1. DEFINITION OF "SCHOLARSHIP IN ENGINEERING EDUCATION" (2)

A. In his 1990 seminal work entitled "Scholarship Reconsidered: Priorities of the Professoriate," Ernest Boyer included the scholarship of teaching as one of the four types of scholarship that faculty can pursue - the others being discovery, integration, and application. Boyer further stated that these four areas of scholarship are equally important to the mission of the research university, and thus all are important for faculty to pursue.

QUESTION: to begin our dialogue let me ask two questions: how would you define the scholarship of teaching, and what elements in your definition make this an important activity for engineering faculty to pursue?

(Boyer's answer: subject knowledge, pedagogical knowledge, commitment to continuing growth as an educator. Richard Felder (Prof. Emeritus of ChemE. at NC State) and others added "involvement in development, assessment, and dissemination of innovative instructional methods and materials").

NOTES:
Discovery: (RESEARCH is only the first step); purely investigative; the search for new information; what is to be known? What is yet to be found?
Integration: what happens when scholars put isolated facts into perspective by making connections across disciplines; work that interprets, draws together and brings new insight to bear on original research; what do the findings mean? Draws connections and examines contexts in interdisciplinary ways.
Application: seeks out ways in which knowledge can solve problems and serve both the campus and the community; how can knowledge by responsibly applied to problems? How can it be helpful to people and institutions?
Teaching: the presentation of information so that others might understand it; not only transmitting knowledge, but also transforming and extending as well; how can knowledge best to transmitted to others and best learned?

NOTE: Boyer served as President of the Carnegie Foundation for the Advancement of Teaching,

QUESTION: will the engineering community accept education research as “important research” and not simply another form of “teaching”?

2. DIFFERENCES BETWEEN ENGINEERING RESEARCH AND EDUCATIONAL RESEARCH (5)

A. QUESTION: are the methodologies used in educational research different than the methodologies of engineering research?

B. In a recent paper entitled "The Scholarship of Teaching and Learning in Engineering," Karl Smith, Richard Felder, and others make the following statement:

QUOTE Certain differences between engineering research and educational research pose significant challenges to faculty intending to engage in engineering education research, e.g., engineering research is fundamentally scientific in nature, accurate models have been developed, phenomena to be studied are objectively defined and observable, and the validity of the proposed theoretical or empirical models can be tested and replicated. However, engineering education research is much less precisely defined. The definitions of student skills, understanding, attitudes, and values are all highly subjective - they cannot be directly observed or calculated, like tensile strength can be. Their existence and level of development must be inferred from observation of student behaviors UNQUOTE

QUESTION: do you agree with these statements, and if so, can we ever hope to find a "cause and effect" relationship between the teaching of engineering and the learning of it that can be unequivocally demonstrated and replicated?

C. In a recent paper authored by David Berliner, Professor of Education at Arizona State, the author makes the following comment:

QUOTE educational research is considered by many to be SOFT SCIENCE, i.e., too squishy, unreliable, and imprecise to rely on as a basis for practice in the same way that HARD SCIENCE designs bridges and electric circuits, sends rockets to the moon, or develops new drugs UNQUOTE.

QUESTION: do you agree with this statement?

D. In a recent paper authored by David Berliner, Professor of Education at Arizona State, the author makes the comment that although people call math and engineering HARD SCIENCES and educational research SOFT SCIENCE, in actuality math and engineering are easy-to-do sciences and educational research is hard-to-do science, in fact, he calls it the hardest-to-do science of all.

Question: what do you think he meant by that statement?

(answer: we face particular problems and must deal with local conditions that limit generalizations and theory building - problems that are different from those faced by the easier-to-do sciences).

E. MESSAGE FROM AN ASEE MEMBER RECEIVED PRIOR TO THE CONFERENCE:

The description of this session in the Conference Proceedings says that the approach we take in engineering education research MUST mirror the broad research strategies successfully applied to other engineering challenges. Is this really true? An ASEE member recently made the following comment to me that took that opposite POV,

QUOTE if research on engineering education is to be scholarly, rather than mirror the research strategies prevalent within engineering research communities, it should strive to avoid them UNQUOTE.

QUESTION: what do you think the ASEE member meant by that statement?

(ASEE member's answer: engineering research is materialistic - it's about technique and technologies; counting and correlating. Engineering education is idealistic - it's about people, their development, growth, learning; and it's about professions and communities of practice. Correlating and counting won't do; we need good narratives from a variety of scholarly perspectives involving historians, anthropologists, sociologists, cognitive people, and even political scientists and literary critics)

3. WHY SCHOLARSHIP IN ENGINEERING EDUCATION SEEMS TO BE LAGGING BEHIND THAT OF OTHER ACADEMIC DISCIPLINES (8)

***A.** In a paper published earlier this year with the provocative title "Do Engineering Faculty Know What's Broken," the author, Sanjay Goel, says that

QUOTE engineering faculty teach for decades without ever exposing themselves to the vast research and literature available on the scholarship of teaching and learning. For example, most engineering faculty have never heard of, let alone performed research in, Problem-Based Learning, Project-Based Learning, Anchored Instruction, Constructionist Theory, Experiential Learning, Learning By Design, etc UNQUOTE

QUESTION: do you agree or disagree with Prof. Goel's assessment?

B. In a recent paper entitled "The Scholarship of Teaching and Learning in Engineering," Karl Smith, Richard Felder, and others make the following statement:

QUOTE few engineering professors are familiar with the qualitative research methods used widely to assess teaching in the social sciences UNQUOTE

QUESTION: rather than "re-inventing the wheel," shouldn't engineering faculty learn from social science research or is the teaching of engineering so different that we need a whole new set of research methods?

***C.** In a paper entitled "Do Engineering Faculty Know What's Broken," the author, Sanjay Goel, says that

QUOTE engineering education offers a very fertile ground for validating, adapting, and inventing new theories in learning science UNQUOTE

QUESTION: what do you think Prof. Goel meant by this remark? Are engineering faculty uniquely qualified to make huge contributions to education research?

D. In a paper entitled "Do Engineering Faculty Know What's Broken," the author, Sanjay Goel, says that

QUOTE the kinds of classroom activities that a typical engineering student is generally engaged in do not help in enhancing creativity, critical thinking, and innovative problem solving UNQUOTE

QUESTION: do you agree or disagree with this statement?

E. Karl Smith from the Univ. of Minnesota, who is in the audience today, recently made the following statement:

QUOTE We've assumed for too long that if you're an expert engineer (i.e., you have a PhD in engineering) then you can teach it. Research in other disciplines, however, indicates that there is specific disciplinary pedagogical knowledge that is needed for teaching. Lee Shulman described this in 1987 as Pedagogical Content Knowledge NQUOTE

QUESTION: who exactly do Karl Smith and Lee Shulman mean by Pedagogical Content Knowledge?

(answer:
- successful teachers do not just have an intuitive or personal understanding of particular concepts, principles, or theories, they also know how to represent these concepts, principles, or theories to students;
- in other words an expert teacher must demonstrate knowledge of the subject being taught AND knowledge of pedagogy; it is where these two areas overlap that the facilitation of learning in a specific subject area begins
- thus, to be an effective engineering teacher requires knowledge of engineering AND knowledge of various pedagogical techniques such as evaluation strategies, lesson planning, classroom management, etc.
- PCK includes conceptual and procedural knowledge, a repertoire of varied techniques and activities that meet different learning styles or preferences, knowledge of techniques for assessing and evaluating, and knowledge of a variety of resources that can be easily accessed for use in the classroom

F. In a recent paper entitled "Engineering Change," Karl Smith and his co-authors make the statement:

QUOTE there are many calls for changes in how we teach engineering - from government, from industry, from ABET, etc -, so why hasn't more change in how we teach engineering occurred faster? UNQUOTE

(William Wulf, former pres. of the Nat'l Academy of Engineering answer: faculty simply don't believer that change is needed; they feel that if it ain't broke, don't fix it; if one hasn't had recent experience in industry, then the fact that it's broke is not easy to see)

G. Richard Felder, Prof. Emeritus in Chemical Engineering at North Carolina State, who is in the audience, has the following statement on his website:

QUOTE: College teaching may be the only skilled profession for which no preparation or training is provided or required. You get a Ph.D., join a faculty, they show you your office, and then tell you 'By the way, you're teaching 205 next semester. See you later.' The result is the consistent use of teaching techniques that have repeatedly been shown to be ineffective at promoting learning UNQUOTE. (Prof. Felder did I quote your website correctly?).

QUESTION: what do you think of Prof. Felder's comment?

H. QUESTION: how can university and engineering administrators facilitate the advancement of scholarship in engineering education?

4. FACULTY REWARDS FOR SCHOLARSHIP IN ENGINEERING EDUCATION (7)

A. In a recent paper entitled "The Scholarship of Teaching and Learning in Engineering," Karl Smith, Richard Felder, who are in the audience this morning, and others make the following statement:

QUOTE The playing field is by no means level at colleges and universities making personnel decisions for teaching and disciplinary research. At most research universities, teaching quality and the scholarship of teaching and learning still count for considerably less than disciplinary research in determining progress up the faculty career ladder. The primary reason for this is the ready availability of funding for disciplinary research since the late 1950's, compared to the lack of funding for scholarship in teaching and learning. If faculty wishing to engage in educational research are to have the same opportunities for career advancement as their counterparts in disciplinary research, they must have the same opportunities to raise money for release time, fringe benefits, student support, equipment and supplies, and overhead costs UNQUOTE

QUESTION: do you agree or disagree with this assessment?

B. In an article recently published in the journal Chemical Engineering Education, by Dr. Richard Felder of North Carolina State, who is in the audience this morning, and his co-authors make the following statement:

'The climate for scholarship in engineering education has become considerably warmer in recent years. … Unfortunately, many who rate faculty performance in engineering are still inclined to discount education-related activities as not worthy of being counted toward promotion, tenure, and merit raises, funded and published though they may be. Hopefully, this situation will also improve before too long…"

QUESTION: do you agree or disagree with this statement, and why?"

C. The National Academy of Engineering study, entitled Educating the Engineer of 2020, recommended that

QUOTE colleges and universities should endorse research in engineering education as a valued and rewarded activity for engineering faculty and should develop new standards for faculty qualifications UNQUOTE.

QUESTION: What are schools of engineering doing in this regard?

D. in an article entitled "The Scholarship of Teaching," published six years ago in Chemical Engineering Education, Richard Felder of North Carolina State, who is in the audience this morning, suggested that the review of an instructor's dossier should focus on answering the following three questions to assess his or her expertise in the scholarship of teaching and learning:

1. to what extent does the instructor's teaching qualify as a scholarly activity?
2. how effective is the instructor's teaching?
3. how numerous and effective are the instructor's educational research and development efforts?

QUESTION: how do you collect data to answer these three questions?

(answers:
- archival data: lists of courses developed and taught, representative instructional materials and student products, numbers of undergraduate and grad students, advised and faculty colleagues mentored, disciplinary and education-related conferences and workshops attended; articles, books, and courseware published.
- learning outcomes assessment data: test results, evaluations of written and oral project reports and other student products; student self-assessments.
- subjective evaluations by others: student end-of-course ratings; retrospective student and alumni ratings; peer ratings; awards and recognition received, reference letters.
- self-assessment data: statement of teaching philosophy and goals; self-evaluation of progress toward achieving these goals)

E. QUESTION: while the scholarship of teaching is a lively and growing area of intellectual dialogue on campuses nationwide, why is its application to criteria for faculty rewards barely developed and under-acknowledged?

F. QUESTION: are faculty who conduct such scholarship helping or hurting themselves in the P&T process?

G. QUESTION: are engineering schools and departments that encourage faculty to conduct such scholarship helping or hurting themselves in national visibility and reputation?

5. DEFINING "RIGOROUS ENGINEERING EDUCATION RESEARCH" (11)

A. QUESTION: the term "rigorous engineering education research" has been used in the literature by several authors, including a few who are in the audience today.

QUESTION: how would YOU define "rigorous engineering education research?"

(Karl Smith's answers:
1. Question: pose significant questions that can be answered empirically
2. Theory: link research to relevant theory
3. Methods: use methods that permit direct investigation of the question
4. Reasoning: provide a coherent and explicit chain of reasoning
5. Replicate and generalize across studies
6. Disclose research to encourage professional scrutiny and critique)

B. QUESTION for David Radcliffe: what changes are needed to establish engineering education as a serious and rigorous research-based discipline? Or let me ask the question in a different way: what kind of paradigm shifts do engineering faculty, who have been trained to conduct rigorous engineering research, need to make to be able to conduct rigorous engineering education research?

(Karl Smith's answer: need to shift from questions that focus on teaching and learning in their classrooms (the scholarship of teaching and learning) to questions that can answer more fundamental questions about how students learning engineering (rigorous research in engineering education)

(Gary Gabriele's answer: need to move from emphasis on curriculum reform to conducting fundamental research in how students learn engineering)

(Kamyar Haghighi's answer: focus more on exploring fundamental questions about engineering learning than on teaching and curriculum development, i.e, conducting rigorous research in engineering education)

C. FOLLOW UP QUESTION: what can be done to prepare engineering education researchers to shift their focus from teaching and curriculum development to exploring fundamental questions about engineering learning?

D. QUESTION for Norman: in your 2004 presentation at the International ME Education Conference you listed severable what-you-referred-to-as researchable questions in engineering education. Can you tell us what those researchable questions are?

(answer: how might we close the gap between engineering practice and education? How might we increase the graduation rate at the UG and grad levels? How might faculty increase the quality of their instructional skills? How is engineering knowledge most effectively acquired? internalized/integrated? applied? transmitted?

E. QUESTION for Norman: The Center for the Advancement of Scholarship on Engineering Education, which you direct, is creating a pilot database linking desired student outcomes to specific educational best practices. I believe you've identified 10 best practices thought to contribute to 15 student learning outcomes. Can you please give us a quick overview of these linkages?

F. current ABET accreditation standards, which became mandatory for all engineering programs in 2001, emphasize the formulation and assessment of learning outcomes, instead of the "bean counting" of previous ABET standards. While ABET does not directly require engineering education research….

POSSIBLE QUESTIONS: …… do you think ABET's current standards have intensified interest in engineering education research? do engineering faculty generally recognize that changes in pedagogy are required to achieve the various outcomes specified by ABET? have new methods for achieving ABET's required outcomes been developed across most engineering programs?

G. QUESTION: how can scholarship in engineering education be best assessed and evaluated?

(answer from Richard Felder: answer the following 3 questions:
- did the teaching qualify as a scholarly activity?
- was the teaching effective?
- were the innovative products and processes developed by the instructor well conceived, implemented, assessed and evaluated, and disseminated?)

H. QUESTION: are there best practices to be followed in assessing and evaluating scholarship in engineering education?

I. QUESTION: how might the engineering community build the capacity for the

conduct, review, and communication of rigorous education research? Until such capacity is built, how do we manage the transition; that is, who judges the early efforts?

J. QUESTION: how is a community of researchers best built and maintained? Can this be done effectively if done only on nights and weekends? Is there room for a single specialist in a large department?
(From Norm Fortenberry presentation at ASME Int'l ME Education Conference; 3/9/04 - see PowerPoint Slides)

K. QUESTION: where changes are needed in engineering education?

1. curriculum
2. pedagogy
3. diversity
4. retention rate
5. the notion that the BS is the first professional degree
6. the system of faculty rewards, and
7. technological literacy in the general population

(from "The Urgency of Engineering Education Reform," by W. A. Wulf, President, National Academy of Engineering, Plenary Speaker of the 2002 ASEE Annual Conference, at http://www.asee.org/conferences/annual2002/wulfplenary.cfm)

6. LESSONS FROM THE LEARNING SCIENCES (6)

A. QUESTION for Jim Pelligrino: you have said that although education researchers have made considerable progress in understanding the cognitive and social variables that are important in the learning process, very little of this basic knowledge been translated into practice.

QUESTION: is that really a fair statement?

B. FOLLOW UP QUESTION for Elaine Seymour: how do we solve these problems?

(answers: prof. dev. programs for TA's and faculty; national programs (use media; active recruitment of STEM teachers via scholarships, waivers, etc.); concurrent STEM disciplinary degrees and teacher preparation)

C. It seems to me that many engineering faculty think that the best way to conduct engineering education research is by student assessment, i.e., surveying students during or after a particular course they are teaching about what the students learned. However, none of these surveys are based on social, psychological, or pedagogical theories. Am I correct in this assumption? Aren't there more rigorous ways to conduct engineering education research?

(answer: need to move from conducting assessment studies of specific courses to conducting scientific or rigorous research)

(Karl's answer: engineering education research needs to move beyond an interest in improving an individual's teaching or developing a specific curriculum to an interest in how students learn engineering; the research must be tied to social, psychological, or pedagogical theories; understand that the methods of educational research are often different than the methods of engineering research

D. QUESTION for Elaine Seymour: are there any new and exciting approaches to the assessment of teaching quality on the horizon that engineering educators should be aware of?

(answers: assessing what students know and how well they know it; measuring the nature of students' accomplishments and the progress of their learning).

E. by and large engineering faculty are not trained in education research methodologies, like the construction of surveys and questionnaires, pedagogy, developmental psychology, and communication theory, so there is much they can learn from their non-engineering colleagues more familiar with these methodologies.

QUESTION: what roles can a non-engineering professional play on a team working to improve engineering education?

(answers: project planning, proposal preparation, and project management)

F. FOLLOW-UP QUESTION for Sheri Sheppard: multidisciplinary collaborations between engineering and social scientists are not without their difficulties. Engineers and social scientists have different vocabularies, different priorities, and different conceptions about research, don't they?

7. ROLE OF INDUSTRY (1)

A. in a 1998 paper published in ASEE's Prism Magazine, William Wulf, president of the Nat'l Academy of Engineering, and his co-authors made an interesting statement. In referring to the potential role played by industry in making the changes needed in engineering education, the authors said

QUOTE although increased industry involvement is desirable, universities must retain their independence. They must refrain from becoming too familiar or too influenced by their industry partners. Both groups have different objectives and serve different constituencies UNQUOTE

QUESTION for Juan Rivera: do you agree with this statement?

8. ENGINEERING TECHNOLOGY'S ROLE (1)

A. In a recent paper entitled "The Scholarship of Teaching and Learning in Engineering," Karl Smith, Richard Felder, who are in the audience this morning, and others make the following statement:

QUOTE while Engineering Technology is related to Engineering in many respects, Engineering Technology uses a more hands-on and less-mathematical approach in its instruction. Since it does not have research as a primary component of its mission, engineering technology may actually precede engineering in accepting the scholarship of teaching as part of the faculty advancement process UNQUOTE

QUESTION: do you agree with this statement? can engineering faculty learn from engineering technology faculty what the scholarship of engineering education is all about?

9. CURRENT U.S. COLLABORATIONS IN ENGINEERING EDUCATION RESEARCH (2)

A. QUESTION for Norman: tell us about some of the recent collaborative research programs, like those funded by the National Academy of Engineering and NSF that bring together engineering and education faculty to do engineering education research?

(answer:
1. National Academy of Engineering's Center for the Advancement of Scholarship on Engineering Education (CASEE) - directed by Norman
- provides funding for 10 teams of 3 engineering and education/social science faculty from Historically-Black Colleges and Universities (HBCU); they participate in an RREE week-long workshop; in its second year; 100 faculty

2. National Academy of Engineering's Committee on Engineering Education

3. NSF's Department Level Reform of UG Engineering Program provides an opportunity for institutions to compete for planning and implementation grants to assist departmental and larger units in:
- engaging faculty in the scholarship of learning and teaching on a department wide basis,
- developing, implementing, assessing and disseminating comprehensive plans to reformulate, streamline and update engineering degree programs,
- developing, implementing, assessing department wide transformational change of student learning experiences,
- incorporating Service Learning opportunities into engineering programs,
- meeting the emerging workforce and educational needs of U.S. industry, and
- incorporating methods for integration of research and teaching.

a collaborative effort between the Directorate for Engineering (ENG) and the Directorate for Education and Human Resources (EHR).

4. NSF's Bridges for Engineering Education Program, which, I believe is no longer being funded by NSF, is a collaborative effort between the Directorate for Engineering (ENG) and the Directorate for Education and Human Resources (EHR). This program provides an opportunity for institutions to compete for planning grants to develop proposals that improve:
- the engineering content in K-12 education.
- the pedagogy in undergraduate engineering.
- engineering technology degree programs)

5. NSF CENTERS for Learning and Teaching (CLT):
Center for the Advancement of Engineering Education (CAEE)
Center for the Integration of Research, Teaching, and Learning (CIRTL)
National Center for Engineering and Technology Education (NCETE)

6. NSF-funded Rigorous Research in Engineering Education: Creating a Community of Practice (RREE), led by ASEE, Ruth Streveler (Col. School of Mines), and Karl Smith (UM), both of whom are in the audience.
- provides funding for 20 eng. faculty; one-year research project; one-week workshop and mentoring throughout the year
- brings together experts from three organizations:
  - ASEE Educational Research and Methods Division (ERM)
  - American Educational Research Association (AERA)
  - Professional and Organizational Development Network (POD)

B. QUESTION: are there other reliable sources of support for scholarship in engineering education?

10. ENGINEERING EDUCATION DEGREE PROGRAMS (1)

A. QUESTION for Jeremy Noonan**:** Purdue, VA Tech, Utah State among others offer engineering education degree programs in their schools of engineering.

QUESTION: what kind of education are these schools requiring for today's engineering undergraduate and graduate students who want to earn degrees in engineering education, or, in other words, what is the best training for someone who wants to become an expert in engineering education?

11. AN INTERNATIONAL PERSPECTIVE (2)

A. QUESTION for David Radcliffe: what are engineering faculty in Australia doing on

the topic of scholarship in engineering education that might be different than what engineering faculty in the US are doing?

B. QUESTION: is anyone aware of any collaborative research programs in other countries, like those funded in the U.S. by the National Academy of Engineering and NSF, that bring together engineering and education faculty to do engineering education research?

12. FINAL QUESTION ON "YEAR OF DIALOGUE" (2)

A. This plenary session launches an ASEE Year of Dialogue on scholarship in engineering education.

QUESTION for each panel member to answer briefly: what advice would you give ASEE and its Year of Dialogue Committee on the best ways to continue this discussion over the next twelve months?

ALTERNATE FINAL QUESTION: what do you think the ideal outcome of this Year of Dialogue should be?

13. MISCELLANEOUS (2)

STUDENT DROP-OUTS

A. QUESTION for Elaine Seymour: what has your research shown about why students drop out of undergraduate science, technology, engineering, and mathematics (STEM) programs?

(answers: cultural and structural reasons:
1) decline in the perceived value of teaching, i.e, teaching far less important than research; imbalance in reward system for P&T; younger faculty advised to defer their interest in improving their teaching and assessment methods and avoid the introduction of education scholarship into their tenure portfolios; also

2) STEM faculty do not encourage K-12 math and science teaching as a career for STEM graduates - they describe K-12 teaching ambitions as 'deviant;" similar discouragement from family and peers (low status, pay, prospects).

3) Poor teaching; concerns about how courses are taught; poor course quality

4) inadequate educational preparedness of grad students for teaching as TA's or as young faculty

5) large body of cognitive research and classroom practice exists but is widely unknown or unused by STEM faculty

SCHOLARSHIP OF ENGAGEMENT

A. In his paper published in 1996 in the Journal of Public Outreach, Ernest Boyer encouraged all of us to embrace the scholarship-of-engagement.

QUESTION: what did Boyer mean by the scholarship of engagement in the context of the scholarship of teaching?

(answer: connecting the rich resources of the university to our most pressing social, civic, and ethical problems, to our children, to our schools, to our teachers, and to our cities)