, say, 25 items would not make up for a student guessing correctly, but a test, with, say, 100 items would balance and give a truer differentiation between those who know the content and those who do not.
If a test is too challenging or not challenging enough, it may be less reliable.

For multiple choice items, the stems should be grammatically correct sentences and longer than the answer choices. The possible responses must all be plausible without being "tricky," and you need at least four of them. If you cannot "dream up" four possible response, then make the item a short response item.
For true/false items, avoid suggesting that a statement is true of false by accidentally using words that give it away.
Use the Bungee Cord pretest/posttest as a guide for writing your tests.

11:00 Homework from Spring online PD

1. Teachers become refreshed on the procedures for instructional design as learned in the spring.

Examine the components of the "Lesson Plan Format for Teachers.doc" and the "Challenge Format for Teachers.doc."

11:30 Share ideas for activities you identified in your existing curriculum that can be infused with engineering design. (Tim's main idea is too secret to share! Just kidding, he does not want to spoil the surprise when he ends up having to teach it to you, but he can describe it using generalities.)

1. Examine and critique curriculum and instructional materials for infusing design into standards-based STEM instruction; propose motivating lessons for STEM classrooms,

Share your ideas and state why or why not you suspect that your idea will meet the criteria for an activity that qualifies as teaching engineering design.

Criteria for Identifying an Engineering Design Activity
Has a motivating, grade level appropriate and realistic scenario.
Has all of the engineering design steps explained.
Includes mathematical and scientific based analysis.
Is predictable.
Uses mathematics and science to optimize some aspect of a possible solution.
Includes a component in which students physically verify their predictions.

1:00 Sharing ideas for activities continues

2:00 Begin developing your instructional units: EDCs and lesson plans.

1. Create motivating lessons for STEM classrooms.

Here are the criteria for deciding how well your instructional design efforts are going.

Criteria for Instructional Design
Identified a standard to be achieved.
Identified how the teacher would know if a student understands the construct.
Plan includes prerequisite instruction.
Plan includes a main lesson that -
-Motivates students to learn (based on the engineering design challenge scenario).
-The steps in the lesson make clear how the student is to apply main constructs and prerequisite skills to the solution of the problem in the engineering design challenge.
-Prompts students to document important indicators of success that will be used to assess student achievement.
-The lesson makes clear to students how they will be assessed.

Criteria for Student Assessment
Developed a rubric based on the standards/objectives identified as important to achieve.
Describes in adequate detail those indicators for student achievement that are above, at, and below standard.
Students are able to read the rubric prior to instruction and understand what will be expected of them during instruction.
Develops additional assessments that have worked for the teacher in the past such as, essays, observation checklists, written tests, criteria sheets for prototype development, student presentations, student portfolios, engineering notebook, group discussion, web sites and online portfolios, etc.

Develops a strategy for assessing both the group and the individual students within the group.

You'll be in two groups with four or five teachers and the facilitators split between the two groups. You'll have 2 to 3 hours to present a lecture type of lesson and demonstrate the EDC sample solution. So your practice teaching will not be exactly like the way you might teach your students, but it will be pretty close. Colleagues and facilitators will complete the assessment form ("Practice Teaching Assessment Instrument 070108.doc") below while participating as if they were your students.

Teacher Being Observed: ___________________________
Rating Scale:
Below Minimum Expectations = 0, Meets Minimum Expectations = 1, Exceeds Expectations = 2

	Rating	Notes
Instructional Design		
1) The standard to be achieved is clearly identified		
2) Multiple means are provided for assessing student understanding		
3) Prerequisite instructions are provided before introducing the engineering design challenge		
4) The lesson components will motivate students to learn engineering concepts		
5) The lesson will enable students to apply constructs and prerequisite skills to resolve the engineering design challenge		
6) Students are prompted to document important indicators of their success		
7) The assessment strategy is clear and readily understandable by students		
Engineering Design		
1) The content and engineering design challenge presented are grade appropriate		
2) The engineering design challenge presents a realistic scenario		
3) The lesson includes an explanation of each of the engineering design steps		
4) The design process requires analysis based on mathematical and/or scientific principles		
5) The solution to the engineering design requires students to optimize one or more variables		
6) The engineering design challenge requires students to predict outcomes		
7) Students are required to verify their predictions using a prototype, model, or simulation		
Student Assessment		
1) The rubric for student assessment is based on identified standards and objectives		
2) Student indicators of achievement specify what constitutes performance at, above and below expected standards		
3) Students receive a copy of the rubric prior to beginning their work and understand what is expected of them		
4) The rubric is supplemented by alternative assessment strategies (i.e., essays, observation checklists, tests, portfolio, prototype)		
5) Strategies are provided to assess the work of individual students and working groups		

Wednesday, July 16, 2008 (8:00 to 5:00 with 12:00 – 1:00 lunch and breaks as needed)

Continue designing EDCs and lessons

- To what extent is the design meeting all of the criteria for Engineering, Instructional Design, and Assessment?
- Anticipate what supplies Vincent needs to buy at the store. Let him know.

Thursday, July 17, 2008 (8:00 to 5:00 with 12:00 – 1:00 lunch and breaks as needed)

Finish designing EDCs and lessons

- Try out the physical parts; such as will your sample solution really work?

Friday, July 18, 2008 (8:00 to 5:00 with 12:00 – 1:00 lunch and breaks between lessons)

Practice teaching EDCs and lessons.

1. Practice implementing design in the classroom; practice assessing student performance.

- You'll be in two groups with four or five teachers and the facilitators split between the two groups.
- You'll have 2 to 3 hours to present a lecture type of lesson and demonstrate the EDC sample solution. So your practice teaching will not be exactly like the way you might teach your students, but it will be pretty close.
- Colleagues and facilitators will complete the assessment form above while participating as if they were your students.

Monday, July 21, 2008 (8:00 to 5:00 with 12:00 – 1:00 lunch and breaks between lessons)

Continue to practice teaching EDCs and lessons.

Revise EDCs and lessons based on feedback from teachers and facilitators

Tuesday, July 22, 2008 (8:00 to 12:00)

What did I do to improve my EDC and lesson?

What did I gain this summer?

What to expect and do in the Fall?

We need you to teach with the pretests and posttests the Food for the World Challenge and the Bungee Cord Challenge as part of our research.

1. Give teachers an understanding what we hope to accomplish during the school year.

PD participant evaluations of the Summer PD

Reimbursement paperwork

Present certificates

School Year Professional Development Extensions

Classroom Visitation Program (12 of 100 hours)

Professional development extends into the classroom with professional development providers and teachers providing feedback on the process of implementing what was learned in professional development and proceeding with instruction. Garet, Birman, Porter, Desimone, Herman, and Yoon (1999) reported that teachers who had support after professional development believed that instruction improved. However, teachers with no post professional development assistance did not report improvement at the same level. Loucks-Horsley, et al. (2003) recommend that once teachers have had a chance to implement what was learned in professional development that they enter a cycle of reflection, support, and practice.

School Year 1: Center professors observe and offer feedback on instruction

Objective:
To motivate teachers to implement what they learned in professional development

Activity:
In order to extend professional development into the classroom and increase the likelihood of meaningful and timely implementation of what was learned in professional development, Center professors will observe and help teachers in the implementation process.

Outcome:
Teachers implement and implementation meets the criteria above.

Success Indicator:
Teachers implement and implementation meets the criteria above.

School Year 2: Teachers visit each other's classes

Objectives:
Manage the classroom implementation of design in courses; Implement design in the classroom; Reflect on classroom practice

Activity:
Teachers visit each other's classes during the observer's planning period so long as the teachers are located nearby or within the same school. (Provide a feedback/observation form so that teachers can reflect on their observations and instruction.) This modified lesson study provides a context for collaboration that focuses on lesson development and lesson effectiveness. However, a number of strategies may be used to satisfy this objective of professional development. For example, teachers who work far apart could arrange for students to stay after school to be taught while the visiting teacher(s) observe(s). Teachers who live very far away may submit videotaped lessons to peers and PD providers in order to share and solicit feedback.

Outcomes:
pacing guide, discussion, teachers try out their lesson with their students; fellow teacher observation notes and/or PD provider notes and teacher's realizations about himself or herself. also one-minute papers and videotape of discussion

Success Indicators:
Initial and sustained implementation, the existence of a network/learning community of teachers.

School Year 3: Administer follow-up surveys to teachers

Activities:
After teachers have implemented engineering design in their curriculum and instruction, and been provided feedback from PD providers and peers, they will then be ready to complete the NCETE PD follow-up survey.

Professional Development Closure

Cohort Meeting (3 of 100 hours)
The cohort meeting is a way to bring professional development to a final close and still encourage participants to continue to infuse engineering design into the curriculum and to encourage them to participate as alumni in the further discussion and interaction.

End of School Year: Participant meetings.

Activity:
Spring of implementation year; includes all teachers who have had professional development so far in the geographic area. The purpose of this meeting is reflection and feedback in order to establish a community of

learners, which is one level up from the technology, science, and mathematics teachers' small learning community at the school level.

Present certificates of completion, publicity news releases, and a letter of recognition

Reflect on:

- Extent to which professional development addressed the overall goals.
- Extent to which planning time and having follow-up in the classroom helped.
- Extent to which teacher knowledge and attitudes changed.
- Previous reflections.
- Changes in student learning.
- Lab management and cooperative learning reflections.
- Content mastery reflections.
- To what extent do teachers believe that teachers can infuse engineering design into existing curricula.

APPENDIX C: Pre-Workshop Frequency Tables

Engineering Design Professional Development

	Yes	**No**
Previous professional development in engineering design	5 (20%)	20 (80%)
Will you incorporate engineering design into your courses	24 (96%)	1 (4%)

Computer and Internet Use

	Not at All	Daily	Several Times a Week	Week-ly	Month-ly	Occasion-ally
How often do you use internet resources when developing activities	1 (4%)	3 (12%)	8 (32%)	6 (24%)	0 (0%)	7 (28%)
Frequency of computer-based activities in your classes	2 (8%)	6 (24%)	3 (12%)	3 (12%)	2 (8%)	7 (28%)
Student access to computer lab/classroom set of computers	1 (4%)	12 (48%)	4 (16%)	3 (12%)	1 (4%)	4 (16%)

Engineering Design Components Currently Using (Pre-NCETE PD)

Component	**Yes**	**No**
Identification of a need	13 (52%)	12 (48%)
Definition of a problem/specifications (design problem)	19 (76%)	6 (24%)
Search for existing design	13 (52%)	12 (48%)
Develop designs	13 (52%)	12 (48%)
Analysis of alternative designs including simulations	8 (32%)	17 (68%)
Decision (matrix)	6 (24%)	19 (76%)
Test prototype	9 (36%)	16 (64%)
Communication (report)	9 (36%)	16 (64%)

Teacher Preparation

	Yes	**No**	**N/A**
I am adequately prepared to use ED in my class	6 (24%)	12 (48%)	7 (28%)

Student Exposure to Engineering Design

	Never	Daily	Almost Daily	At Least Weekly	At Least Monthly	Occasion-ally
On average, students in my class are exposed to ED components	32	12	4	24	28	0

Current Classroom Activities

	Daily	Weekly	Monthly	Rarely
Individual projects	2 (8%)	4 (16%)	6 (24%)	13 (52%)
Use engineering design for cooperative learning projects	2 (8%)	2 (8%)	10 (40%)	11 (44%)
Student group projects include engineering design	2 (8%)	2 (8%)	7 (28%)	14 (56%)
Students develop their own learning environment for engineering design	2 (8%)	1 (4%)	2 (8%)	20 (80%)

Outside Individuals Assisting Students with Engineering Design

	Yes	**No**
Business partners	9 (36%)	16 (64%)
College/University Partners	2 (8%)	23 (92%)
Content experts	5 (20%)	20 (80%)
No outside partners	9 (36%)	N/A

Student Access to Engineering Design Materials and General Exposure

	Yes	**No**
Engineering design in other academic classes	14 (56%)	11 (44%)
Access to one or more engineering design texts in my classroom	6 (24%)	19 (76%)
Engineering resources for student use within the school	17 (68%)	8 (32%)
Evidence of student use of engineering design on display in my school	12 (48%)	13 (52%)

Teacher Engineering Design Resources and Incentive to Infuse Engineering Design into the Classroom

	Yes	**No**
Scheduling options allow for the addition of new curricular materials	12 (48%)	13 (52%)
I have access to curricular materials that include engineering design components	5 (20%)	20 (80%)
Local resource people are available to assist me with engineering design activities	3 (12%)	22 (88%)
The school has staff/resources to assist me with integrating engineering design activities into my classroom	6 (25%)	18 (75%)
The state curriculum mandates that technology education incorporate engineering design	5 (20%)	20 (80%)
The inclusion of engineering design in required by state standards	5 (20%)	20 (80%)
I believe my students would be interested in learning about engineering design	11 (45.8%)	13 (54.2%)

Best Approaches for Integrating Engineering Design Components into Teaching and Learning

	Yes	**No**
Specialized group activities	20 (80%)	5 (20%)
Lecture	8 (32%)	17 (68%)
Individual projects	19 (76%)	6 (24%)
Involvement in community, state, and national science and engineering competitions	7 (28%)	18 (72%)
Through integration of engineering principles in other science	15 (60%)	10 (40%)

classrooms		

Current Implementation of Engineering Design

	Yes	No
I am proficient at developing instructional activities that require students to understand engineering design components	6 (24%)	19 (76%)
I implement instructional activities that require students to demonstrate their knowledge of engineering design concepts	10 (40%)	15 (60%)
I share my engineering design approaches with other teachers	8 (32%)	17 (68%)
I introduce other teachers to engineering	4 (16%)	21 (84%)
I integrate community resources into classroom learning activities	9 (36%)	16 (64%)

Confidence with Engineering Design

	Not Confident	Confident	Very Confident
How confident do you feel in your ability to integrate engineering design into your curriculum	7 (28%)	15 (60%)	3 (12%)
How confident do you feel in your ability to support other teachers with the integration of engineering design into their classrooms?	10 (40%)	12 (48%)	3 (12%)

Current Assessments Used

Assessment Type	Yes	No
Portfolios	6 (24%)	19 (76%)
Rubrics	14 (56%)	11 (44%)
Checklists	11 (44%)	14 (56%)
Tests	13 (52%)	12 (48%)
Quizzes	13 (52%)	12 (48%)

Type of Teacher/Student Role that you Believe Best Supports the Integration of Engineering Design into your Classroom

	Strongly Student-Centered	Mostly Student Centered	Mostly Teacher Centered
	5 20%)	17 (68%)	2 (12%)

APPENDIX D: Post-Workshop Frequency Tables

Engineering Design Challenge Preparation

	Strongly Disagree	Disagree	Agree	Strongly Agree
Improved ability to prepare engineering design challenges for students	0	1 5.9%	8 47.1%	7 41.1%

Expected Student Responses

	Strongly Disagree	Disagree	Agree	Strongly Agree
Students will enjoy working on engineering design challenges	0	2 (11.8%)	4 (23.5%)	11 (64.7%)
Students will benefit from infusing engineering design into classes	0	1 (5.9%)	7 (41.2%)	9 (52.9)

Teacher Preparedness and Confidence

	Strongly Disagree	Disagree	Agree	Strongly Agree
Greater understanding of engineering theoretical foundations	0	0	4 23.5%	11 76.5%
Greater understanding of hands on applications of engineering concepts	0	1 5.9%	5 35.3%	10 58.8%
Greater understanding of what makes an activity/concept engineering design	0	1 5.9%	5 29.4%	10 64.7%
Greater understanding of math knowledge needed to understand engineering concepts	0	0	10 58.8%	7 41.2%
Greater understanding of science knowledge needed to understand engineering concepts	0	1 5.9%	7 41.2%	9 52.9%
Feel better prepared to infuse engineering design into my classroom	1 5.9%	1 5.9%	9 52.9%	5 35.3%
More confident in my ability to infuse engineering design into my classroom	0	1 5.9%	11 64.7%	5 29.4%
More confident in my ability to support other teachers with infusing engineering design into their classes	0	2 11.9%	6 41.2%	9 47.1%
More confident in my ability to develop assessments for engineering design activities	1 5.9%	1 5.9%	10 52.9%	5 35.3%

Expected Use of NCETE Taught Concepts and Techniques

	Never	Daily	Weekly	Monthly	Quarterly/ Semester	Annually
Will use math techniques learned at NCETE in the next academic year	1 5.9%	2 11.9%	1 5.9%	4 23.5%	6 41.2%	2 11.9%
Will use science techniques used at NCETE in the next academic year	2 11.9%	1 5.9%	2 11.9%	4 23.5%	5 35.3%	2 11.9%
Will use engineering design concepts learned at NCETE in the next academic year	0	1 5.9%	4 23.5%	3 17.6%	6 35.3%	3 17.6%

Ranking of Best Approaches for Integrating Engineering Design into Learning

	Best Approach	Second Best Approach	Third Best Approach	Fourth Best Approach
Specialized group activities	15 88.2%	2 11.9%	0	0
Lecture	0	0	4 23.5%	13 76.5%
Individual Group Projects	1 5.9%	14 82.4%	2 11.9%	0
Involvement in Science and Engineering Competitions	1 5.9%	1 5.9%	11 64.7%	4 23.5%

Workshop Satisfaction

	Strongly Disagree	Disagree	Agree	Strongly Agree
Satisfied with amount of time spent with developers	1 5.9%	2 11.9%	6 35.3%	8 47.1
Overall, satisfied with professional development	0	2 11.9%	5 29.4%	10 58.8%
Would recommend the NCETE professional development series to other educators	0	1 5.9%	5 29.4%	11 64.7%
Valuable to work in teams with other teachers	0	0	4 23.5%	13 76.5%

APPENDIX E: Plans For Teacher Implementation Of The NCETE Pilot Professional Development Effort In Their Classrooms During The 2008 – 2009 Academic Year

The following is based on the items under agenda item 1 from the agenda for the September 19, 2008 Salt Lake City planning meeting.

Goals

The primary goal of school year activity is to accomplish NCETE PD Goal 7 and NCETE PD-related Goal 8.

7. *Infuse engineering design experiences in their science, technology, and mathematics on a regular, on-going basis so their students acquire key engineering concepts while exploring the STEM disciplines* (Mundry, 2007).
8. *Assess the effectiveness of the professional development model* (Tushnet, et al., 2006).

Therefore, our practical, tactical goals are to:

☐ Assist teachers in the implementation process by visiting each teacher to observe instruction for the purpose of providing feedback on how to improve instruction and on how to overcome obstacles to implementation.

This advice will be documented through notes kept by the observer. This advice emphasizes engineering design related content, but may also include input related to instruction or other issues. Additionally, indicators for success, used to evaluate and revise the PD model will also be used to provide feedback advice for teachers.

☐ Observe teachers in the implementation process in order to gather indicators of the extent to which teachers are successful at implementing what was learned by them during the spring and summer professional development activities. Administer (if agreed) the teacher and student survey.

These indicators are being gathered for the purpose revising the PD model and for providing advice to teachers on improvement.

☐ To enhance the professional development opportunities and the development of teaching and learning communities, members of the Cal State L.A. cohort will gather for two or more meetings to share their implementation experiences to date. 9This may include members of previous professional development cohorts, where appropriate.] Due to logistical limitations, North Carolina A&T will provide similar opportunities through online meetings.

Teachers will be encouraged to visit each others classrooms during implementation of the engineering design challenge lessons to enhance collegial cooperation and further foster development of teaching and learning communities

☐ Gather teachers for a final meeting in which the teachers reflect and share experiences. Discussions will related to items in the following list. Emphasis will also be placed on teachers identifying themselves as a learning community, which is an effort to address Goal 4 even though Goal 4 was also addressed during the summer PD effort.

4. *Engage in reflective practice as members of the learning community by analyzing instructional effectiveness, modifying lessons, and revising materials in order to improve subsequent instruction* (Garet, Birman, Porter, Desimone, Herman, & Yoon, 1999; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003)*;*

Teachers will reflect on and discuss:

- Extent to which professional development addressed the overall goals.
- Extent to which planning time and having follow-up in the classroom helped.
- Extent to which teacher knowledge and attitudes changed.
- Previous thoughts and reflections.
- Changes in student learning behaviors.
- Lab management and cooperative learning reflections.
- Content mastery reflections.
- To what extent do teachers believe that teachers can infuse engineering design into existing curricula.

☐ Analyze success indicators; the criteria sheets; field notes; surveys (if agreed); teacher and student artifacts; Dan's, Sonya's, Kurt's, and Nate's notes; Cameron's and Nate's findings based on their publication; and Jim's and Jodi's findings

These data and indicators will be used to generate recommendations for what to change about the PD model.

- [ ] Write a refereed publication describing the model, its development, and its revision with recommendations for further study and use.

- [ ] Write a monograph that will provide a rationale for the PD model's design, an account of how it was revised, a description of the model, an appendix with a complete "lesson plan," and advice for using the model.

Expectations

- Each teacher is encouraged (but cannot be compelled) to implement both the Bungee Cord activity and the lesson that he or she designed in PD.
- PD providers are expected to both help teachers by extending PD into the classroom and help them succeed.
- PD providers are expected to observe for success indicators and provide for the administration of any instruments.
- Jim and Jodi are expected to administer any additional surveys that they have designed based on their understanding of the PD model.
- PD providers are expected to help motivate participants to complete any surveys designed and administered by Jim and Jodi.
- PD providers are expected to analyze the data that they collect.
- PD providers are expected to facilitate the end of the year meeting of the PD teachers.
- PD providers are expected to help write a refereed journal article about the PD model.
- PD providers are expected to help write a monograph about the PD model.
- PD providers are expected to make a presentation about the PD model this year at ITEA, ASEE, and/or regional conferences.

Activities

- PD teachers will implement what they have learned during spring and summer PD.
- PD providers will visit implementation classrooms, observe, collect data, provide feedback.
- PD providers will analyze data.
- PD providers will host a end of the year PD teacher meeting.
- PD providers will help write a refereed journal article about the PD model.
- PD providers will help write a monograph about the PD model.
- PD providers will make a presentation at ITEA and/or ASEE.

Schedules

Teachers have been asked to write back with estimates on the months in which they predict that they will implement various things that they learned in PD.

September, 2008 to May, 2009: Observation and data collection

November, 2008 to Summer, 2009	Some writing may begin
April, 2009 to July, 2009	Data analysis begins
May 30ish, 2009	PD teacher meeting
June, 2009 to August, 2009	One to two weeks' worth of effort - data analysis completes and writing completes

Logistics

Here are the anticipated logistics for field observations and helping teachers.

- Teacher must let the PD provider know of impending implementation.
- PD provider must complete a travel authorization (at A&T arrange for a hotel if needed)
- Teacher's students and parents must complete consent and assent forms in order to gather data for research.
- Principal's permission must be obtained in writing for both helping the teacher and researching the teacher and students.
- PD provider must drive to the teacher's school with notepad and criteria sheet.
- PD provider should collect, sign, and copy all consent and assent forms, meet with the teacher before classes, obtain principal's written permission, set up video camera (if permitted), observe, meet with teacher after class, visit the principal (if possible).
- Submit travel reimbursement.
- Compile data from visit.

Here are the anticipated logistics for the end of year teacher meeting (which will vary based on the differences between PD sites).

- Teachers are advised on when the meeting will take place. It needs to be during a time that is most convenient for most of the group.
- Teachers will be advised on where they can stay. They will already be used to this because of staying in hotels during the summer PD.
- On campus rooms are not a problem.
- Parking and travel reimbursement is not a problem.
- An additional idea is that if one teacher has a lot of artifacts to share with the group, this could be uploaded to the Yahoo site. We're a bit hesitant to hold this meeting anywhere except Greensboro because Greensboro is fairly centrally located to all of the A&T PD teachers.

Here are the anticipated logistics for data analysis and writing.

- Ethan and Vince work with their own CoPIs and coordinate with each other frequently.
- We may find that we need to use that 800 conference call phone number of USU's and that Web conferencing feature that the Center is using for the online core courses in order for all involved in these two tasks to communicate more effectively.

Arrangements

If this plan is revised and approved, arrangements needed to carry it out would include:

- Keeping teachers informed of what we expected and needed from them.
- Generating travel authorizations, reserving hotel rooms.
- Providing videotaping during observations.
- Providing common collaboration time for CoPIs during which data analysis and writing is coordinated.
- Setting up the end of the year teachers meeting and recording the discussions.

Protocols for observations and interactions of professional developers, teachers, and students

When visiting:

- Meet with the teacher and set him or her at ease, gather background and get orientation on what will happen.
- Get the principal's written permission.
- Collect, sign, copy and return all consent and assent forms.
- Whether the PD provider is observing and interacting in order to help with implementation or collect data, his or her interference with class should be minimized.
- Sit in the back with notepad.
- For those sites where video has been approved, set up camera so it does not have to be moved, it is inconspicuous and does not interfere.
- When the observer does not fully understand something that is happening he or she should be able to ask the teacher or a student without implying an answer.

- It should be acceptable for either the teacher or the observer to administer the survey (if agreed upon).

For observations, the observer will be looking for evidence that relates to:

The instrument attached to the end of this document will serve as a scale for those factors observed of teachers and students when possible.

Spring 1: Working as a Team Success Indicators

- The extent to which students are participating in groups.
- Evidence that the teacher or student realize the advantage of working as a group compared to working as an individual, such as a comment or infighting or the appearance of cooperation.
- To what extent do various student-developed decision matrixes reveal that students have made group decisions?
- Survey asking teacher and student opinions regarding the value of working as a group.

Spring 2 and 3: Engineering Design Success Indicators

- The teacher's apparent content knowledge regarding engineering design.
- Engineering design content is evident in discussions and comments, lesson plans, handout, engineering notebooks, student artifacts/implemented solutions, teacher assessments of students, data from student and teacher surveys, and teacher responses to external evaluator surveys.
- Teachers' sample solutions that they developed to use as teaching aids.
- Videos and one minute papers from spring PD.
- Teachers' engineering notebooks from spring and summer PD.
- Bungee Cord and Food for the World rubrics completed on teachers during spring and summer PD.

Spring 4: Developing Student Performance Assessments

- Teacher developed performance assessments (rubrics).
- Teachers' use of our Bungee and/or Food for the World rubrics with the students, where appropriate..
- See criteria and scale on the Engineering Design Challenge Lesson Observation Form, a copy of which is included at the end of this document in the Assessment section.

Spring 5 through Summer 5" Instructional Design

- See criteria and scale on the Engineering Design Challenge Lesson Observation Form at the end of this document in the Instructional Design and Engineering Design sections.
- Engineering Design Challenge proposal forms submitted during PD.
- Teacher completed and PD provider completed criteria sheets used to assess the teachers' practice presentations.
- Teachers' lesson plans in the field, the extent to which they show evidence of meeting criterion included on Engineering Design Challenge Lesson Observation Form.
- Teachers' lesson plans from summer PD, the extent to which they show evidence of meeting criterion included on Engineering Design Challenge Lesson Observation Form.
- Teacher-created examples and sample solutions developed to use as motivators or teaching aids.
- Summer PD videotaped discussions and one minute papers.

These items are independent of those additional items that Jim and Jodi have or will ask teachers through surveys.

Meeting IRB requirements

Each campus will need to handle these issues based on their campus protocols. At North Carolina A&T, the current IRB simply needs to be updated with an "amendment" form submitted to the IRB with the above protocol and the instrument at the end of this document. Other IRB procedures have been outlined above regarding principal, parent, and student consents and assents. Teachers have already completed consent forms that have descriptions that are not changed by any information contained in this document. Cal State L.A. is in the process of clarify campus requirements for this phase. It proceed as prescribed by campus leadership.

Logic Model – goals, activities, outcomes, indicators

This part of the "narrative/rationale" document needs to be revised to better reflect what is included in the "lesson plan" document.

Evaluation criteria

The primary evaluation criteria are the extent to which we were able to meet the goals listed in the "narrative/rationale" document. For example, how many teachers implemented? How many teachers reached sustained implementation? Therefore, the evaluation criteria are also those data described in the protocol above. The extent to which findings from the data collected cause changes to the PD model is perhaps some measure of the success of the PD model's original design. The extent to which changes to the PD model are based on collected data should be a criterion for the "value" of the revised PD model.

Evaluation procedures

The data analysis, I think, has to be considered as a big picture. What are the trends across the teachers. Did only one try the Food for the World Challenge or did most teachers try it? How many teachers implemented the lesson that they designed in PD? Then these trends will help us to decide whether or not a goal was met and whether or not a PD model component needs to be changed.

Budgetary requirements

Budget proposals were submitted already as separate documents.

ENGINEERING DESIGN CHALLENGE LESSON OBSERVATION FORM

Engineering Design Challenge: ____

Course: ______________________________________ Teacher: __________________________________

Teacher Activities: ____ Date: ________________

Student Activities: ____ Day Number ______ of _______

Rating Scale:

0 = No evidence
1 = Below desired level – incomplete and/or unclear or confusing
2 = Complete – all criterion observed with opportunities for improvement
3 = Meets minimal expectations – all aspects effectively achieved
4 = Exceeds expectations – multiple presentations, examples strategies incorporated

	Rating	**Comments**
Instructional Design		
The standard to be achieved is clearly identified		
Multiple means are provided for assessing student understanding		
Prerequisite instructions are provided before introducing the engineering design challenge		
The lesson components will motivate students to learn engineering concepts		
The lesson will enable students to apply constructs and prerequisite skills to resolve the engineering design challenge		
Students are prompted to document important indicators of their success		
The assessment strategy is clear and readily understandable by students		
Engineering Design		
The content and engineering design challenge presented are grade appropriate		

The engineering design challenge presents a realistic scenario		
The lesson includes an explanation of each of the engineering design steps		
The design process requires analysis based on mathematical and/or scientific principles		
The solution to the engineering design requires students to optimize one or more variables		
The engineering design challenge requires students to predict outcomes		
Students are required to verify their predictions using a prototype, model, or simulation		
Student Behaviors		
Students are engaged in active learning		
Students are working in teams		
Students appear motivated		
Student Assessment		
The rubric for student assessment is based on identified standards and objectives		
Student indicators of achievement specify what constitutes performance at, above and below expected standards		
Students receive a copy of the rubric prior to beginning their work and understand what is expected of them		
The rubric is supplemented by alternative assessment strategies (i.e., essays, observation check-lists, tests, portfolio, prototype)		
Strategies are provided to assess the work		

of individual students and working groups		

Appendix F: Post-Implementation Participant Interview Protocol and Results

Professional Development Activities

1) What attracted you to it sign up for the program? (value to you)

Initially it just sounded interesting and I knew about the course credits which would go towards my salary count. At the time I was quite broke so I was looking for anything extra money wise. But at the time it sounded interesting to me and I have enjoyed building and creating- engineering and bringing it into the classroom.

I've been teaching for 8 years now and have an engineering background. I agree with the program how it's trying to infuse engineering principles into, at least for me, into my math curriculum, where the kids see a relevance to the method they are doing. I teach adv math so I think it fits well into the engineering principles. I just thought I would give them a diff look at things and I agree with that.

I've got an engineering background and I teach an engineering class so I'm always looking for something new and exciting to get the points across.

The academy that I teach under at my high school is global technology. I thought that for the demographic that I work with, the program sounded like something that would be good and it would appeal to my students and would be beneficial for me to learn some. And also because I try to get some activities that I tie in the math content to real life and I thought this would give me an opportunity to learn how to do that.

The district said that they were curious if people wanted to know a little bit more about engineering technology and different things for the education system. And I was moving into architectural drafting and we're starting a program here called ACE – and it stands for architectural construction and engineering. And so I thought it might be interesting for me to be able to – along with my ability to graph and do architecture on the computer – to know something about the engineering aspect of it.

We have an architecture and engineering academy here at our school and my background in primarily in architecture. So, I've always been a bit interested in going deeper into the engineering side. To be able to offer a little bit of both.

I'm teaching an integrative math - and I am really kind of biased because I have an electronics background in college so I am kind of interested in the engineering part and how I could use it in my class. Part math and how you could introduce engineering with it. The title – when I saw engineering design and how you could integrate this into your classroom.

I had seen when I read the email for the engineering design it said that I would be learning things that I can use in my classroom. And I was really interested in doing that. I was thinking that it was going to be projects that I can use for classroom.

I am a math teacher and I used to work in the computer programming field. And this is my fourth year teaching and when I started teaching it seemed so abstract. So, it looks really attractive when they integrate engineering design or engineering projects into math especially teaching higher math.

I like to teach through application when at all possible. I don't get a lot of time to do that any more. So I was hoping to be able to get some pretty straight forward applications. To b honest I would not have done it without the stipend. It's math engineering and I teach math so it is right up my alley.

2) How would you improve the content and structure of the program?
   a. Is the content appropriate for you in what you teach?

I teach 2 classes. In one I basically create the curriculum my self so I have already implemented one of the projects and hope to implement 2 or 3 more. Yes, definitely

I teach math. Yes, I did a good job of adapting it to whatever we teach. Well suited to me. Yes, it was very pertinent and available to be modified for my classroom experience

I think that they should hook up with teachers like us, who have been through the program and teach some of these projects and adapt them to the CA standards that they have in HS. So that way when a teacher goes through this…. when we are going through they want to give us the background and all this theoretical which is great, but give us a project that is ready to go that is already aligned to the standards. If you are teaching algebra 1 and you want to teach this particular set up here you go, here is the project for these standards right here. I think that would have way more impact for teachers utilizing the projects.

I think some more time needs to be spent really dissecting….when I sat through it….. I've been working in the industry for 25 years and teaching for 7 years and working with youth for my entire life so I had no problems…but when some of these teachers got up there to present their presentations in NC, I'm sitting there thinking OMG you are in front of a classroom? Maybe we are not "tearing" them up enough. I don't know if its going to buy anything but it bothered me- maybe I'm wrong,

I thought it was great. The only thing was, for me and I think I was unique in the program, it didn't have a lot of small projects. It had a lot of large (projects)… and I think most people in it were math majors which I think is great. But, I think more small based projects would have been better I think for me. It involves a lot of calculations and that's okay, I've had calculus too but I'm really more of a hands on kind of guy and I like to build stuff. But, we did a lot of that. I was in biology teaching environmental science. There was little that was helpful in those courses. Although some of it could be adapted but for biology it wasn't near as appropriate as people teaching math and using some engineering. I think that's real technology and the higher end of technology would have been okay too. Although the reason I took it was because I was going into architecture and really very little of it applied to architecture. But the principles of what we're learning or researching and testing – I think the engineering principles were sound and that's what I liked about it most. So, in that area, yes, it was appropriate in biology or architecture. The research aspect – in other words, you create… on every topic you not only try to develop the reasoning for it but then we would develop a model and test it. So that was good and I can apply that in all my fields.

Just time in the sense that there were a couple of times where it seemed like too much time went by before we went on to the next step. The meeting dates – sometimes we would go weeks without actually meeting so it kind of threw me off. I'm used to the idea of if you're taking a class they're at least once a week and you get feedback or… just in that sense. Just the way the classes were broken up where a little bit in the summer, before in the spring – just kind of threw me off. I would have wanted it all together. Currently, I'm working with a physics teacher here on campus and we're going to be re-writing a course that is going to be called principles of physics and engineering. So we're kind of applying some of the concepts that I learned. The class is going to be focused on five engineering design challenges. And both the automotive program, myself, and the physics teacher got together an picked out five projects that would touch on both the engineering side from our point of view and automotives. And it wasn't too far away from what the physics teacher was already doing. So we're in the process of writing a course and hopefully getting approved for next year.

I really liked it the way that it was. I think that a lot of teachers who don't have the math background are having struggles with some of the calculations and stuff. But we did have help though… more support of the math part for the teachers who are not as comfortable with the math compared to some who have the background. Overall I really liked the way it was. I'm using it right now and I like the way that it is set up. A good thing that I got from the professional development is the lesson planning they taught us. It was backward design or something like that. And secondly I immediately used the project – what I actually *created during the summer time – I implemented it immediately I think in the third week of my class. And my students liked the integration of something different in my math class.*

I would have preferred to have projects already in place that I can apply directly to the curriculum that I have to teach. And the way the program was set it wasn't set that way. I had to come up with one project and it was really tough to do because we were supposed to come up with an extended project but with the pacing and curriculum that we have set in our district it really doesn't allow for that because we really don't have that kind of time. I thought that it was a little over my students' head. We did see some projects… the seismic or the earthquake or I think it was the water in a tank. It just seems like it was a little too much for my students. I don't think that they would have grasped the concept and I don't think I would have been comfortable enough teaching it either. I teach intermediate algebra but then there's some other teacher that teaches algebra one so there is a range within abilities. And so I think that's where it becomes hard because otherwise you have to start breaking it down or making groups of people so that you can teach it to those certain kids.

*I like the professors they are really, really qualified. But maybe this is the first time they tried it out with us. Like us coming up with a program – I just feel that that reinforcement, it's not as strong as I expected… Some people are not on task and it's very hard. They had us the whole day. And I know we are all **** with the professor. I think it was the last two meetings – people become a little bit more proactive. But by then it's a little bit too late. I liked all the projects and maybe the content will be if you can list out how it is actually related to high school curriculum. I know it's all related but it can be a little more specific. But probably these are activities that the professor would have to work with us together. That really improves the content a bit more because the project is wonderful.*

I liked what they did this year in terms of they had us design our own challenge. The one I came up with just ends up being pretty complicated so I don't know if I have the time to bring it to a classroom. Last time is sounds like they had one challenge and they worked that one challenge for weeks. I just don't know how useable some of this is in the classroom because of how complicated it becomes. We just don't have a whole lot of time. It's almost like if they could create a school – you know I love the technique an I think kids learn a lot better through application. Yeah, I just don't know where the time is going to come from.

3) Please give specific examples your ability to use engineering design in the classroom has improved.

One of the things I took from the program- a lot of it was talking about working with your hands, in groups and brainstorming- not having canned answers – having open ended problems So I have taken those principles and have definitely used them in my classroom and made it and my curriculum more enjoyable. But when you are talking about the engineering design and principles, I just haven't used those in my classroom yet. I would like to, but I just haven't done that yet.

As a classroom teacher the ultimate goal is for us to increase achievement that is the bottom line, so whatever vehicle you use to do that…. I think that approaching it in this manner where kids are doing hands on projects and applying the math behind it….it solidifies it for them instead of….”where is this stuff used?” Let's say I'm solving a quadratic equation- where is it used? To them, it has no relevance. So I really don't have any hard cord data yet-maybe I will have more hard-core data by the end of Feb. or March or something.

I've been modeling the design process in the past, but I haven't come up with projects that walk all the way through everything. We used the Barbie jump and out of all the projects I've used before… that one really opened everybody's mind to…Oh wow we can predict! That's the benefit I've gotten out of it. Just trying to do better projects and enforce….I wasn't doing a lot of predicting for the process when I was teaching it, now it's, I wouldn't say forcing myself to, but its giving me a different path to go by

I learned more about what the engineering design looks like the steps to the process. And I learned how to take a project and how to actually make it fit that design. I still way off on the science- the physics, the equations; I have no idea how to do that on my own.

They were flexible with the… we created and designed our own project. And since I'm teaching architecture I created a solar design for residents. And then test various glass thicknesses and insulation qualities and glass size for heating inside of a box – actually an insulated house. So, that was very practical.

I've trained the kids to think… um, because we work in teams everyday I make them think that they are like engineers and they are trying to solve a problem. And it's not necessarily something really vague because the math that I am teaching them I don't do the board thing because they are trying to discover what the concept is behind everything that they're doing. So they're presented with a problem every day that they come into class and they try to solve that. And they are actually using engineering design – not the whole thing but parts of it that they do every day. Beforehand I used to try using groupings and stuff and trying to make the kids think but it was always difficult to manage the kids in groups and make them think that they are trying to solve a problem. When I got into the professional development and I saw a structure that I could help the kids think along that line and I presented it to them and I kind of trained them that you have to think this way and follow these steps. And they've improved a lot and it basically became a part of the way the teams work. They don't really notice any more that they are doing the engineering design steps. Not all of it like I said all the time but every day they use. So I've improved a lot and my kids have improved a lot when I came back when I came back from the professional development I go during the summer time.

I hate to say that I haven't really applied much of what we learned in there just because of the time constraint. Like I have said I would have liked to use in more than just an overarching project. Try to tie concepts together. But just because of the pacing I don't have time to do that. One of the things that we did do that I really liked was working together in groups with the other teachers that were there. And I've applied more of that which I didn't used to do in the classroom before.

I haven't really implemented because this year I'm teaching the lower level kids. And I have a lot of disciplinary issues – that kind of die out now. But personally I am enriched. I will seek to at least introduce the concept – like I think it has like 12 steps or 10 steps and so I will see if I teach an intermediate algebra class next year I will introduce that.

The bungee Barbie. That's so great and I would modify it right off. I think that would be a great activity. I'm glad you brought that up. And that's part of the problem. These things have to stay in front of you because once you get into the classroom you tend to forget the cool stuff that you have learned and just going to start turning pages. The challenge part of these applications can make these things really difficult. Especially if we are going to discover the formulas – that's probably not happening. There was one project from one of the attendees this year where he shot Mickey out of a canon and that was pretty cool and I could see using that because it used a nice parabolic path and you speculated on when Mickey was going to land and that sort of thing. That could be fun to work in a little competition there. The guys who are running this program are really good and very, very dedicated. It's almost like they need to spend some time in a public school classroom for maybe a little bit of a reality check. Just to see what level the kids are operating at. Because I know teachers even frustrated the people in charge because we didn't come with a certain level of information or level of knowledge – and they need to drop by a classroom. . The way to use something like this would be to get together and… one would need to see like a topic, ah conic sections maybe and then come up with an engineering design challenge that would mandate the use of conic sections. So, I mean the things they gave us were very good but they were outside our standards – you know what I mean, the curriculum standards that we are all kind of hog tied to at this point. So the difficulty is bringing these standards and challenges together. The people in charge need to keep an eye on these standards – and not saying that what they were doing was outside the standards but they just need to help us figure out where it would all blend.

It's made me better able to ask questions and field questions related to application. I haven't used it to come up with a project at this point because working with some of the guys over the summer they knew what they wanted from an engineering design challenge. And what I'm doing would not be it. You know where you have to find a problem and then examine the different ways of approaching it and then do a rough draft. It's given me a better appreciation of it but have I used it per se? Probably not. The content *knowledge is huge because if a kid ever goes – when am I going to use that? Then I can say this is where we did it – we did something with water pressure and pipes and we used log rhythmic curves to decide the pipe diameter and when do we use logs? Well, if you are going to be hairdresser never but should you wind up into some sort of engineering this is where you could be using it. So, I gained a lot of information.*

4) What specific skills and benefits do your students get from ED activities?
   a. Describe how participation in PD activities have influenced student experiences and opportunities within your school.

I saw the benefit of the project when I first got the literature on it. But I was a little nervous into the amount that I was doing. Unfortunately I can't work with….We are such a large high school we don't have students that are in my tech class, in my math class. So, I had to do a lot more in prepping and lot more in the science…..its not that I can't do it….its just that I had to change the way I was doing things to make sure I covered everything that needed to be covered.

I think it's made me a better teacher in the sense that as I look at things I try to look at them a little bit differently and so I think my students benefit from that. I try to think back to the models and not just through the theory. Because we go to theory and then we design projects around them – but actually create models. I don't have time to create many of them but I have done one and I think that was functional. But the though process – carrying you through that. I think I look a little deeper into what I'm doing. I don't know about opportunities in their school but for but for their experiences, yeah. I think it takes them a notch further in the depth that I teach. I think the application, the analysis and synthesis of what we're doing, is where I'm taking them a little bit farther.

The project that I used so far was the one that I created during the summer time and they learned to used the multi tester? I think that was one thing and not all of them were taking any electronics. I had one class that was taking electronics but the rest of classes had no idea about Ohm's law and how the multi tester can be used to have a current. So I think that's one skill that piqued their interest and a lot of them it made them think of going into engineering because of the experience. And right now I am still trying to put into place my plans for using the bungee cord experiment which is one of the things I learned from the professional development. And I am actually thinking of bringing a team of kids because we have a symposium for all of the STEM school in Northern Carolina and I am thinking of bringing a team of kids and having them present what they would come up with the bungee cord experiment. The way that they think and the skills that they acquire from the interests that were brought out because of what they have done in the class – based on what I had taken out from the professional development and brought in the classroom. And it really did help out a lot what I did and what I learned in the professional development kind of boost up my confidence in doing more team work in the class. And to encourage kids to think more of the problems and how they can solve it as a team. That was a lot of benefit in my class. I had the same students in my class from last year to this year so I have seen how they changed and how my attitude toward engineering design and doing teamwork in the class have changed. Right now I am in another professional development program and it had piqued my interest based on what I had from the engineering design. And I saw another professional development program they call tech math and using math in real life. And I am seeing how I can integrate what I have learned in the engineering design and use it in this professional development and kind of add to it. My co-teachers got involved in other professional developments which are in line with engineering but I think they are more focused on things like robotics. And a lot of influence from what I have experienced with the engineering design professional development.

I would like to eventually use my project but I think it's going to come towards the end. They'll see the benefit of what I did in the engineering design class and they'll get to see what I created in the powerpoint that I put together. The one thing that I did get out of this is meeting the other teachers because I didn't know anyone else outside of this program. And so now I've been able to reach out to them. But in terms of using their projects I haven't done that either.

Maybe application and a lecture on future careers – what they're interested in to study in college. Because a couple of people do voice that they'd like to be engineers. And even for those who would not be interested I think it would be great for them to open up their eyes and see the real world and how everything is really *engineer design. That would be something that they would come away with and it would be great that they also do the math and finish a project they can see from the beginning to the end. I am not personally aware of it (new experiences/opportunities). I think that basically math and science teachers should work together but in our school it really doesn't. We are lacking that aspect.*

Hopefully I can make my projects more realistic so I tend to ask more from the kids as they start getting involved in a project. Hopefully the old projects and new projects won't be so much step 1, step 2, step 3. Because the idea is for them to understand it and gain an appreciation for the work that they're doing. At this point I would say no. There are two of us here… who have now been through the program. The guy wasn't able to complete it but I think he really brought an appreciation for the concept of the challenge and I think he probably uses it in his classroom more than I do. He does architectural design and that is just made for engineering design challenge.

5) What barriers and enablers did you experience in your classroom implementations

Re: Ferris wheel project. I build one at the training sessions, then I built more (5) but I had a hard time getting them to spin properly which messed up my data and was frustrating to the students. So, next year I would

As a classroom teacher we already have enough on our plate. For me to take a project like the ones they gave us and use that, after we tweak it a lot. For me, I love math and I have a background in math, the concepts were very complicated. So, for me it was kinda like a challenge. I think teachers enjoy those types of projects. But, the problem is, I can't give that to my 10th- 11th graders- I would have to dumb it down. And that takes time. They gave us all this stuff, which was nice of them but it not being utilized. I can bet the other teachers are not using it either.

From the teacher point of view….we were dealing with college professors. I don't think they understand the level that these kids come in to us….I teach at Long Beach in a low performing school where the kids area 2-3 grades below where they need to be. So to implement these principles, I have to water it down for them and it takes time- almost like me creating a new project.

The biggest problem I have, its frustrating to me, is the lack of base knowledge kids have when they get to HS. I have to go back further back then I would thing I would have to. I shouldn't have to teach a 10th grader how to read a ruler. That base knowledge that these HS kids are coming in with, is a huge barrier for this engineering design process. In my opinion, students don't want to go through all the hoops to get to the end- they want to "tell me how to finish it and I'm done". Now, that's frustrating to me. The other frustration is now; we don't have as much money as we would like to have to put these things into place. I got really behind last semester. It was hard enough to cover my content at all. But I do have the project that I did; I would really like to try it. And the Barbie bungee jump that we did, I would really like to try that with the students.

Just time. You've got to prepare a lesson and to take it down to where we take a theory and then we test it and develop and build a model it is so time consuming. In high school teachers it's here comes another comes another class, here comes another subject and is it tough. The professors were wonderful people and very helpful and I think if anything that would be (it). At the school I am not sure we have any additional resources. But they were always a source of knowledge and they had outside help from the engineering department and a couple other people. But I just thought it was great, very helpful.

*My class is a state tested class and there's just not enough time to do all of it. If I wanted to I would have done a lot of it and even used some of the things that my *** mates during the professional development because they have done an awesome job with a lot of the plans. There are a lot of things I could have done in the class if we only had the time to do it. You know it takes time for these kids to do these kinds of things – they have to think a lot, build stuff. And I don't have the facilities in school as well to do a lot of the manual part because we are kind of new and we don't have labs and a lot of the materials that you would need if you really wanted to do the whole thing that I saw during the professional development. And the pressure being a state tested class. My principal is the biggest backup in everything that I am doing in the* *classroom. He's really into the new stuff and he's just willing to support me in what I need. It's not easy for him at times because he is also pressured with a lot of people… but he's encouraging me all of the time if there's anything I can do for the students that's just out of the way and is not the regular type of math class he's willing to support me. So he's one of the enablers in the school for me.*

The time constraints are big. And that was one I had thought about and had mentioned while we were in the workshop that when am I going to fit this in is what I had wanted to learn or what I wanted them to help me with. I know that when I was doing the project itself I was having difficulty with the actual physics of it. Because even though I am a math teacher the project itself had a lot of physics. And so just understanding the concept was really tough for me. And I did have one of the professors helping me but I don't think I totally grasped the concept. So, that's another challenge that I faced. I just kind of worried about presenting it and not actually knowing what I'm talking about myself. Enabler: The professor that was helping me – he was really helpful and he gave me his email so he said I could always email him and get more info. He also gave me a lot of websites that I can look at for information. I have other math teachers that were also in the workshop that I would feel comfortable enough to ask them and I can most certainly find the physics teacher and ask for a little bit of assistance on what I need assistance with.

*Fitting it into the standards and the content – going by the study pace, uh – the curriculum guide because I hate to say this but we teach according to the unit exam. So once it gets started there's not a chunk of time that you can do it in. And when it goes to that lesson I was looking for what I taught last year. There's one lesson which is towards the end of a unit exam. It takes planning, enough time, and also the pacing. A ton of it is also that I probably need help need help to come up with a more simplified model – really think through it. It's not that you can't implement it but to bring it down to that level – I'm still learning it so it makes it a little difficult. Which the professor brought it out – we talked about it. It was a good discussion. Enablers: Just how I learned about engineering design and how I learned to bring it into different components. Maybe not as detailed as the professors but I can break it down into bigger chunks and how to ***** it to the students.*

I need to sit down with a topic and whether it be lines or conic sections or parabolas or whatever and from the very beginning – I mean I can't just input one of these challenges into the curriculum because it will become too time intensive. But if I could take a topic and introduce the topic via the challenge and then the material could be taught while we are going through the challenge. Which would be really kind of cool but I need time to sit down with people with whom to brainstorm and come up with so we could come up with a curricular packet for like I said a parabola unit or something. A couple of the other people that I went through the program with – you know a couple of the other students (teachers) really went for this thing hook, line, and sinker and they would be really fun to work with. The majority of the people really need to be pretty open minded, ready to brainstorm, be creative. And then we would probably need one person from you guys (NCETE) to keep us headed in the right direction because it is really easy to go engineering design challenge light and that's not really the same thing. Enablers: The kids are excited about it. The kids for the most part – I mean there is a bit of hesitancy in them beginning and you have to get over some inertia – but once the go with the project they really enjoy it. And they gain a whole lot more out of what they've done than just turning pages. I truly realize that this is a more powerful way to teach, I just need to figure out how to successfully integrate it into the curriculum.

6) Please describe how participation in PD activities has influenced teaching and learning in your school or class.
    a. What changes have occurred in your content knowledge?

The feed the wolf (?)   one- I haven't tried that one and I'm afraid to. Because that math even hit me nervous when I was going through it. It's not that I can't do it, its just it was intensive enough that I figured my students would either turn me off or hold my hand through each step. That one I thought was too advanced. The Barbie is and it isn't. Where I got hurt was when they came up and did the classroom audit- they did that early in Sept. and I wanted to do the Barbie jump when they came up and for me it was too early. I should not have done that and I paid for it. If I had did this in the second semester it would have been great. It was my own fault to try to do it for the observation, but I learned.

Mostly the science content because I am not as good with that and the time. Having trouble finding the time in my curriculum to add anything new let alone cover everything I am supposed to get through.

Some of the content was just so far above our heads, even as college grads and teachers, it was very difficult to sit through this training and see how we were going to take it into the classroom so maybe if we had projects that were little closer to our curriculum or more accessible to high school students that would be nice.
As far as emailing with the professors, sometimes they were good about getting back to us and sometimes they weren't so if we needed help outside of the workshops it was hit or miss if we were going to receive it.

Yeah, just the things I've already said. The thought process with the engineering model and of course than we build – we test models. I don't have time to build models to test much but the thinking through the process really helps. And then the models that I did build in the class.

I have learned a lot during the summer time when I was with the teachers and even the professors they have provided us with. I have a background in electronics. I wasn't really that good with the multi tester or the resistors and stuff and that was one thing. And even the math – I am a math teacher but I still learned a lot or the professors and teachers when they presented other formulas for how to solve a problem. Just learning from them when the presented it or helping with my content.

I was really personally interesting to me since I don't know much – my background is not in engineering and I think it will enrich me more if I know a little bit more. It really really has been a great time.

It's encouraged me – well I'm lucky enough to have some the upper level math classes and so I can run them kind of seminar like – because it was very nice at the workshop, kind of the give and take between the attendees and the presenters. And so it's kind of encouraged me that way with the kids. Because the students appreciate that, it makes them more willing to learn if they're not being treated as a lesser form of life. The whole concept that bungee cords aren't just bungee cords but there are all of the formulas that you have to work through for weight and elasticity and all of those things. The earthquake project was so interesting – the idea that a building's frequency if it matched the earthquake's frequency was coming down so a one story building could be less stable than a high rise depending on its resonance. Maybe as a result of this workshop at one time we were presenting a log rhythmic topic because the Rictor scale is log rhythmic so I went and put together a power point project so the kids could see earthquake damage in the area…. Trying to bring it home to them.

b. What changes have occurred in your teaching strategies?

I can't compare- I have never done projects before. Just doing the project was a huge departure from what I normally do. But during the project itself there wasn't a lot teaching per se. I taught everything I normally teach then we would take a day and do the projects and it incorporated all the concepts that we had been doing for the last month or so. During the projects I would walk around and monitor, but I wasn't doing any teaching itself really.

I'm learning how important it is to work in teams and how important it is to think like an engineer and just trying to solve a problem. The kids – they're – and me as well, I don't up on the board as much. I'm passing on the responsibility of learning onto them. And they're actually owning up to it to the extent that would argue not calling me until they have asked everyone if they know how to do the problem. They only call me when they're really really confused about it already. So it gives them independence when they start thinking along that line. And what happens after thinking that way – they become more problems solvers and more inclined to thinking instead of just being fed with answers to the problem.

In the way that they did the grouping – in that we would participate and I really liked to do that. And I felt fairly comfortable after doing it myself several times to actually to put it out in the classroom because I felt like I can have that classroom management that I saw at the workshop. And even though we were adults I saw how they would treat us and get us back together and I have been using that in my classroom. I learned the 7 step process but I haven't really been able to apply it as much as I would like to. And I think *that would take place when I do the projects when I would use it. Because otherwise I am a straight lecture sort of and it doesn't really lend itself to doing the actual engineering process.*

Part of it is analysis – in engineering design find the problem, look for alternatives, and then come up with the solutions. Analyze and then come and check back which totally works out for math.

I keep looking for the applications and the project I put together for this thing is still sitting in my garage and I keep – it's made me less satisfied with standard teaching and so I tend to ask more questions. I'm looking.

How have you been able to infuse ED into your classroom?

During the program we took one project and tailored it to our own needs- I think that is good. I am definitely going to use that one. But all the other projects that they gave us it would be more beneficial…if they were more tailored to certain classes or could be linked to the standards. I am happy that I did that because I have something to take back to my classroom now.

Well, my solar project was one of the things – the insulated house model. And then we could test with some labs we tested the heat ratios with different layers of glass, with different thicknesses of glass and also different widths of surface area for heat increase inside the model. I thought that was really good. It really forced me to do a lot of research on solar energy and how the houses are designed and why the are designed facing south. Different amounts of window glazing… different angles to the sun. And it was really valuable for me in what I teach in architecture. To research that and be able to develop and test a model.

Partnership Activities

Please describe how participation in PD activities has influenced your institution's relationship with Cal-State/NC A&T (or partner school districts).

As the program gets better and better I think those relationships will grow a lot more. Teachers want useful stuff. If there was any way that we took these projects and tailored them to geometry class or algebra 1 and when the teachers sign up for professional dev its very much out of the box project – you don't do anything.

I was nervous at first because of the number of hoops we have to jump through to do anything like this- to get someone else to get in the classroom and monitoring and all that. I had phenomenal support from my principal. It was just going through all the hoops necessary to get the county support. What was neat, I got the county support, is that I got the head of tech ed of Prince William county to come in that day. He sat through my presentation. He really enjoyed everything we did that day and visiting with Vince.

My school only had math represented and a technology teacher.

I know Eric, the science resource person at the district level, has had other teachers go through it – engineering teachers, physics teachers math teachers. And he's the one that recommended it to me so I think the relationship has certainly improved in that area. I wouldn't have known about it had it not been for Eric and like I said he is district level. And he mentioned it that two or three other teachers had gone through it tha he knew and thought it was good.

I know that one of the gentlemen has invited my class to go and visit Cal State LA, the engineering department. The time notice was very short so I was not able to make it. But I know that they have been keeping in contact with us in that sense and trying to get our students to come and visit them.

We're maybe 35 minutes away from Cal State LA so other than things like this workshop I'm not familiar with our relationship with Cal State LA. I think we've also done maybe the pre-testing… where at the end of class you can test the pre-calc kids for calculus readiness. But we don't do much with Cal State LA that I know of.

It gave me a greater respect of Cal State LA – wow, I didn't know they did all the things they did.

a. What changes have occurred in ETE program offerings?

We're just staring an engineering program and the first semester our teacher didn't work out, he decided to quit. So, I don't know.

Right now we have an engineering class we call Engineering the Future. And I think the biggest barrier of our school is more the money part and just approval from the board and everyone from the central office. My principal has already recognized the need to have classes on engineering … and helping the kids think along that lines. Because we are actually a STEM school also. I guess the biggest barrier is more on the budget and the approval and if you can get a teacher and enough materials for the lab. We've tried to hire someone from last year to offer a class for this year but it never happened because of that.

It's come across me and the other math teacher from my school that attended the conference so it's more like a personal enrichment. I was never really communicated to the department head and she never asked. But we never brought it to that level. And we're not in a position to bring in influence.

The people who went from my school are all from math. Actually, we were talking about doing a bungee Barbie thing during a department meeting one time just to get everyone on board with bungee Barbie. As I was putting together my project I spent some time talking to the science department. But school wide I don't know. To bring it in a class we really almost need a unit. And to get a new class off the ground can be pretty brutal unless you can come in on something that happened and has maybe closed. But the class time still exists in the district books somewhere. This was a very high level class as far as the teachers were concerned – the college professors made it quite clear that they didn't necessarily feel the same way. If we could institute maybe an engineering class or a supplement math applications class for the low level kids to try to get them hooked on math and science we would have to be real careful about the applications and the level of difficulty.

b. What changes have occurred in your school's capacity to provide opportunities to students in STEM areas?

I'm the only one in the school that went through it that I know of. I think I've only mentioned to one or two people what I did. There's been a change in our offerings here more on an individual level here which has been an advantage for me.

We've talked about it and we've discussed about offering more classes along engineering but I'm not sure how it's going to happen as of now because of a lot of barriers.

Other question possibilities

- Describe benefits and opportunities from the team approach - work with teachers from other schools and subject matters.

We did a great team work activity when the plane crashes….it is similar to that…. The difference is not everyone is in an unknown situation. For example, when you look at the hard core math we were doing, some teachers were not really up on the math, they were very unfamiliar, so for me as a math expert I would have to break it down and kinda help them out- so we each bring something to the table. It was nice- similar to the plane crash we did at the beginning. Some people have been through different scenarios: they have been to boy scouts or survival type situations, but whereas maybe I haven't seen anything like that. So you get a little bit of knowledge from everybody, different aspects and different points of view. I think that was beneficial. These were not teachers from my school on my team. There were two teachers from my school there but we tried to separate. I thought that was good.

I came down w/o people from my school, but I did work on a team down there: 2 tech ed teachers and a math teacher which was a lot of fun because it was really interesting to get an insight from another dept. I see the advantage of bringing down my own team from the school, but I was thinking I might gather more if I were teamed up with a different science or math teacher from a diff school to get diff ideas over and above what I'm going to gather from my own school. We did get to provide them feedback. There were some tech ed teachers down there that had no business being in a classroom. It's not just people outside of their discipline. The math teacher we were working with did a heck of a job putting together her lesson to accomplish what she wanted to accomplish. She was nervous doing it mainly because she is used to teaching math and getting more into the technology, but she did a good job. It's just that some people don't belong in the classroom. The team approach is necessary I see that. I think I gathered more benefit from being with people from another school, but that's just me. I like the program and got a lot out of it.

We're working with integration and articulation with Long Beach City College and one of the people from the (NCETE) workshop is in that with me so we're going to meet four times this year in that. And then I've got an ongoing architectural training program on Saturdays – it's a workshop in Corona so I see another teacher that I was in the workshop at with those. It's ongoing – we email each other and help each other with different things. So I think that relationship has been valuable.

I communicate with one of them (teacher) and she's a technology teacher in Bryson North Carolina. But I communicate with her email-wise. The others – it's not as much as it used to be. We work all the time together – we plan lessons and we work together as a team. I shared it (NCETE PD) with them and all and we do work together. We've always worked together, even before the professional development so it wasn't something new. So I guess the biggest challenge is using what I have learned in the professional development in their class because right now my team is only composed of an English teacher and a science teacher. And the earth and environmental science teacher is a new teacher so right now she's still trying to get into the mode of being a teacher because this is her first year teaching. So, I didn't pressure her. I kind of just told them about it. With the English teacher it is kind of difficult to do that. I was hoping with the science teacher but right now I'm first letting her get adjusted to the life of a teacher.

- What did you find most meaningful about the ED PD experience?

Probably putting your lesson plans together backwards- I thought that was probably the….its like "oh wow, you are an idiot, why didn't you think of that". Since I have been doing that I think I've had better lesson plans. If I had one thing that I really got out of it that was a real "oh wow" that would be it.

I enjoyed the idea of the program its just going to take me a bit more time to work my head around it and find the science partner to work with to enable (me) to get it, so that its something I can actually do. But I did like the idea of it.

When we actually got to make our own projects – design and make our own projects, that was the most meaningful.

Because of what I have learned during that professional development it boost my confidence in pushing through and encouraging the kids to work as teams because when we did that there we were also in teams. And I shared that with the kids that even adults have to be in teams and it's because in real life you have to be in teams. And with the engineering design most of us are thinking along those lines, but with the kids you need to train them. And that also helped me a lot to give them a structure about how they should think about problems and how they can come up with a solution. Most of the teachers don't go to professional development for as long as the time frame because of family and kids and stuff. It kind of worked out for me because I am single. I'm not sure how we can attract teachers going into professional development without having to think about family and the time they will have to spend out you know being with other people during the summer time. I tried to get the other science teacher involved with it together with me but she refused, not because she didn't want to, but because she has family and her kids and they had plans and I said okay I'll just go alone.

The most beneficial was meeting other teachers from my district. We hardly get a chance to talk to others and so it was nice to see other people in the district who actually had the same interests. The workshop wasn't what I expected it was going to be 'cause I was hoping it was going to be projects that were already prepared. And they were going to hand these to us and show us how to go through them and show us how to teach them. That's what I really want to go and learn and it turned out to be something different but that was a challenge in and of itself. And it was really cool to work with other teachers that I hadn't worked with before.

The time spent with the people because you get so many good ideas and you learn what's going on around the country. And interacting with the other people that are involved in education and it's very good for high school to interact with college and vice versa. Because we know what college is looking for and they know then where we are and what we're working with.

Appendix G: Post-Implementation Facilitator Interview Protocol

The purpose of this interview is to share findings from the recent interviews conducted with participants in the NCETE Professional Development program with the program facilitators.

Based on our analysis of the transcripts, we identified four major findings. We would like to incorporate your comments in the final report that will be distributed in the next few weeks. Included in the final report will be the transcripts from the interviews.

Finding 1: All participants indicated that they have used some of the teaching strategies and steps in Engineering Design in one or more of their classes. Comments from participants included:

> …a good thing that I got from the professional development is the lesson planning they taught us. It was backward design…
>
> Beforehand I used to try using groupings and stuff and trying to make the kids think but it was always difficult to manage the kids in groups and make them think that they are trying to solve a problem. When I got into the professional development and I saw a structure that I could help the kids think along that line and I presented it to them and I kind of trained them that you have to think this way and follow these steps. And they've improved a lot and it basically became a part of the way the teams work.
>
> One of the things I took from the program- a lot of it was talking about working with your hands, working in groups and brainstorming- not having canned answers – having open ended problems. So I have taken those principles and have definitely used them in my classroom and made it and my curriculum more enjoyable.   But when you are talking about the engineering design and principles, I just haven't adapted that language into my classroom yet.
>
> We never really talked about what we had completed or anything like that. Now we take the time to look back at the project, the process and do a quick little writing activity.
>
> a) Was this a finding that you (as a facilitator) expected? What do you believe contributes to this finding?
>
> *First of all, we're behind on monitoring all of our folks. I've been going through some health issues and the bottom kind of dropped out on our time. We haven't observed most of the teachers, yet. We're in the process of catching up. All that said, what the teachers have stated was our intention. I am pleased with the findings, because what I would have expected was one or more of a subset, that we weren't as pleased with, were doing something more than observe. There are one or two people that we're concerned about where they are. Generally, the teachers are really a neat group and most of them took the stuff that we did very seriously.*
>
> *One of the aims of the PD wasn't to get them to adopt a curriculum instead it was to adapt what they were doing with the engineering design and so the fact that they took some of that and incorporated it into what they were already doing is no surprise. But what is a little surprising is that they kind of liked the backward design lesson planning because typically what I find is that teachers don't like to plan in detail. Backward design lesson planning format is a detailed lesson planning format. Although it's effective. So kind of being a pessimist regarding lesson plans because I'm a methods teacher too where you have to write lesson plans. And principles find that too. They'll say everyone needs to have lesson plans and the teachers are like 'oh, do we have to do lesson plans?' So I figured they would go on off and not really use that lesson plan format. I think it's the fact that it forces you to consider assessment before you design an activity. Really a better name for it should be correct lesson planning. (Goes on to describe backward design) … it will force students to do behaviors that you can assess.*
> *My guess is that it helps them keep their eyes on the assessment of the student.*
> *Could be that they got it as software and are able to use the format as a template. So they don't have to rewrite everything, just the things they want to fill in the blanks with. It was a word document… But also the example lesson plan was I think one of the activities we did too so they could see it come to fruition.*

b) What implications do you believe this finding has for future implementation of this PD model?

We spent a lot of time thinking about the pluses and minuses of what we've done and if we were to start over, what would we do. Certainly, we wish that we are the beginning of the five years, instead of at the end. If we wanted to implement this in a way that was more comprehensive and complete, we'd probably want to do this PD to a cohort. Then we could infuse engineering design across the entire curriculum so students were getting this in more than one class and teachers were really collaborating. Then it would be more like a integrative model where engineering design would really be infused. Another idea if we really want to get this implemented at a level that we really like, you need to have significant administrative buy-in (not direction). We would love to get together a cohort, like an academy model, where you have the principal in there from the beginning so you have the logistics and moral support, building schedules and curriculum, to implement this kind of thing. By the way, if you integrate it differently, it changes the configuration of your time blocks. Also, there is a facility issue. One of the things that is real clear, particularly with the math teachers, is the lack of space and experience of having students that do not move out of their seats for the entire amount of time. The fact that we want students to get up out of their seats, move around, put things together and do hands-on experiences and activities and experiments is something that math teachers don't do. Sometimes, teachers have pointed out that they don't know how they would do things in their facility. So, if you had something where you had a more comprehensive plan and a team effort, supported by a senior administrator, then these problems should go away.

Chris Merrill was saying that good PDs got to really focus in on pedagogy and to me being a methods teacher pedagogy means practicing your teaching skills. And you know we only have one hundred hours with these cats and they've got to learn this new design process and try it out a couple of times. And even though it's easier here in the fifth/fourth year than it was in the first year project-wise it's still real complicated. I don't see how we have time to help them hone their pedagogy. What I think I am doing is misunderstanding what people actually mean. What they mean is stuff like you are talking about like having a sensible lesson planning structure, having a process to follow for the kids when they're working in groups, and using the design process as a strategy for instruction. That's what I think they mean now that I look back on things. And so the implications are that for the future of if we redesign is I guess the structure that we provided in the professional development is important and should not be taken away from the design of the professional development model. And the reason I say that is because you can talk about all the stuff and then they wouldn't go do it. But if you're able to have them demonstrate to themselves that the stuff you're recommending works and their own light bulbs go off like they want their kids' light bulbs to go off when they see a value in it. And the only way you can get that to happen is through the structure. ***Anything you would change?*** *I guess the process was more important than the actual activities they were taught. Because if they've got an already a crowded curriculum…*
After the people at NSF had decided that they need student achievement data and experiments, true quasi experiments, in order to make their research worthy of being funded [Dan] started wanting us to do some of that work, wishing out loud we could have done it. And so what we should have done was we should have not had this grant as a university grant but had it as these math and science grants from the department of ed where the school system itself is a real partner in the money. And they can sort of force all the teachers to do what they want. So what you've got is everyone teaching engineering mandated curriculum and then you can collect all of these big globs of data that they want. So we weren't able to do that. Our idea is that there are a lot of tech ed teachers out there. They've got curricula that they have to teach. Those curricula might not be entirely related to engineering because it's just one of the twenty standards. And we would want them to have something that they can infuse into their existing curriculum.

Finding 2: Most participants indicated that they Did Not implement an Engineering Design challenge in their classes. Reasons for this finding included appropriateness of the content, the time required to fully implement a challenge, and lack of interest or feasibility with their current curriculum. Comments from participants included:

Some of the content was just so far above our heads, even as college grads and teachers, it was very difficult to sit through this training and see how we were going to take it into the classroom so maybe if we had projects that were little closer to our curriculum or more accessible to high school students that would be nice.

I can't just input one of these challenges into the curriculum because it will become too time intensive. But if I could take a topic and introduce the topic via the challenge and then the material could be taught while we are going through the challenge.

I haven't really applied much of what we learned in there just because of the time constraint. Like I have said I would have liked to use in more than just an overarching project. Try to tie concepts together. But just because of the pacing I don't have time to do that.

a) Was this a finding that you (as a facilitator) expected? What do you believe contributes to this finding?

It's disappointing that the engineering design challenges aren't being implemented. One of the things that I know as a parent in California is that teachers are pushed and pushed and pushed to teach to the test. We have an overabundance of standardized tests. The school districts call on an automated system two weeks before students take mandated tests and remind you to ensure that students get a lot of rest and eat healthy foods. They are testing stuff; they are not testing learning. The things that we're trying to do, that increase meaning and depth of learning, are not being viewed as efficient. Principals are held up to public ridicule if their teachers are not getting kids up to the tests. When we picked the district we wanted to work with, we purposefully picked one with a mix of blue collar and higher workers. The school district is pushed a lot to perform well on the tests. That is the reality in which we live – we're not teaching learning, we're teaching feedback skills. Is this result to be expected? Yes. If we did this in a more authentic academy model where we were looking at the bigger picture, it may be that the things we're recommending and asking teachers to do would become more visible. The other thing is that we're doing this as a one year PD, but it is probably more like two years – and that is probably too short of time if you are talking about implementation at this level. Teachers would have to plan this before you start the school year, as you have to plan a year ahead. If you are asking teachers to do this as an isolated experience in their class, they are not set up for it (the rooms, the context). They have the willingness and interest to do it. Now with the academically challenging things, I think a lot of that has to do with how long you take this thing to gestate. I think there are lot of issues about how teachers change the order in their class. It is not a willingness issue, it's a how do you do it question.

What is important to us is that they implemented the activity that they themselves designed. It's not so important that they did the food for the world or the bungee cord. Those have to come from their own curriculum or they are not going to do it. The other thing is procrastination. I know that they are ducking and dodging. Here's a couple of thoughts I had about the ducking and dodging. You know what happened in earlier iterations of the professional development we used up all of our locals… and now looking back to it if I could ride out to a school easily and harass someone without losing my research privileges because of the IRB – but just my presence and paying a friendly visit to someone who's not implementing is a motivator. But when they are 80 miles away I can't just drive by… And what I should have done is I should have had the locals back for this new iteration. Cause even back with other iterations of the effort I still have procrastinators. [goes on to provide example of 8 participants… projects went right along with their curriculum). So I don't buy the part where it doesn't fit in with the curriculum.] **Asked to react to time constraint teachers have***: Kim (teacher) is very rushed for time. Being a math teacher they are real sticklers about their curriculum sheets. But the tech ed folks even though the North Carolina ones have end of course testing, I know that… they are afforded enough time to sneak in some things. In Virginia, there is even more freedom than in North Carolina to do stuff. [Suggestion made to look at proportion of comments of it not fitting the curriculum and what the subject is taught by the participant. Also look at time constraints by subject taught by participant]. Dan was real skeptical they could write their own activities. And I think we demonstrated they can write their activities but we really wanted to encourage them to pick activities that would fit with their curriculum.* ***Asked for reaction to teachers' concern about material being too complicated for them and their students.*** *There's this deal where there's true engineering versus adapted engineering… (goes on to describe this). 25min point If you take a full blown engineering design challenge and you decide to do only one part of it, let's say do some simple optimization. So then to an engineer it is no longer engineering. They just goofed around with some math. The students in public* *schools have to have things pretty simplified for them. And to me as a tech ed teacher and not as a tech ed teacher educator if someone used mathematics to improve their design before they started building a prototype then they've succeeded. In the first year Chris [Hailey] and all of us said one of the strengths would be to capitalize on the expertise of our engineering partners like Ali and Mark. I know Ali's an electrical engineer and so I said let's design us a challenge that capitalizes on Ali's electrical engineering experience. If it would have been college students learning interfacing it would have been a great problem but it's teachers used to teaching the kids curriculum and it's just too hard to adapt down to the kids. (described activity used) So the next year we scaled the same project way down so it wasn't so tedious and industrial sized but that was still too hard to adapt down to the kids. In Illinois… that volume barge even though we didn't want to do it… because it doesn't demonstrate all of the steps. But it taught us what kind of simpler activity we need to be teaching. And we were real confident this year going into this next attempt that the bungee cord was simple enough to do. That their projects that they designed were simple enough to adapt. And we thought that the food for the world challenge would be simple enough also. Up until this point I was thinking that their own activities were doable and that the bungee cord is doable but I think that we pretty much found out in the middle of PD in the summer time based on our own survey that the food for the world's too complicated. What's complicated about it? It's not that the math is to hard it is that the problem is large.*

b) What implications do you believe this finding has for future implementation of this PD model?

I actually think that we would have to do a lot more with developing implementation plans. We're delivering the baby and saying here is the book on the first three years – see ya. We really have to work with these folks and there has to be some commitment on how you can be successful with these things. We're asking a math teacher to make a big switch. If we look back to other cohorts and ask where have we done really good things, Tamara is doing really good because she created this block of time after state testing. But, she had to create that time. We could never have created that for her and known that it would work. Then there is Charise, who even before she was in this special academy was able to build things into it with things that she is doing. Even when you have a dozen teachers that are willing and interested in something about this, could be the units, could be the money, you don't really get that. What I have told Matt Soldania, from the district adult education, is that we are committed past the end of this year whether there is funding or not. We are willing to look at what can be salvaged because we feel like we are finally getting somewhere and we don't want to lose it.

There has to be some rhythm to the teacher's implementation. So if I do bungee cord and then the one I wrote then maybe I've got guts enough to do a harder one. It's probably that you've got to have more than one, two, or three chances to do some engineering design with you kids before you get comfortable with it. Here's an example of what I'm talking about. Take cooperative learning for example. There's not enough time in the curriculum for teachers to get good at leading their kids in cooperative learning because W basically has everyone studying for tests. So if there weren't standardized tests to be afraid of and I wanted to have good problems solvers not meaning paper problem solvers but ilstructured problems solvers I'd start the beginning of the year out with groups of three kids. And they each have a job to do and I provide handouts to help keep the tasks structured. Cameron and Todd? when they were asking teachers some stuff of all of the engineering design steps there are the teachers in the beginning tell some of them to the students versus having the students think them up on their own. So they're making things less ilstructured and more structured. Now later on in the year if you have the luxury of being able to continue doing cooperative learning and problem solving you provide less of the spoon feeding. And the kids get in this routine of working in groups and knowing what their jobs are. And I think the same thing would be true for the teachers – the more opportunities they have to do some engineering design, oversimplified in the beginning and becoming more complex in the end the more willing they are to do more complete cycles of engineering design. ***Reaction to PD's seeing classes before had to see HS students:*** *We've got to watch how much we dummy it down. The people who are saying that they need to teach the whole process to really get a feel for engineering. I'm not as paranoid about that as say an engineer would be but they're right. If we get so simple it possible that there is nothing really to show that really is engineering. So if your kids are too ignorant and they lack the basic skills to do some simple math maybe engineering isn't going to be a tool for your particular kids. (Described experience in year 2 where teacher used* *optimization only and commented he didn't want to put to much math into it for fear that students would stop taking his courses). So as an elective subject that's a concern. They don't want to make it too hard so people will stop taking it as an elective… I'm not sure we could dummy this down much more and have it be recognizable. It's more than just practice teaching it in the workshop and practice teaching it a couple of times with the kids.* ***Anything to do differently with teachers to help them get past this bump?*** *They take a math course first to get more confident about their math skills. We kind of debated that – giving them math tutorials after a math diagnostic and we decided that there wasn't enough time, that they math was simple enough to do. All it is is adding and subtracting.*

Finding 3: All participants indicated students derived benefits from teaching strategies or elements of activities from the PD that they were able to implement. These benefits included an increase in critical thinking, more student-centered focus, improved attitudes toward group work, increased interest in abstract subjects such as math. Comments from participants included:

The kids are excited about it. The kids for the most part – I mean there is a bit of hesitancy in them beginning and you have to get over some inertia – but once the go with the project they really enjoy it. And they gain a whole lot more out of what they've done than just turning pages. I truly realize that this is a more powerful way to teach, I just need to figure out how to successfully integrate it into the curriculum.

I had one class that was taking electronics but the rest of classes had no idea about Ohm's law and how the multi tester can be used to have a current. So I think that's one skill that piqued their interest and a lot of them it made them think of going into engineering because of the experience.

And it really did help out a lot what I did and what I learned in the professional development kind of boost up my confidence in doing more team work in the class. And to encourage kids to think more of the problems and how they can solve it as a team. That was a lot of benefit in my class. I had the same students in my class from last year to this year so I have seen how they changed and how my attitude toward engineering design and doing teamwork in the class have changed.

a) Was this a finding that you (as a facilitator) expected? What do you believe contributes to this finding?

The comments exceed my expectations. The neat thing is that instructors are really good teachers. They relate well to people. We're used to doing interactive, hands-on stuff, so we set up experiences that were inviting and we set up role modeling so the teachers would be able to say that the activity would be really exciting to my students. To their credit, the teachers did a nice job of participating. They wanted to do well and learn new things. Since most of them were math people, this idea of actually doing stuff, talking, and interacting, was like a whole new world. We had one national board certified teacher who just didn't do stuff like this in the classroom. If you expose people to neat stuff, they will see the value. It is interesting that the teachers are raving about the activities, but they didn't implement too much. I think it is true that they probably took elements from the activities, but then I want to scream, but then think what would happen if you did the whole thing!

That's not a surprise. That's expected because even though a lot of the literature and stuff you see in the journals talks about my students getting to do a non-boring… activity a whole bunch of teachers just teach canned activities and a whole lot of tech ed teachers teach from text books, more than you might think. There have been activities that are problem-solvingesque in nature but the teacher knows what is going the happen. And here I think what could be happening is being able to use some math and subsconsciously some science to improve these solutions before they start working on them in the lab is pretty eye opening to them. I think that it's just more opportunities to do problem solving. ***Unexpected?*** *No.* ***What contributed to students gaining a lot out of this****? That comment (seems to refer to all of the comments) it makes me wonder what subject area the teacher is in and to what extent they were able to implement because if they were activity started before implementation and they got to have both the bungee cord and the teacher's activity then that's going to make some eyes open up and some smiles come on some faces. Take A for example… her kids had been working in groups regularly. And her kids were used to working with math… but they weren't doing it as though they were little engineers or little groups of engineers. So here instead of satisfying the experiments purpose like in principles of technology they got to be a company* *and used their math for a purpose beside just demonstrating a Newtonian physics phenomenon. So it's plausible that a good teachers whose kids have already worked together in groups and used math would see gains from it. And it's also plausible that a teacher that did a lot of book learning and canned activities would see a lot of gains. (if could peek in on all tech ed classes) … A majority of incidences would have you see people getting to make stuff for fun versus solving a problem. And so solving a problem and getting to make stuff for fun in the midst of solving the problems probably head and shoulders above in terms of student gain that just getting to make stuff.*

b) What implications do you believe this finding has for future implementation of this PD model?

One of the things that we've talked a lot about in our group is this question of comparing the strategies of implementing versus constructing an engineering design challenge. We don't have complete closure, but we generally believe that if we gave them multiple design challenges that had been piloted. Between North Carolina's and ours we'll have at least ten tested challenges that we could share. There is always this notion that if you've created it, you own it, and that is better then if you just try to pick up a model that someone else did. So, we've thought that if you look at a model that is multi-year, then the first year, you would have the teachers use previously developed design challenges and during the end of the first year, they take a baby step using an engineering design challenge that they create. Then, going into the second year they would have some summertime in-between and put in multiple challenges the next year. We need to do more with giving the teachers more models that we can rehearse with them how to infuse the challenges into the classroom and the math, science, and behavioral components. Then, when you get to the next level, you are going to design your own. Use incremental steps. I think the other things is that you need to do some really good monitoring and support.

I guess that the model itself is inherently problem solving. A few of us coughed up some intro to engineering textbooks and that's where we came up with our engineering design steps. (describes that there were slightly different steps used when 5 sites offering PD) [The Dartmouth] model's inherently problem solving. Stick with the model.

Finding 4: Most participants indicated value associated with working with other teachers (interdisciplinary teaming) on activity development and implementation. Comments from participants included:

I came down w/o people from my school, but I did work on a team down there: 2 tech ed teachers and a math teacher which was a lot of fun because it was really interesting to get an insight from another dept. I see the advantage of bringing down my own team from the school, but I was thinking I might gather more if I were teamed up with a different science or math teacher from a diff school to get diff ideas over and above what I'm going to gather from my own school.

It did introduce me to people within my district. One guy did a pretty cool thing with the sinusoidal curve and the unit curve. So next time I see him at a meeting that all of the schools are at you've given me some people to reference.

The most beneficial (aspect of the PD) was meeting other teachers from my district. We hardly get a chance to talk to others and so it was nice to see other people in the district who actually had the same interests.

So you get a little bit of knowledge from everybody, different aspects and different points of view. I think that was beneficial.

However, teachers found it difficult to maintain partnerships upon returning to their own school:

I think that basically math and science teachers should work together but in our school it really doesn't. We are lacking that aspect.

I communicate with one of them (teacher) and she's a technology teacher… But I communicate with her email-wise. The others – it's not as much as it used to be.

a) Was this a finding that you (as a facilitator) expected? What do you believe contributes to this finding?

Everyone who's ever been a teacher knows that the teachers are isolated even within the same wing of a building. How can we get them to stop what they're doing at school, not in the workshop, and go in and help each other.
That kind of gets back to my dictator model, that is if a school system had half the money for the center and was kind of just led by someone like Chris Hailey – like Dan had after the fact wanted. Well, then the principal can force the teachers to plan together. Because even if the school system itself says 'hey we want you to teach this curriculum and you're going to have to cough up some evaluations of each other' at the change of the semester they're still not going to do it because they've still got all of this other stuff going on that the school requires of them. And so at the last minute they'll go in and peak at each other. They might not have common planning because it's an elective subject and they're getting dumped on by the core people who do have common planning. As a research like myself, I can't compel anyone to do anything or I violate my IRB… If you have a principal on board he or she is going to make sure that the STEM teachers have common planning time… or make them go observe each other at least. ***Anything the PD model can do to assist teacher with the transition back to their schools?*** *In the future professors like myself aren't going to be providing this kind of professional development for the most part. What I think is that once this is posted on the web as a model it is going to be state and local supervisors who are going to mostly want to use it. And they have the ability to make their people get together. And so if you have the instrument (from Todd?) you keep that component involved. Part of the assignment was that they were supposed to go home… and do the modified lesson study with that form. And there is no way that I can make them do it but there is a way that their local supervisor can make them do it. So, I'm thinking you let it ride because either you've got administrative support – you find a principal that is willing to give them common planning time or you're not. So, if they've got the luxury of being able to have a structure in place where they're prompted to go see each other in the same school that's terrific. But the local supervisor has a little more power than an outside professor… The other thing the supervisor does is maybe every two months during a teacher work day in the last half of the day they… in the second half they all meet at one teacher's school and they have a curriculum area meeting and so then they are able to get back together… Professors might be assuming professors are going to use this. My assumption is that supervisors will use it. Or at least a professor will use it to teach a supervisor's teachers under the watchful eyes of the supervisor. Otherwise, even money is not a motivator for that… Administrative support is key.* ***Is there a way for developers to get more involved with supervisors?*** *I think the model that we post on the web should say that – it won't be experimental after we post it – so, they can boss people around and provide structure. We would want to put on there that the local supervisor has got to get the principal involved so that teachers are able to visit each other…*

b) What implications do you believe this finding has for future implementation of this PD model?

We're a bit behind on the idea of a self-sustaining learning community. Teachers will tell me that it was exciting when they created these interdisciplinary programs. They speak of the people that coordinated these programs with great reverence. The fact that nobody in that district is facilitating this program; so, it is interesting that they see value in the teaming. I think you have to do this at two different levels. One, at the district level you need some cross-pollination. At the school level, you need an administrator that sees a role as a catalyst.

c) To what degree do you believe this interdisciplinary work was a part of the PD model? Do you believe that teacher participants should model teaming in their own settings?

As I recall, the PD goal for NCETE was to infuse math and science into technology. Now, our goal is to integrate math, science, and technology across each other. So, our mission has changed and the question still remains what is the best way to approach this. Everyone in our cohorts are trained specifically and have experience doing something, and it is not infusing engineering design. When you take someone that has been preparing for a long time to be a math, science, or technology teacher, then we shouldn't be *surprised if we see limited results when we try to prepare them to be something else. Ideally, we should ask how to do this at the pre-service level.*

At end Vincent provided debriefing – indicated some good implementation examples with teachers. Five of eight teachers are implementing (4 of 8 have already, one plans on it).

National Center for Engineering and Technology Education
Annual Report External Evaluation Addendum

Submitted by

Inverness Research

June 2009

EVALUATION APPROACH

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

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

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

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

EVALUATION TASKS

Over the last 12 months, Inverness has continued to provide external formative evaluation and support for NCETE. At the beginning of this past year, we worked in concert with NCETE leadership to reformulate the external evaluation plan to focus primarily on the doctoral fellow strand of work, and to begin to design a study of the research component of the Center. Throughout the year, we have completed our tasks with an eye toward providing more summative data as the project comes to the end of its grant period.

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

We engaged in the following specific tasks:

- Collaborated with NCETE leadership on reformulating a plan for the external evaluation of NCETE for years 2009-2010 and 2010-2011 and to focus on the research effort of the Center, July 2008 – January 2009
- Communicated with the internal evaluator, Jim Dorward, on evaluation findings regarding the professional development workshops that occurred over the summer 2008, August 2008
- Attended an NCETE research meeting telephone conference, September 24, 2008
- Revised and finalized evaluation plan for the following two years, January 2009
- Attended numerous conference calls with NCETE leadership, July 2008 – April 2009
- Administered a comprehensive survey to both cohorts of doctoral fellows, March 2009
- Received updates on the seed-grant process, March 2009
- Attended the annual pre-ITEA NCETE meeting in Louisville, KY, March 25, 2009
- Attended the annual meeting of the International Technology Education Association meeting in Louisville, KY, March 26 – March 28, 2009

While Inverness Research had planned to complete a study on NCETE's substantial research efforts, that work is still in progress. The studies for which we will provide and analyze data in our next report include:

- A thorough review and study of the seed grant process, including analyzing progress and results from the seed grants that have completed the data analysis phase
- Follow-up interviews with participants in the research process, including those who attended NCETE's research symposium
- Recruiting an expert external review panel, to provide input on NCETE's impact on the research efforts of the field

ABOUT THIS REPORT

In February and March of 2009, Inverness Research developed and administered a survey of all doctoral fellows from both cohorts who were participating in NCETE, to build upon the knowledge we gained from prior interviews. The survey items and scales were based on those Inverness has used to evaluate other NSF-funded Centers for Teaching and Learning, including CILS (Center for

Informal Learning and Schools) and ACCLAIM (Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics), in an effort to assess (and provide quantitative evidence of) the Center's progress along particular drivers. For each driver, we disaggregated the data by cohort, to determine if there were substantial differences in experiences between the two cohorts of doctoral fellows in NCETE (those that began in 2005 and those that began in 2007).

What follows is a summary of our reflections on NCETE's progress over the past twelve months, along the five drivers, based on the results of the comprehensive survey of doctoral fellows, our observations of and reflections on NCETE's presence at the International Technology Education Association (ITEA) conferences, and our numerous meetings with and updates from the NCETE leadership. We conclude the report with a summary of the Center's accomplishments this year and the challenges it still faces.

FINDINGS BY DRIVER

CONTRIBUTIONS TO LEADERSHIP

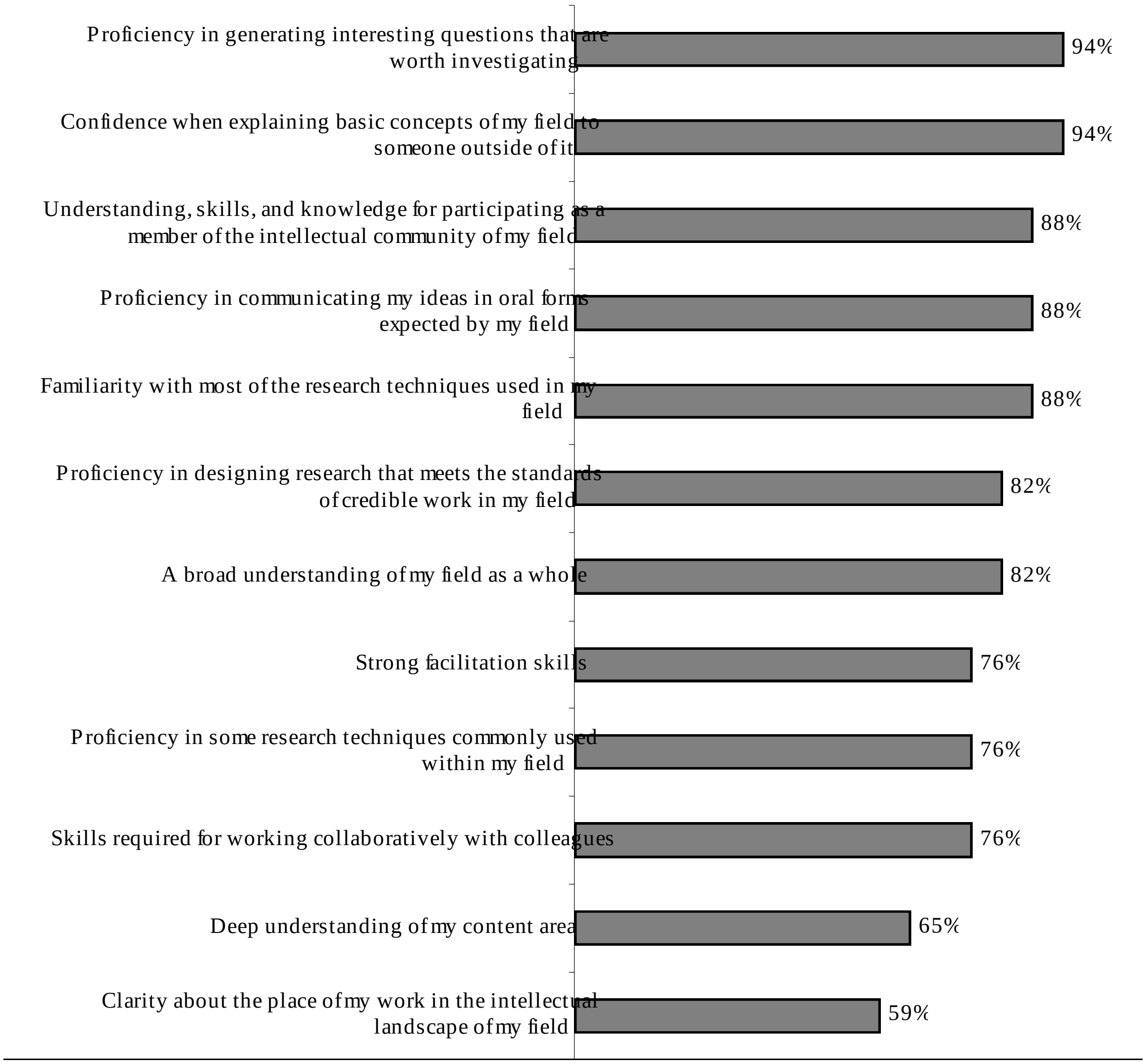
According to the drivers Inverness has identified for Centers for Learning and Teaching, leaders are those individuals who have a deep working knowledge (both practical and theoretical) of their domain and are skilled in promoting improvement in that domain, particularly by fostering relationships with other individuals who are skilled in complementary ways. NCETE has made substantial progress in providing leadership opportunities for Center faculty and for students. In addition to creating a cadre of potential leaders in technology education by supporting 18 doctoral fellows in two cohorts, this year, the Center has been proactive in assuring that doctoral students in Cohort 2 have sufficient opportunities to participate in leadership skill-building activities. As many as three fellows from Cohort 1 have gone on to accept assistant professor positions at Purdue University. Others have accepted positions at institutions such as Purdue University, Dunwoody College of Technology in Minneapolis, State University of New York (SUNY) in Oswego, and Utah State University.

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

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

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

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



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

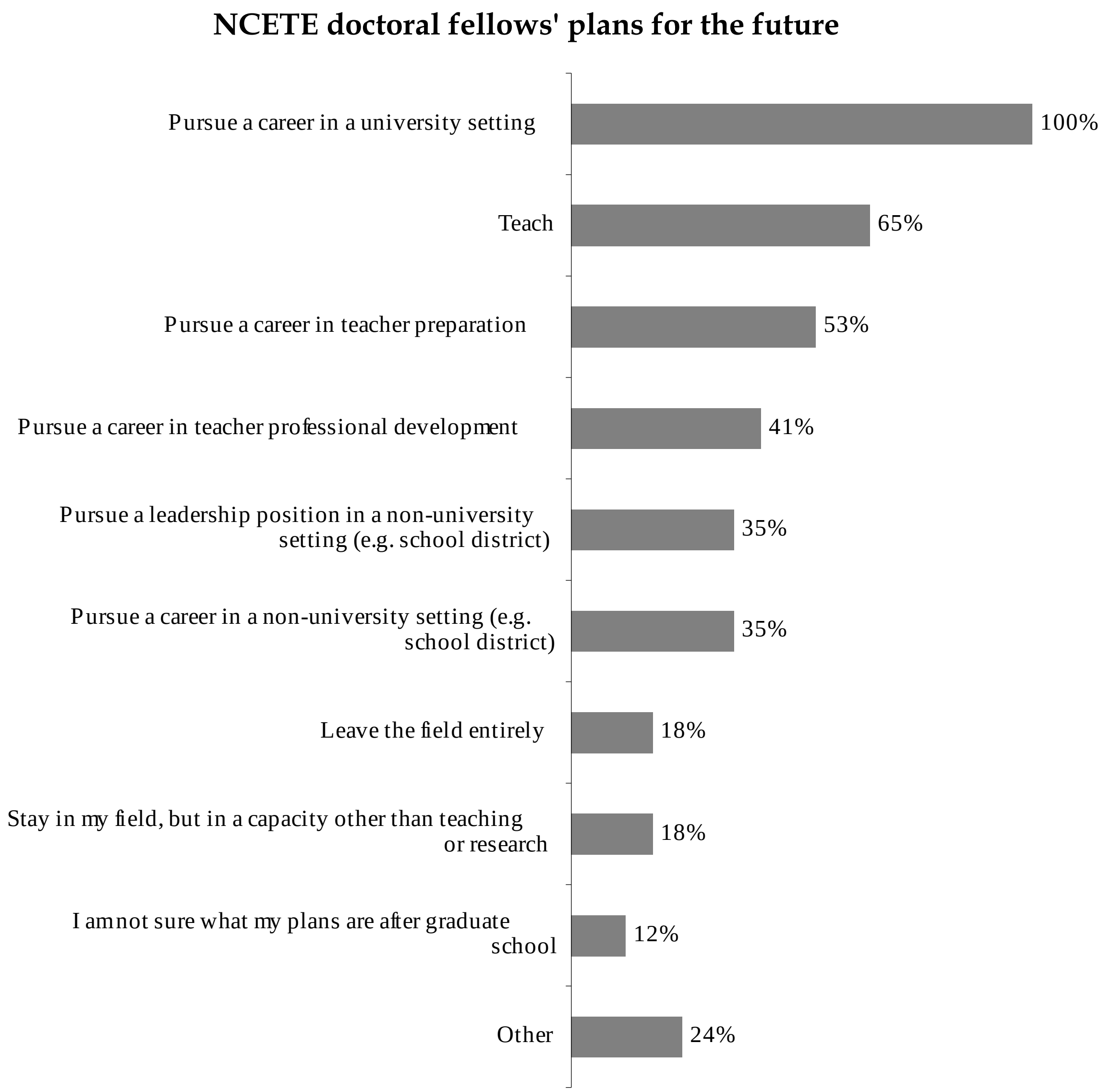
The differences between the cohorts regarding their perceived preparation for leadership roles are not strong, with slightly higher ratings given for most questions by the first cohort, but not significantly higher. One area – skills related to oral communication – may be significantly stronger for the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

Future Plans

Many of the doctoral fellows see multiple possibilities for the future.

> *I feel prepared to conduct research and am pleased with the Center's contribution to my education. I am confident that I can identify research questions with intellectual merit and broader impacts, write grants to support research and conduct studies. I am also confident that I can teach future teachers using my own teaching experience and understanding of the field through literature.*

On average, survey respondents checked three to four potential future positions for themselves, of those offered. According to the survey findings, all of the doctoral fellows are interested in pursuing an academic career, and just over half are interested in teacher preparation. Four in 10 (40%) say they are interested in teacher professional development. Only 1 in 5 (20%) see the possibility of leaving the field, or not doing either teaching or research. Four of 5 (80%) see multiple possible roles in the field, including teaching and/or research.



All fellows (100%) from Cohort 2 strongly believe they will continue their association with NCETE after graduation, versus 29% of Cohort 1 who believe they will continue their association with the Center. Yet participating in NCETE has affected the career plans of both cohorts equally.

> *I hope to collaborate more often and in a more substantive manner with my colleagues, and to help further the developing the mission of NCETE through my research and teaching.*

> *I will continue to maintain my relationships with my friends and colleagues from NCETE. I would like to continue to work with NCETE as*

a faculty member but it has not been clear to what extent NCETE will continue after the funding has ended.

KNOWLEDGE GENERATION AND FLOW (RESEARCH)

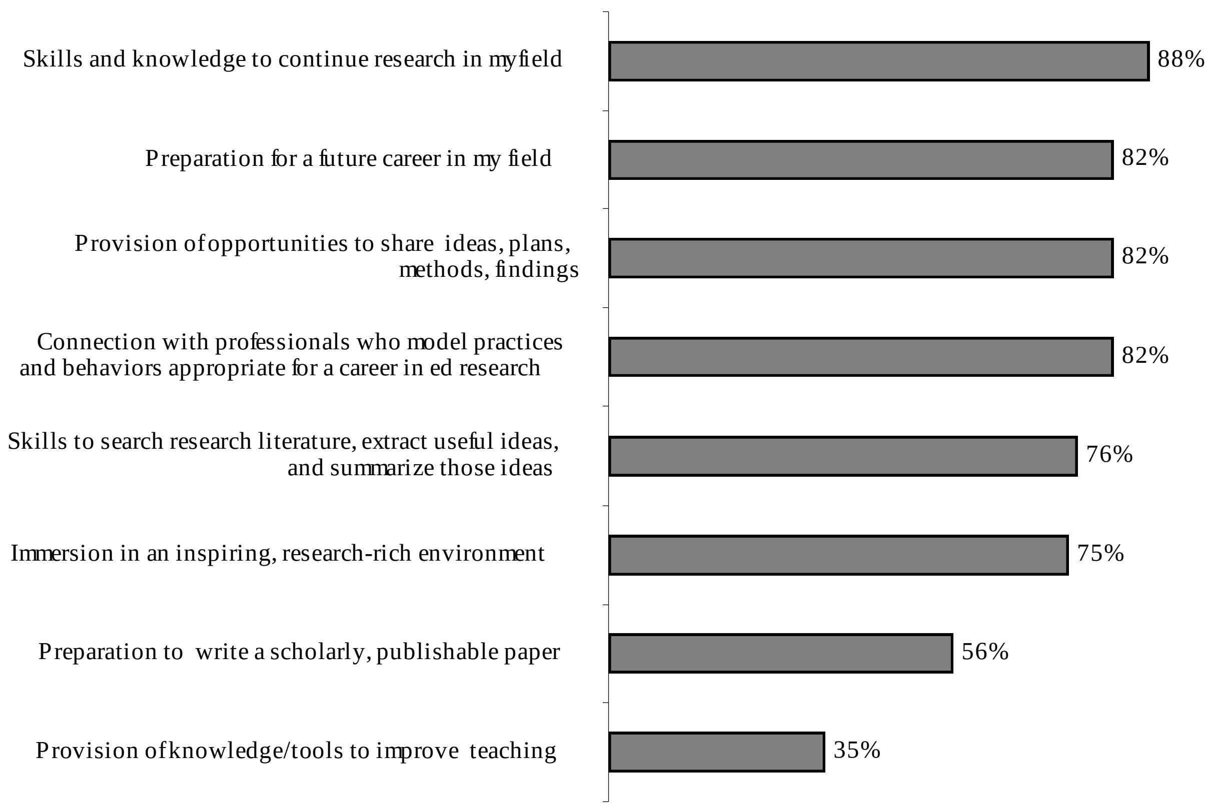
There are multiple levels of **knowledge** a national Center for Learning and Teaching is positioned to gather, generate, use, and disseminate, including knowledge of the policy, practice, improvement, and curriculum landscape associated with the Center's domain.

Importantly, NCETE created a process this year for soliciting rigorous seed-grant proposals and issuing funds for research that meets the needs of the field. In addition, the Center has sponsored research on professional development practices and curriculum in technology education. The knowledge generated from the seed grants coupled with the findings from the landscape studies on professional development and curriculum, will contribute to those organizations and individuals interested in the idea of infusing engineering design principles into technology education.

In NCETE, the doctoral fellows in both cohorts have become more aware of how their research topics and methodology are aligned with the mission of the Center itself, as well as how they meet the needs of the field. Cohort 2, in particular, has been encouraged since the beginning to think hard about their research topics and the niche they would fill in the field of technology education.

According to the findings from our survey of NCETE doctoral fellows, it appears that the NCETE doctoral program is preparing them for most skills necessary for continuing as a researcher in the field, with the exception of the knowledge and tools to improve teaching, and preparation to write a scholarly paper.

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



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

According to our survey results, it appears that the cohorts differ in their perception of the extent NCETE is preparing them for careers in research. Consistently, a *lower* percentage of Cohort 2 responders felt their research experiences in the NCETE doctoral program was providing them with opportunities to share their knowledge, since fewer of them felt the program was connecting them with professionals who model practices and behaviors appropriate for a career in educational research, and providing them with opportunities to share their ideas, plans, methods, and findings.

> *Across the partner institutions the quality and quantity of research varied greatly. Meetings could have been geared more toward enhancing individuals' research skills. It is apparent that this is something our field is weak in, and talking about it over and over does nothing; but developing specific skills can perhaps.*

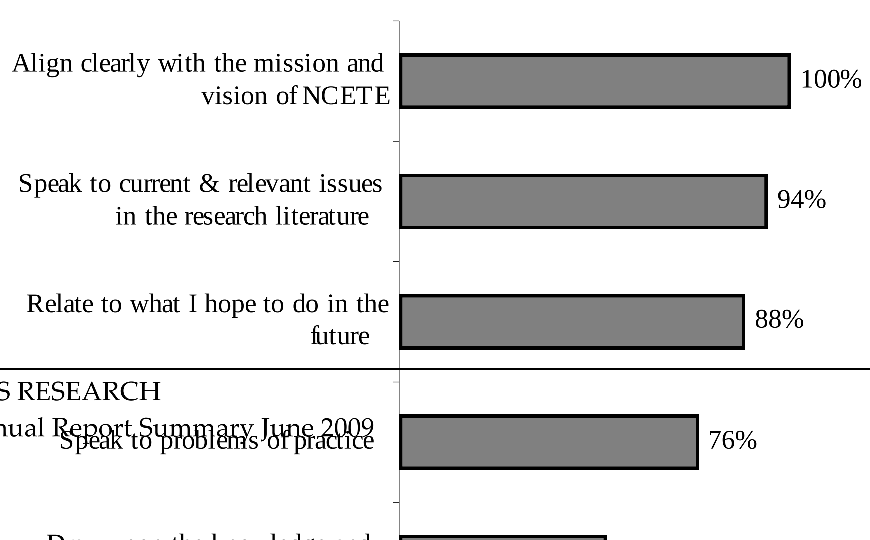
In addition, fewer of the Cohort 2 responders felt that the program was: providing them with knowledge and tools to improve their teaching; immersing them in an inspiring, research-rich environment; and equipping them with the skills to search the research literature, extract useful ideas and summarize those ideas.

> *I don't feel like I (or we) have gained much definitive information from our core courses on how to walk into a room of preservice teachers and teach them about engineering design. I know that teaching is only part of our goal, and that there is currently no right answer for how to do this, but I think we could have made more progress towards how to do it well. With respect to developing the ability to produce scholarly papers, I think I have come a long way towards this goal, but some different methods could have been used to further my progress.*

However, a *higher* percentage of Cohort 2 responders felt that their research experiences in NCETE were preparing them to write a scholarly, publishable paper, and preparing them for a future career in the field.

The doctoral fellows believe their dissertation research projects are clearly aligned with the NCETE mission. The only weak area is the extent to which these studies draw on the expertise of the NCETE faculty.

Percentage of NCETE doctoral fellows who think that their dissertation



research will have positive outcomes

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

Interestingly, later in the survey, these doctoral fellows report they don't interact as much with NCETE faculty as individuals, but they find the interactions they do have very valuable. This might suggest encouraging or enabling more opportunities for students to interact with Center faculty. With the exception of the extent to which their dissertation research speaks to problems of practice, the two cohorts are more or less aligned in their perceptions.

RELATIONSHIPS AND CONNECTIONS WITHIN AND OUTSIDE OF NCETE

Visibility in the field - ITEA

NCETE continued this year to cultivate relationships and connections with engineers at the partner universities, as well as with people active in the political and funding arenas. Of particular interest to Inverness Research this year was NCETE's presence at and within the International Technology Education Association, since ITEA is the "home" professional association for most, if not all, participants in NCETE.

Having attended ITEA for three years, Inverness can begin to note NCETE's visibility in the field across the last three years (see Appendix B for a listing of NCETE participants' posters and presentations at ITEA for the past three years). Our intention was to ascertain the extent to which the Center is creating an awareness in the field of their mission to infuse engineering design principles into technology education. The fact that NCETE has had its annual meeting on the day preceding the beginning of the ITEA conference every year is significant because it brings all of NCETE's participants to a place where there are opportunities to make connections, build relationships, and disseminate knowledge.

Our observations at the conference this year suggest that the research emphasis of the Center has come into sharper focus. While the total number of presentations and posters did not increase this year over last year (when the conference was in Salt Lake City, UT), there were a greater number of mentions of NCETE in the presentations of individuals not directly participating in NCETE, such as those by NSF program officers and the past-presidents and presidents-elect of ITEA themselves. The mission of NCETE seems aligned with the trajectory of ITEA itself, which is significant for the potential lasting legacy of the Center. NCETE as an organization and a set of principles is appearing in the thinking and discourse at ITEA, beyond the faculty and students directly associated with the Center. While we cannot claim causal relationships, we can say that NCETE's message is reaching out and more obvious in the field, and the Center is building connections outside of itself.

Of particular note is the fact that from our observations of three ITEA conferences in a row, there appears to be less of a need on the part of NCETE to justify the importance of its fundamental mission. Whereas in the past, much of the discourse debated the validity of engineering design principles being infused into technology education, this past year at ITEA, the very idea seemed to be the accepted direction of the field. In fact, in a session at ITEA 2009 (Louisville, KY) entitled "The Future of K-12 Engineering and Technology Education", both the past-president of ITEA Len Litowitz and George Rodgers who was representing the Engineering and Technology Division of the Association for Career and Technical Education conducted a session in which they did not question NCETE's mission but in fact, talked about how technology education should represent technology, engineering, and design. They went further to propose a name change for ITEA –to a name that would include the word 'engineering' in the title. Litowitz said:

> *"Should we, as an organization, consider a name change for our organization? When I look at the best of what we are doing – open-ended things with real materials – I don't care what you call it, I see the same good activities rising to the top of the list. There are some good reasons to lean toward engineering.*

This is an obvious symbolic shift in how technology education is defining itself and NCETE has been on the leading edge of that perspective.

Finally, it is noteworthy that for each of the past three years, at least half – and sometimes all – of the NCETE presentations and poster sessions at ITEA involved NCETE doctoral fellows. This is an indication of the infusion of energy and the inclination to share knowledge that these new potential leaders are bringing to the field. One doctoral fellow reported:

> *NCETE has provided a network connection of both fellows and faculty through various research related conferences from the most recent in Minnesota to ITEA. Through this connection, we have an awareness of what researchers are doing both inside and outside the Center. Presumably, awareness is the prerequisite to collaboration.*

Activities and Engagement of NCETE Doctoral Fellows

In terms of how NCETE has influenced the relationships and connections of the doctoral fellows, we return to our survey results. Between 2/3 and 3/4 of the doctoral students appear to be very engaged in building relationships relevant to graduate study.

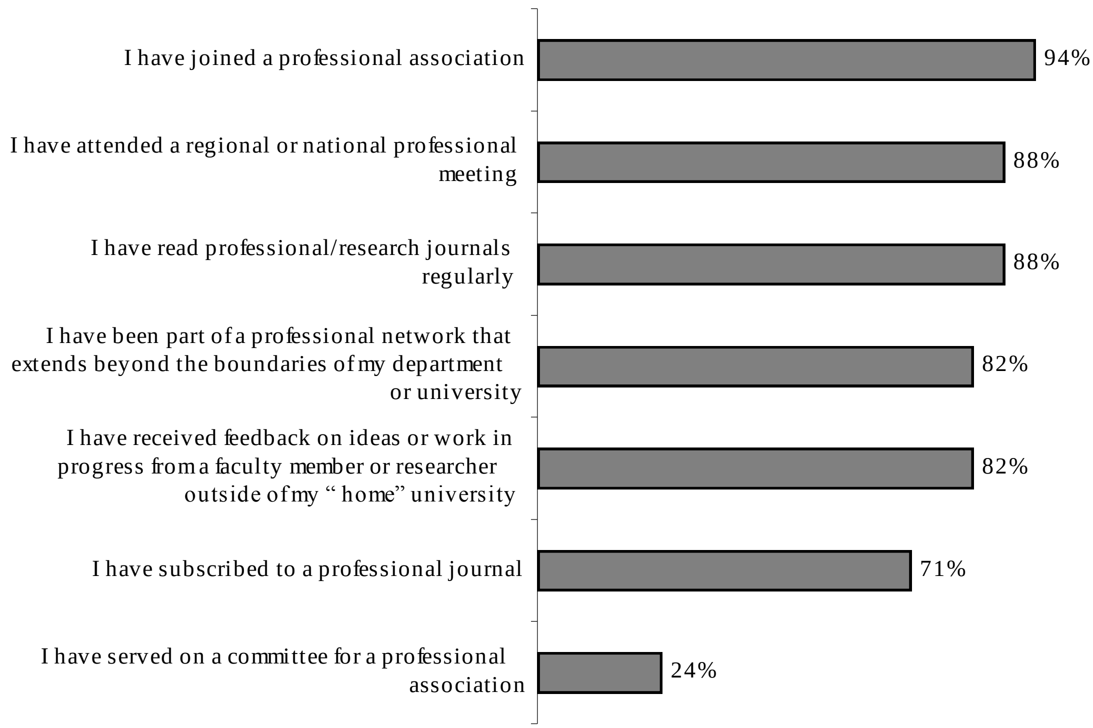
> *As a Fellow for NCETE I can honestly say that I was afforded many opportunities to share and collaboratively create knowledge that has help spur on my professional career. Working on various research projects at my respective university only enhanced this aspect of my matriculation.*

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

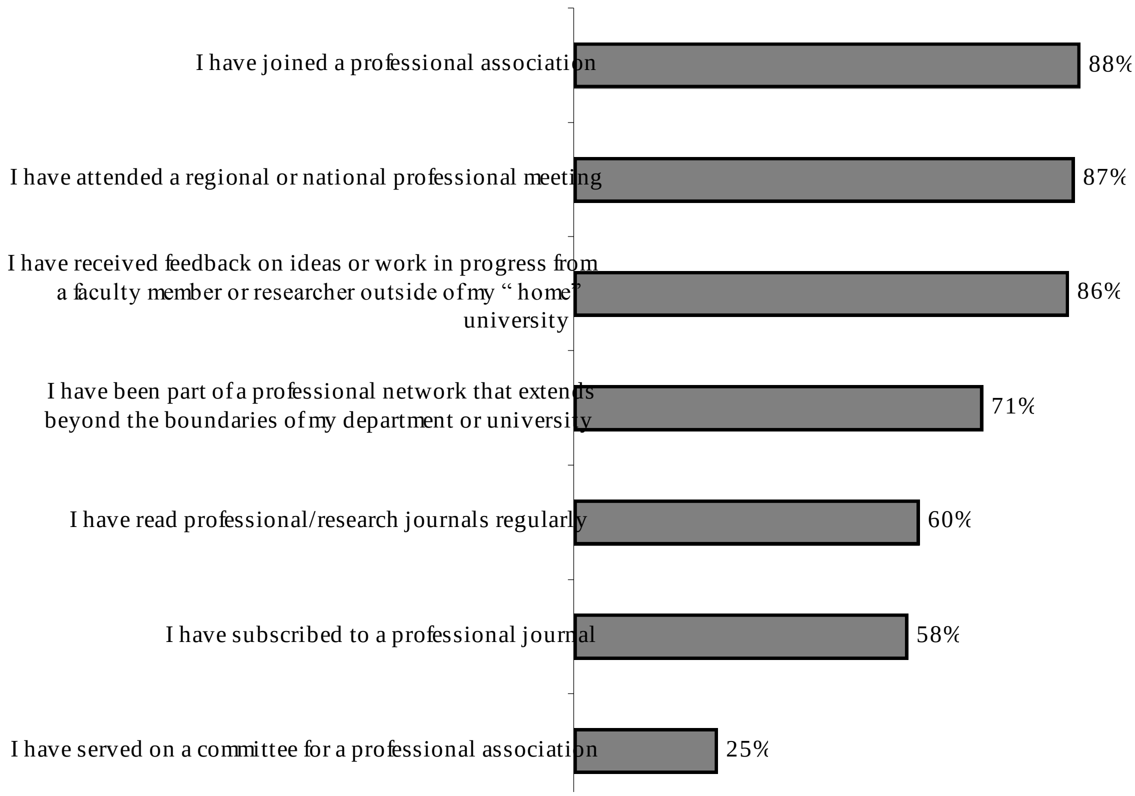
100% of the doctoral fellows reported that they had served on an NCETE committee, 75% said they had organized graduate student events, and 71% said they had been a part of an intellectual network that went beyond their immediate classmates, including colleagues senior or junior to themselves.

The doctoral fellows also appear to be very engaged in the broader disciplinary community. They also report that NCETE is a strong factor in helping them make those professional connections.

Percentage of NCETE doctoral fellows who have engaged in activities related to the broader disciplinary community



For those activities in which NCETE doctoral fellows have engaged, percentage where NCETE was a factor in their involvement



While the 1st cohort has done more related to NCETE than has the 2nd cohort, the two cohorts have been about equally involved with the broader professional community.

Contacts and Interactions

Doctoral students report a lot or a great deal of contact with other students in the Center, followed by NCETE Advisors, PIs, faculty, other researchers and teachers.

> *The Center, through collaboration with faculty, teachers, and fellows have provided me a tremendous opportunity for networking. Although some relationships between faculty were not healthy because of professional or personal differences, this did not affect my opportunity to learn from NCETE participants at all levels.*

Most every one of the doctoral fellows has had some contact that they find useful. The first cohort perceives they have had more contact with others in the Center than the second. Both cohorts feel the contact they do have with others is both productive and useful.

In your NCETE doctoral experience so far, how much contact have you had with each of the following groups? How productive or useful have your interactions been?

	None/ a little	Some	A lot/ great	Not or slightly	Mixed	Useful Or very
Other NCETE students (not at my institution)	0%	18%	82%	0%	6%	94%
NCETE advisors	31%	19%	50%	13%	25%	63%
NCETE leadership/PIs	24%	29%	47%	0%	13%	88%
NCETE faculty (not at my institution)	12%	59%	29%	0%	12%	88%
Researchers in the field	35%	41%	24%	0%	25%	75%
K-12 practitioners	44%	44%	13%	8%	8%	85%

Value of the Cohort Structure

In general, the NCETE doctoral fellows find the cohort structure of the Center to be of value.

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

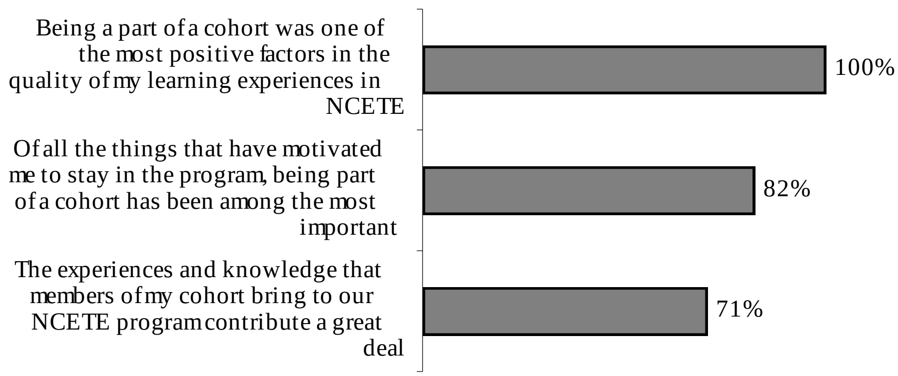
> *The cohort has provided a critical mass of people who are focused on a similar goal. This is rather unique in my experience since, technology education, typically is a small group of folks. This critical mass has provided a motivating factor in that we support each other. The small disadvantage is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

> *My vocabulary lacks the words to quantify the importance of going through all phases of a doctoral program with at least a few others experiencing the same pain simultaneously. Not that the pain is always a bad thing. But there were times I seriously questioned my decision to pursue a PhD and having one other person feeling the same pain to serve as a sounding board helped pull me through. In addition there is much to be gained from the expertise of fellow fellows. The initial pool of candidates that were sought from Technology Education and Engineering was well intended and helped spread a wealth of professional knowledge from within the cohort. I learned a great deal from these cohort members. The*

greatest disadvantage of a cohort is that if there are a few weak links in the chain, others end up carrying the weight for them. When quality people begin to shut down out of frustration it weakens the cohort and has negative consequences for the intended goal/mission of NCETE.

While all students report that the cohort is a positive factor in the quality of their learning experiences, they do not all agree that their peers are bringing knowledge that contributes.

NCETE doctoral fellows' attitudes towards belonging to a cohort



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

There are no noticeable differences between the cohorts related to the cohort experience.

STRUCTURES, POLICIES, AND PROGRAMS

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

NCETE also revised the core courses for the doctoral student strand of work, in an effort to provide additional coherence and structure to the sequence. About 2/3 of the doctoral fellows reported that the core courses are generally good or excellent, and most of the rest say they are mixed.

[In my university], the NCETE courses were our only opportunity to interact with other technology/engineering education researchers and topics, thus they were critical to our development. Without these courses the program would have been much more difficult and we would have gotten much less out of it had we elected to complete it at all.

Quality is rated higher than usefulness. There also appears to be a great deal of perceived variation among the courses, with usefulness less varied overall than quality. Slightly more than 1/2 perceive the core courses as somewhat or very complete/coherent. Again, there is a fair amount of variation in how coherence is perceived. Finally, only a few people do not think the core courses are as valuable as other courses in their program, 2/3 find them somewhat valuable, and the rest of moderate value.

Overall assessment of NCETE Core Courses

	Very poor or poor	Mixed	Good or excellent
Average course quality	6%	29%	65%
Average course usefulness	0%	59%	41%
	Not at all or slightly	Somewhat	Quite a lot/ a great deal
To what extent did the quality of the core courses vary?	0%	35%	65%
To what extent did the usefulness of the core courses vary?	12%	47%	41%
	Somewhat or very incomplete/ incoherent	Mixed	Very complete/ coherent
How would you rate the overall completeness and coherence of the set of core courses?	24%	24%	53%
	Of no or little value	Of some value	Of great or very great value
Compared to other courses you have taken as part of your doctoral program, how would you rate the value of the NCETE core courses?	6%	35%	59%

These data suggest that the courses may have improved for the second cohort, since the second cohort rated the extent of variation in usefulness and quality lower than the first cohort. Moreover, the second cohort rated the coherence of the set of courses higher than the first.

The courses cited as most beneficial most often are The Role of Cognition and Engineering Design and Technology Education:

> *The cognition course was by far the most rigorous, coherent, and beneficial course with far-reaching applications and research preparation. None of the others even came close to comparing to this course.*
>
> *As part of the cognition course, we designed and carried out an actual research study, which was a tremendously beneficial experience at the start of a doctoral program. At the end of this course I felt like I both knew and had what it took to be a researcher. In addition to the research project, the material presented in the course was challenging, essential for any cognitive work in our field, and fundamental to understanding how people learn and think. This course was not only the most beneficial core course, but the most beneficial of all of my course work to date.*
>
> *The cognitive science course has become the lens for which a great portion of my research now and later in my career will take. Additionally, the course was rigorous and relevant. I felt the pedagogy was superb.*
>
> *Student learning is at the heart of all educational matters. The exposure provided to cognitive science and the attempt at bringing us into the literature in our field early on was a very important first step. What I took from this course in the form of a research experience and more importantly with an understanding of methods of gauging student learning/understanding/comprehension was crucial to my dissertation research.*

Other courses also had their advocates:

> *I felt that Core Course 4 was the most beneficial because we had an opportunity to develop curriculum content that was relevant to infusing engineering based content into general education. What the other core courses lacked was a focus on hands-on projects wherein we could actually engage in engineering design rather than reading articles and discussing the implications that these articles had on STEM integration.*
>
> *The course contained a hands on project which provided experience working in groups with colleagues across institutions as well as directly addressing the question of how engineering might be infused in technology education. The technology education and engineering faculty at the site (UGA) made a concerted effort to tie their discussions together into a single class.*

The least beneficial courses cited most often were Dynamic and Network Engineering Processes for Technology Education and Seminar: Engineers and Engineering Design.

CENTERNESS

Doctoral Fellows' Perspective on Centerness"

Overall, doctoral students have a positive perspective on NCETE as a Center, with opportunities to connect to other disciplines.

> *The greatest strengths of the NCETE doctoral program have been my interactions with doctoral students and faculty from other institutions. These interactions have raised my level of awareness of the field, have contributed to the formation of relationships that will last throughout my career, and that have challenged my thinking.*

Only three people out of 17 were less positive on this dimension:

Please indicate the extent to which you believe NCETE, as a Center, represents the following:	Not At all	Some	Large or very great extent
An opportunity to create a new field – engineering and technology education	12%	6%	82%
A place where students have a role and an opportunity to contribute	6%	18%	76%
A place where faculty, students, and postdocs are connected, interact, and speak freely about the work associated with NCETE	0%	24%	76%
An opportunity for participants to learn about two or more disciplines and how to integrate them.	6%	24%	71%
A central node in the technology education field that facilitates access to resources, faculty, practitioners, funding, and a sense of intellectual community	6%	35%	59%
A portal to the world beyond your own professional context and perspective	18%	29%	53%

The cohorts do not differ a great deal on items related to the "centerness" of NCETE. However, it appears the first cohort feels most strongly that NCETE is a place where students have a role and opportunity to contribute, and cohort 2 feels more strongly than the first that NCETE is a place where students, faculty, practitioners, etc are connected, interact and speak freely about the work of the Center, and that participating in NCETE has provided a portal to the world beyond their professional context.

> *NCETE is a collaborative network of scholars and this is very helpful. It brings national perspective to our work. As I mentioned before, it generates a critical mass of people all focused on the same goals and provides support for reaching these goals.*

> *The ability to bring together professionals and fellows under one academic roof to learn and educate each other on the concerns, current changes and*

future directions of the continually advancing field of engineering and technology education.

While the students appear to be positive about the program as a whole, at least half have major reservations. Notably and consistent with other sections of this survey, the courses and preparation for research are rated lower. However, overall students are very satisfied with their doctoral program. Noteworthy here are that the items related to the extent to which the Center has a clear mission and vision (cohort 1 44% large/very great vs. cohort 2 88% large/very great); has courses appropriate to fellows' needs (cohort 1 22% vs. cohort 2 63%). While more fellows in cohort one felt the Center provided training in a variety of research methods and perspectives, in both cases, the ratings are relatively low for such a critical aspect of doctoral training.

ACCOMPLISHMENTS & CHALLENGES

Accomplishments

The Center has made substantial progress in **defining and refining the professional development work** and its purpose for the Center. While we did not study this directly this year, based on what we heard at the meeting in Louisville, and the findings of the internal evaluator, this work seems to have found its role in the overall work of the Center.

The Center also designed and implemented a **seed grant request for proposals process** that has resulted in the funding of eight studies that address some aspect of infusing engineering in technology education. These seed grant proposals were rigorously reviewed and several were revised before they were funded. At the meeting in Louisville, preceding the ITEA conference this year, recipients of the seed grants shared their progress on the studies. Inverness is planning a comprehensive review of this seed grant process, and the nature and quality of the studies that result in the coming months.

Last year, we noted that faculty and students continue to express concern regarding the **lack of a common vision, an understanding of the intellectual landscape, and the potential future opportunities available in the domain**. This seems to be **less of a concern** now, perhaps due to the thoughtful and strategic efforts put into orienting the second cohort.

When the leadership group viewed the preliminary results of the doctoral survey, they were particularly concerned about the students in cohort two reporting a perceived lack of opportunities to develop their leadership skills. They immediately set up a meeting in July 2009, with NSF and NAE where Fellows will meet with lobbyists and program officers to discuss potential future opportunities. In general, the **NCETE leadership has been very responsive to our evaluation feedback**.

Challenges

NCETE continues to face **issues regarding the core courses**. While the courses seem to have improved considerably, at least according to the feedback from the doctoral fellows, they would benefit from further review and refinement, especially with regard to their usefulness, if they were in fact being offered again, which is unlikely. In addition, the extent to which the courses prepare doctoral fellows to conduct rigorous research remains somewhat variable. While doctoral fellows' levels of preparation to conduct rigorous research are likely to differ according to their home institutions, the Center might consider providing additional research preparation opportunities (perhaps hosted by an external organization) that would provide a minimum standard of rigor for all doctoral fellows and faculty.

Similarly, there continues to be a **challenge associated with the rigor of research that is being produced by the Center**. The seed grant review process was an important first step in creating a standard of what solid research and a challenging review process in this field should entail.

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

Finally, as we mentioned in our last annual report, NCETE would do well to **develop and progress towards a strategic vision for how to ensure the legacy** that it wishes to leave.

APPENDIX A: The CLT Drivers

Leadership

Leaders are people who:

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

Evaluation Tasks

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

Knowledge Generation & Flow

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

Types of Knowledge – multiple levels of focus (grain size)
- About engineering & technology education improvement
- About policy related to engineering & technology education
- About the landscape of engineering & technology teaching and learning
- About the cognitive aspects of learning in engineering & technology education
- Knowledge of influential practices; curriculum

Increased capacity for collating, generating, using and disseminating knowledge

Evaluation Tasks

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

Relationships & Connections

Examples include:
- Professional Networks
- Higher Ed – K-12 Connections
- Engineer – Educator Connections
- Regional – National Connections
- Engineering – Technology Education Connections

- Communication Channels and Avenues

Programs, Structures, Policies

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

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

"Centerness"

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

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

Appendix B: NCETE Presentations and Posters at ITEA

Presentations 2007 – San Antonio, TX
(12 total - 7 involving doctoral fellows)

Childress, V., & Rhodes, C. (2007). Engineering outcomes for high school: Follow-up. Paper presented at the meeting of the International Technology Education Association, San Antonio, TX.

Daugherty, J., Westrick, M., Zeng, Y., Merrill, C., & Custer, R. (2007). Delivering core engineering concepts to secondary level students using the STL. Paper presented at the meeting of the International Technology Education Association Conference, San Antonio, TX.

Daugherty, J., Zeng, Y., Westrick, M., Merrill, C. & Custer, R. (2007). Delivering key engineering concepts using the STL. Paper presented at the meeting of the International Technology Education Association Conference, San Antonio, TX.

Denson, C., Avery, Z., & Hill, R. (2007). African American students: Perceptions of technical careers. Paper presented at the meeting of the International Technology Education Association, San Antonio, TX.

McAlister, B. (2007). Analysis of pre-service / licensure technology education programs in the U.S. Paper presented at the meeting of the International Technology Education Association, San Antonio, TX.

Mentzer, N., & Stewardson, G. (2007). Technological literacy and USU general education students. Paper presented at the meeting of the International Technology Education Association, San Antonio, TX.

Merrill, C., & McAlister, B. (2007). U.S. preservice/licensure technology education programs. Paper presented at the meeting of the International Technology Education Association, San Antonio, TX.

Roue, L. (2007). Young women's perceptions of technology and engineering. Paper presented at the meeting of the International Technology Education Association, San Antonio, TX.

Walrath, D., Denson, C., Daugherty, J., & Zeng, Y. (2007). Global insights on engineering design as content. Paper presented at the meeting of the International Technology Education Association, San Antonio, TX.

Welty, K., McAlister, G., Meyer, S., & Sullivan, J. (2007, March). Manufacturing

engineering: A lean approach. Paper presented at the meeting of the International Technology Education Association, San Antonio, TX.

Welty, K.D., Merrill, C., Shumway, S., & Hill, R. (2007). Integrating engineering into technology teacher education. Paper presented at the International Technology Education Association Conference, San Antonio, TX.

Wicklein, R. & Kelley, T. (2007). Making engineering work at your school. Paper presented at the meeting of the International Technology Education Association, San Antonio, TX.

Presentations 2008 – Salt Lake City, UT
(14 total – 7 involving doctoral fellows)

Castillo, M. (2008). Using a game-based approach with STEM. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Castillo, M. (2008). Sharing a student-made tech ed lab querying system. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Childress, V. (2008). Engineering and diversity: The Black Inventors Project (grades 2-3). Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Childress, V., & Rhodes, C. (2008). Engineering concepts educators say are important. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Cox, K., & Avery, Z. (2008). Engineering design in high school technology classrooms. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Daugherty, J. (2008). Cardiac arrest: An engineering-infused medical design challenge. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Kelley, T., & Hill, R. (2008). Cognitive processes of students solving ill-defined problems. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

McAlister, B., Daugherty, J., & Custer, R. (2008). An overview of STEM pre-engineering professional development. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Merrill, C., & McAlister, B. (2008). U.S. preservice/licensure technology education programs. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Walrath, D., Swapp, A., & Mentzer, N. (2008). Dust in the wind: Exploring renewable energy. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Welty, K. D. (2008). Enriching elementary curricula with technology topics (grades 3-5). Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Wicklein, R., & Hill, R. (2008). Test of engineering design. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Wicklein, R., & Kelley, T. (2008). Redirecting technology education: Engineering design focus. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Wicklein, R., Kelley, T., & Denson, C. D. (2008). Integrating engineering design – the Georgia perspective. Paper presented at the meeting of the International Technology Education Association, Salt Lake City, UT.

Presentations 2009 – Louisville, KY
(8 total – 4 involving doctoral fellows)

Childress, V. (2009). Engineering design teacher professional development: A model. Paper presented at the meeting of the International Technology Education Association, Louisville, KY.

Dixon, R. (2009). Cognitive strategy and core thinking skills. Paper presented at the meeting of the International Technology Education Association, Louisville, KY.

Kelley, T., (2009). Engineering design content in technology education. Paper presented at the meeting of the International Technology Education Association, Louisville, KY.

Lammi, M. (2009). Student attitude and achievement with virtual instrumentation. Paper presented at the meeting of the International Technology Education Association, Louisville, KY.

Lipton, E. B., Maurizio, D., Tufenkjian, M., & Castillo, M. (2009). Teachers integrate engineering in high school classes. Paper presented at the meeting of the International Technology Education Association, Louisville, KY.

Lipton, E. B., Tufenkjian, M., Maurizio, C., Castillo, M., Childress, V., Lee, K., & Deeble, P. (2009). Introducing engineering design challenges into your high school classrooms. Preconference workshop presented at the meeting of the International Technology Education Association, Louisville, KY.

Merrill, C., & Daugherty, J. (2009). The future of TE masters degrees: STEM. Paper presented at the meeting of the International Technology Education Association, Louisville, KY.

Pearson, G., Welty, K., Gomez, A., Basham, L., & Newberry, P. (2009). K-12 engineering education: NAE projects update. Paper presented at the meeting of the International Technology Education Association, Louisville, KY.

Posters 2007 – San Antonio, TX
(10 total – 9 involving doctoral fellows)

Avery, Z. (2007). *A systems-based approach for technology education professional development using the engineering design process.* Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Custer, R., Merrill, C., Daugherty, J., Westrick, M., & Zeng, Y. (2007, March). *Delivering key engineering concepts using the STL.* Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Daugherty, J. (2007, March). Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Denson, C. (2007, March). *African-American high school student's perception of engineering.* Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Kelley, T. (2007, March). *Students solving ill-defined technical problems: An observational protocol study.* Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Mentzer, N. (2007, March). *A comparative analysis of novice and expert*. Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Merrill, C., & Custer, R. (2007, March). *Delivering core engineering concepts to secondary students*. Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Roue, L. (2007). *Young women's perceptions of technology and engineering.* Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Walrath, D. (2007, March). *Microgravity environments: A comparative analysis of expert and novice cognitive reasoning abilities.* Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Zeng, Y. (2007, March). *Roles of mental models in engineering re-design*. Poster session presented at the annual meeting of the International Technology Education Association, San Antonio, TX.

Posters 2008 – Salt Lake City, UT
(8 total – 8 involving doctoral fellows)

Avery, Z. (2008). *The impact of NCETE professional development on infusing engineering design content into STEM classroom and laboratory projects.* Poster session presented at the annual meeting of the International Technology Education Association, Salt Lake City, UT.

Daugherty, J. (2008, February). *Evaluation of engineering by design professional development.* Poster session presented at the annual meeting of the International Technology Education Association, Salt Lake City, UT.

Denson, C. (2008, February). *Impact of mentorship programs on African-American high school students' perceptions of engineering.* Poster session presented at the annual meeting of the International Technology Education Association, Salt Lake City, UT.

Kelley, T. (2008, February). *Examination of engineering design in curriculum content and assessment practices of secondary technology education.* Poster session presented

at the annual meeting of the International Technology Education Association, Salt Lake City, UT.

Mentzer, N. (2008, February). *Engineering design challenge: Infusing engineering into technology edu*cation. Poster session presented at the annual meeting of the International Technology Education Association, Salt Lake City, UT.

Walrath, D. (2008, February). *Complex systems in engineering and technology education: The role software simulations serve in student learning.* Poster session presented at the annual meeting of the International Technology Education Association, Salt Lake City, UT.

Walrath, D., Mentzer, N., & Swapp, A. (2008, February). *Dust in the wind: Exploring renewable energy.* Poster session presented at the annual meeting of the International Technology Education Association, Salt Lake City, UT.

Zeng, Y. (2008, February). *Women: Support factors and persistence in engineering*. Poster session presented at the annual meeting of the International Technology Education Association, Salt Lake City, UT.