

## Opposition to Mandatory Use of PE/FE Exams as Assessment Tools

Vincent P. Drnevich, P.E. and Robert K. Tener, P.E.  
Purdue University, School of Civil Engineering

**Abstract:** The authors oppose the required use of PE/FE Exams as assessment tools. To consider the PE exam has no merit, since it is taken by only a fraction of engineering graduates and exam performance is strongly influenced by many factors independent of the BSCE education. This paper then focuses on the issues involved in the proposition for mandatory use of the FE exam as an assessment tool. Opposition to such required use is fundamental. The makeup and philosophy of the exam is contrary to the philosophy of education of professionals as expressed in numerous recent studies. Further, the FE exam intent and content is inconsistent with the principles of Criteria 2000 of the Accreditation Board for Engineering and Technology. Educators should have the option of using results from the FE exam as one means for assessing outcomes of certain program objectives. Mandatory imposition of the FE exam would, in general, both violate the independence of program design which ABET intends in Criteria 2000 and warp the curriculum and pedagogy development which the department must have freedom to carry out in the interests of fundamental principles of engineering education.

### Introduction

The authors are opposed to the required use of the Professional Engineering (PE) exam or the Fundamentals of Engineering (FE) exam as assessment tools. In this paper are presented the rationale for this opposition and strong evidence supporting the rationale. There is increased impetus from many sectors for accountability and assessment on the part of civil engineering educators. There also is increased awareness that the education of engineers, to address the problems of the future, must encompass much more than introductory topics in math, science, economics, engineering sciences, and engineering design. Educators are pressed to find and use assessment tools to comply with assessment requirements. The FE /PE Exams, because of their availability and widespread use, appear to be the "quick answers" to our need. We will show that use of the PE Exam is totally inappropriate and that nature of the FE Exam is inconsistent with the principles of engineering education as put forth in the new accreditation policies of ABET, Criteria 2000.

### Objectives of Engineering Education

The objectives of an engineering education today transcend fundamental knowledge of technical material. According to "Engineering Education for a Changing World", a joint project report by the Engineering Deans Council and Corporate Roundtable of the American Society for Engineering Education<sup>1</sup>,

Today, engineering colleges must not only provide their graduates with intellectual development and superb technical capabilities, but following industry's lead, those colleges must educate their

students to work as part of teams, communicate well, and understand the economic, social, environmental and international context of their professional activities.

In today's world and in the future, engineering education programs must not only teach the fundamentals of engineering theory, experimentation and practice, but [also] be RELEVANT, ATTRACTIVE and CONNECTED:

- RELEVANT to the lives and careers of students, preparing them for a broad range of careers, as well as for lifelong learning involving both formal programs and hands-on experience;
- ATTRACTIVE so that the excitement and intellectual content of engineering will attract highly talented students with a wider variety of backgrounds and career interests—particularly women, underrepresented minorities and the disabled—and will empower them to succeed; and
- CONNECTED to the needs and issues of the broader community through integrated activities with other parts of the educational system, industry and government.

"The Changing Face of Engineering Employment in Industry" by the Industry Advisory Group of the National Society of Professional Engineers<sup>2</sup> tells us that

The most important technical training which can be imparted by formal education, and the area in most need of improvement, is teaching students how to learn in a self-directed mode.

From the most recent ASCE Education Conference<sup>3</sup> comes the statement

The intellectual foundation of the civil engineering baccalaureate degree should be broad, well-rounded, multi-disciplinary, and strong in technical and scientific knowledge. Undergraduates should be exposed to: 1) a global vision and approach to problem identification and problem solving in areas such as infrastructure, environment, facilities, and systems; 2) a basic management knowledge base in areas such as business, resources, personnel management, communication skills, costs and value judgements, and time management; 3) a solid foundation in personal and interpersonal attributes and ethics, and 4) an involvement with engineering practice as the formal education evolves.

Other significant forces influence educational objectives besides those cited above. Civil engineering departments, as they set their educational program objectives, in general feel directly the influence, advice and opinions of their local industry advisory committees and of employers of the program graduates. These people are, in the view of most educators, our "customers." Nonetheless, it may be correct to assume, from anecdotal and "grass-roots" communication, that the beliefs of local industry leaders and employers -- our customers -- are entirely consistent with that published by ASEE, NSPE, and ASCE. That is, industry is telling us locally as well as nationally that it needs well-rounded graduates who have a broad range of "soft skills" in addition to the traditional set of engineering abilities. For some programs at least, the influence of these local customers on educational objectives is significant.

Clearly from the above, an engineering education must provide far more than facility with mathematics, science, engineering science, and discipline specific subject matter.

## Accreditation Criteria

With the implementation of Engineering Criteria 2000<sup>4</sup>, two especially important criteria are:

### Criterion 2. Program Educational Objectives

Each engineering program for which an institution seeks accreditation or reaccreditation must have in place

- (a) detailed published educational objectives that are consistent with the mission of the institution and these criteria
- (b) a process based on the needs of the program's various constituencies in which the objectives are determined and periodically evaluated
- (c) a curriculum and process that ensures the achievement of these objectives
- (d) a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program.

### Criterion 3. Program Outcomes and Assessment

Engineering programs must demonstrate that their graduates have

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs
- (d) an ability to function on multi-disciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

These two criteria appear quite consistent with the objectives discussed in the previous section. They also point out that instruments that measure knowledge of simple subject matter may not be satisfactory measures of any of the outcomes assessment items listed in Criterion 3 above.

## Outcomes Assessment

The advent of new accreditation criteria (ABET<sup>4</sup>), along with pressures from all sectors for increased accountability in engineering education, focuses much attention to the topic of outcomes assessment. An excellent guide is available to assist programs with the assessment process (Rogers and Sando<sup>5</sup>). The valuable working symposium, "Best Assessment Processes in Engineering Education," held at Rose Hulman Institute of Technology (Rogers and Sando<sup>6</sup>) and sponsored by ABET, NSF and others, featured a wide range of presentations, papers and discussion on outcomes assessment means. A second such symposium is scheduled for Fall 1998, again at Rose-Hulman, and AAHE has scheduled its second conference on assessment for June, 1998.

Through these and other contemporary communications, the full intent of ABET Criteria 2000 and the range of effective means for carrying it out become increasingly clear. Profound among these realizations is the imperative that each assessment means and method must be directly linked to, and specifically selected to measure outcomes from, the stated objectives of each CE department's individual program. A widely adopted and respected guide to developing outcomes assessment plans (Rogers and Sando<sup>5</sup>) makes clear how essential the linkage is between a CE department's stated program objectives and practices and the design or selection of the appropriate assessment vehicle used to measure outcomes.

Recognizing the importance of assessing engineering education programs, the major stakeholder organizations in engineering education in the United States formed the Joint Task Force on Engineering Education Assessment<sup>7</sup>. The aim was to examine the value of using the Fundamentals of Engineering (FE) examination in undergraduate engineering education assessment. Represented on the task force were the National Council of Examiners for Engineering and Surveying (NCEES), which prompted the report and served as the group's secretariat; the Accreditation Board for Engineering and Technology (ABET); the American Society for Engineering Education (ASEE); the ASEE Engineering Deans Council (EDC); and the National Society of Professional Engineers (NSPE).

The task force report, published on July 7, 1994, recommended that the FE examination be restructured so that it more broadly measures outcome of the total engineering education experience. The sponsoring organizations recognized that a restructured FE examination would constitute only one part of the assessment process, knowledge-based specifications. This position is consistent with those advocating the use of the FE exam for outcomes assessment (Lefevre<sup>8</sup>).

The authors of this paper agree that an assessment tool is needed that "broadly measures outcome of the total engineering education experience", but contend that the restructured FE exam does not meet the recommendation of the Joint Task Force to "more broadly measure outcome of the total engineering education experience".

One comprehensive view of the nature and purpose of assessment of higher education programs is given in Reassessing (and Defining) Assessment (Angelo<sup>9</sup>), as follows:

Assessment is an ongoing process aimed at understanding and improving student learning. It involves making our expectations explicit and public; setting appropriate criteria and high standards for learning quality; systematically gathering, analyzing, and interpreting evidence to determine how well performance matches those expectations and standards; and using the resulting information to document, explain, and improve performance. ....

It is unnecessary to assess the performance of each student to know if engineering graduates from a particular program are generally developing the attributes of an ideal engineering graduate. Stated another way, we should not confuse the ability of the engineering education community to articulate a vision for the ideal graduate as a mandate for every graduate of every engineering program to demonstrate competence and proficiency in every attribute.

The ASEE Joint Task Force<sup>10</sup> in the ASEE Assessment White Paper confirms the statements from Angelo<sup>9</sup>, above,

A fundamental purpose of assessment and evaluation, it should be emphasized, is to learn as much as possible about how to structure educational environments so as to maximize talent development.

From the above, it is unreasonable to utilize an instrument for assessment, such as the discipline-specific FE exam which is designed to cover nearly all subdisciplines within a given discipline.

### **Inappropriateness of PE Exam**

Considering the PE exam as a vehicle for assessing outcomes of undergraduate education has no merit. The intent and content of the PE exam are not designed to assess BSCE education outcomes. Even if that were not so, only a fraction of BSCE graduates take the PE exam; they experience a long interval of time after graduation, and their PE exam performance is influenced by many factors independent of their undergraduate education. For all these reasons, the PE exam concept is discarded.

### **Inappropriateness of the FE Exam**

The Fundamentals of Engineering (FE) exam is an inappropriate assessment tool for engineering education for two fundamental reasons. The first is that the exam, if established as the nationally-normed standard for outcomes assessment, would establish criteria for engineering education that is inconsistent with Engineering Criteria 2000. This is especially true if the discipline specific portion of the exam is required of student. That portion of the exam, for civil engineering students, has questions in each of eleven subdisciplines (Steadman<sup>11</sup>):

1. Computers & numerical methods,
2. Construction management,
3. Environmental engineering,
4. Hydraulics & hydrologic systems,
5. Legal and professional aspects,
6. Soil mechanics & foundations,
7. Structural analysis,
8. Structural design,
9. Surveying,
10. Transportation facilities,
11. Water purification & treatment.

Rather than allowing programs to establish their own objectives, the FE exam would force programs to align their objectives with the subject matter of the exam. Other programs that choose to specialize in a subset of subdisciplines, whether by choice or by resource limitations, would be discriminated against by the use of this exam. For civil engineering, the ABET Program Criteria<sup>12</sup> only requires "proficiency in a minimum of four (4) recognized major civil engineering areas".

The second fundamental is that the nature of the exam itself is a rather shallow instrument for measuring "application of science and engineering". There are many, multiple choice, questions in each topic and hence, the questions have to be quite simple. Test takers are provided a "FE

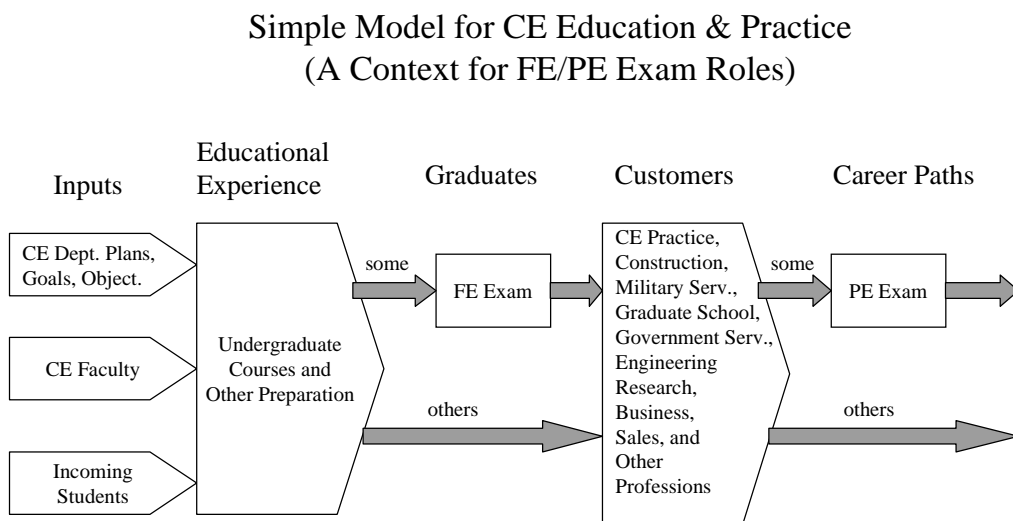
Reference Book" for use in the exam. It contains definitions and equations for each of the topic areas. The exam becomes an exercise in "plug and chug".

The National Council of Examiners for Engineering and Surveying (NCEES<sup>13</sup>) generates the FE exam and sells review guides and other aids for exam preparation. There are commercial firms that sell manuals and aids as well. One such firm claims that the "New edition of EIT Review Manual--[is ]the book that guarantees you'll pass".

In addition to the above two fundamental reasons, there is at least one additional practical reason for not using the exam. The rules for when the exam can be taken vary widely from state to state. In some places, it may be taken in the junior year. Other states require that students have completed so many credit hours toward the degree, typically 120, while still others limit the taking of the exam to seniors in their last semester before graduation. Many states don't even require that the person be an engineering student to take the exam.

### Systemic Factors External to the FE Exam

Consider the FE exam in the context of a simple model of the engineering education and practice system (Fig. 1). The FE exam has but incidental connection to the educating of undergraduate engineers. In most programs, at least some BSCE graduates do not take the exam because the department very deliberately does not consider the exam integral to the process of education, including assessment. This is not a whim of engineering educators, it is a strategic choice. Mandatory imposition of the FE exam would, in general, both violate the independence of program design which ABET intends in Criteria 2000 and warp the curriculum and pedagogy development which the department must have freedom to carry out in the interests of



This warping effect would be especially contrary to desired outcomes at those schools whose mission is weighted towards research and whose students value preparation for such futures as graduate school and research, whether inside or outside the university.

Further, mandatory imposition of the FE exam would result in "teaching the exam," likely through both course objectives and instructional behavior in engineering classrooms. Put simply, through multiple effects the tail would commence wagging the dog.

The future community of U.S. civil engineers must be broader in its capabilities as well as entrepreneurial in finding new ways for applying civil engineering education. To confine this broadening by forcing all programs to conform to "wagged objectives" through mandated use of FE exams would be to regress to the detriment of the profession.

### **Opinions of Civil Engineering Department Heads**

In March 1998, the Civil Engineering Department Heads/Chairs of the approximately 225 ABET accredited programs in were sent an informal survey to obtain their opinions on this issue. A total of 56 responses were received with more than half of the respondents providing written comments on one or both items. The data are outlined in Figs. 2 and 3 below. The two items in the questionnaire are:

1. Use of the FE Exam Results for Outcomes Assessment related to Accreditation:

- A All engineering programs should be required to make use of the results of the FE exam for their graduates as part of the outcomes assessment in the accreditation review. (This would establish the FE exam as a nationally-normed measure of engineering education.)
- B Use of the results of the FE exam for their graduates in the accreditation review should remain optional.
- C The purpose of the FE exam is to promote uniform licensing procedures of engineers and should not be used for assessment of specific educational programs.
- D Other (Please specify): \_\_\_\_\_

YOUR SELECTION (A, B, C, or D): \_\_\_\_\_

COMMENTS: \_\_\_\_\_

### Use of FE Exams for Outcomes Assessment

(Responses from Department Heads/Chairs, 3/98)

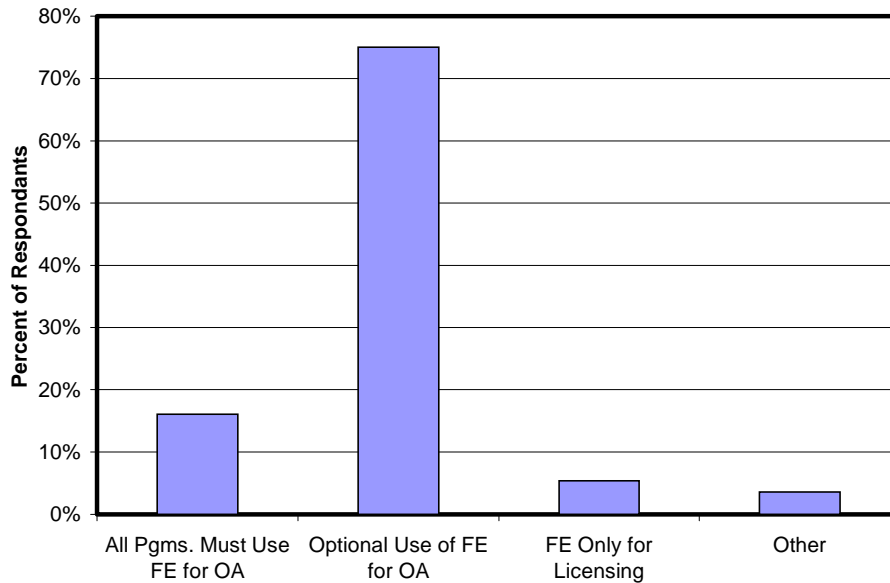


Fig. 2. Opinions of CE Department Heads/Chairs on Use of FE Exams for Outcomes Assessment.

#### 2. Recommendations for the FE Exam:

- A The FE Exam should be mandated for all graduating engineering students with the requirement that the students take the portion of the afternoon part of the exam that is specific to their discipline.
- B The FE Exam should be mandated for all graduating engineering students but allow the students to take the portion of the afternoon part of the exam of their choice, i.e., either the general exam or the one specific to their discipline.
- C The FE Exam should be optional for all graduating engineering students but with the requirement that the students take the portion of the afternoon part of the exam, i.e., specific to their discipline.
- D The FE Exam should be optional for all graduating engineering students and allow the students to take the portion of the afternoon part of the exam of their choice, i.e., either the general exam or the one specific to their discipline.
- E Other (Please specify): \_\_\_\_\_

YOUR SELECTION (A, B, C, D, or E): \_\_\_\_\_

COMMENTS: \_\_\_\_\_



**Recommendations for the FE Exam**  
(Responses from Department Heads/Chairs, 3/98)

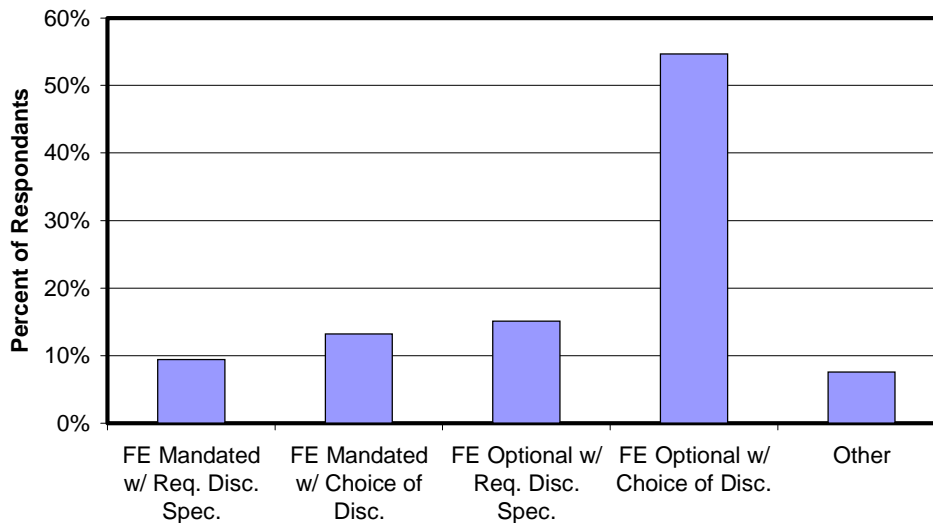


Fig. 3. Opinions of CE Department Heads/Chairs on Mandated Use of FE Exams

It is clear from the above figures that use of the FE exam should remain optional and that choice should be allowed for either the general or the discipline specific portion of the exam. The written comments received strongly support the notion that the FE exam should remain a tool that a specific program may or may not choose to use for one of its assessment instruments.

**Some Keys for Advantageously Using the FE Exam**

In view of the arguments above, some concepts are recommended to those CE departments who may opt to employ selected components of the FE exam as one among a set of several assessment tools.

1. Department must formally link the intended outcomes (objectives) of the BSCE program to those portions of the FE exam which are to be used for assessment. This concept is espoused and well elaborated on by Walter LeFevre<sup>8</sup>.
2. Department faculty as a body must "buy-in" to the use of the FE exam as an assessment tool. Achieving this imperative condition is difficult at best in many faculties. Nonetheless, the leadership effort expended to attain faculty "buy-in" is essential and will pay multiple dividends (Tener<sup>14</sup>).
3. Students must be given to understand why the FE exam is being used to assess their education. The returns from gaining this understanding by students can have payback both to the faculty in the short run and to the NSPE/ABET community in the long run.

## Summary and Conclusions

**Objectives of Engineering Education** - As articulated by leaders in engineering practice and education through a variety of messages, engineering graduates of tomorrow need to be educated across a broad, well-rounded spectrum of capabilities which significantly transcend the topics of math, science, engineering science, and discipline specific matter. Knowledge and abilities in problem-solving, self-directed and lifelong learning, communicating, working in teams, the societal context of engineering, global contexts, and management knowledge are demanded and expected.

**Accreditation Criteria** - Important among the Engineering Criteria 2000 are the requirement for educational objectives consistent with the mission of the institution, and demonstrated abilities in graduates which are listed in eleven broad, comprehensive subject sets many of which are not reflected in FE exam intent or content.

**Outcomes Assessment** - The literature and the current consensus among educators and practitioners concerned with outcomes are totally clear with respect to assessment means. They must be tailored to the educational objectives of each respective institution, they must assess the broad range of outcomes expected of the program, and they must enable structuring educational environments so as to maximize talent development.

**Inappropriateness of PE Exam** - The PE exam has no merit as a means of assessing undergraduate education outcomes. It is not designed or intended to do that, and PE exam performance is influenced by many factors independent of undergraduate education.

**Inappropriateness of the FE Exam** - The FE exam is inappropriate as an assessment method because (1) its use would establish educational criteria inconsistent with Criteria 2000, (2) its use would move faculties to teaching the exam, and (3) because of the nature of the exam it would be at best a shallow instrument. Further, requiring the use of the FE exam would violate the precept of Criteria 2000 which promotes independence in program design among institutions, and would be especially contrary in universities where research and graduate education are key program goals for graduates. Significantly, to standardize assessment means with a nationally-normed exam would be to regress from the desired direction for U.S. civil engineers, who are expected to continue to broaden their capabilities and contributions, and to find new ways to apply their civil engineering education in continually changing environments.

**Opinions of Civil Engineering Department Heads** - From a recent survey, 56 responses from CE Department Heads and Chairs recorded overwhelming consensus against requiring use of the FE exam for outcomes assessment in the accreditation review.

**Some Keys for Advantageously Using the FE Exam** - Should a department opt to employ selected components of the FE exam as one among a set of several assessment tools, it is advised to (1) formally link the objectives of the BSCE program to relevant portions of the FE exam; (2) strive for faculty "buy-in" to using the FE exam as an assessment tool, and (3) give students to understand why the FE exam is being used to assess their education.

**Principal conclusion** - It would be totally inappropriate to consider the mandatory use of the Fundamentals of Engineering exam as a means for assessing the outcomes of undergraduate civil engineering education programs.

## Bibliography

1. ASEE, "Engineering Education for a Changing World", A joint project report by the Engineering Deans Council and Corporate Roundtable of the American Society for Engineering Education, October 1994, 28 pages.
2. NSPE, "The Changing Face of Engineering Employment in Industry", A Report by the Industry Advisory Group of the National Society of Professional Engineers, October 1996, 10 pages.
3. ASCE, "Summary Report of the 1995 Civil Engineering Education Conference", ASCE, Denver, Colorado, June 1995, 16 pages.
4. ABET, "ENGINEERING CRITERIA 2000", Accreditation Board for Engineering and Technology, Inc., THIRD EDITION, December, 1997, <http://www.abet.org/EAC/eac2000.html>
5. Rogers, G. M. and J. K. Sando, "Stepping Ahead: An Assessment Plan Development Guide," Rose-Hulman Institute of Technology, 1996.
6. Rogers, G. M. and J. K. Sando, "Best Assessment Processes in Engineering Education, A Working Symposium", Rose-Hulman Institute of Technology, 1997.
7. Joint Task Force, "Engineering Education Assessment", Represented on the task force were the National Council of Examiners for Engineering and Surveying (NCEES), which prompted the report and served as the group's secretariat; the Accreditation Board for Engineering and Technology (ABET); the American Society for Engineering Education (ASEE); the ASEE Engineering Deans Council (EDC); and the National Society of Professional Engineers (NSPE), 1994.
8. Lefevre, E. W., "Using the NCEES FE to Assess Instruction," in Proceedings, Best Assessment Processes in Engineering Education, Session 51S, Rose-Hulman Institute of Technology, April 1997, 11-12.
9. Angelo, T.A., "Reassessing (and Defining) Assessment", American Association for Higher Education Bulletin, November, 1995, pp. 7-9.
10. Joint Task Force, "Assessment White Paper: A Framework for the Assessment of Engineering Education", By The Joint Task Force on Engineering Education Assessment, 22 June 1996, <http://www.asee.org/pubs2/html/assessment.htm>
11. Steadman, J. W., "Use of the Fundamentals of Engineering Examination for Outcomes Assessment", Best Assessment Processes in Engineering Education, Session 050S, Rose-Hulman Institute of Technology, April 1997, pp. 41-45.
12. Civil Criteria, "PROGRAM CRITERIA FOR CIVIL AND SIMILARLY NAMED ENGINEERING PROGRAMS", Submitted by the American Society of Civil Engineers to the Accreditation Board for Engineering and Technology, Inc., 1997, <http://www.abet.org/EAC/eac2000.html#CIV>
13. NCEES, "National Council of Examiners for Engineering and Surveying", Clemson, S.C., 1998, <http://www.ncees.org>
14. Tener, R. K. , 1997, "Outcomes Assessment and the Faculty Culture: Congruence or Conflict?" in Proceedings,

Best Assessment Practices in Engineering Education, Session 34S, Rose-Hulman Institute of Technology, April 11-12.

## **Biographies**

Vincent P. Drnevich, P.E. is Professor and Head of the School of Civil Engineering at Purdue University. He is the Secretary/Treasurer of the Civil Engineering Division of ASEE and is the Chair of the Department Heads Council of ASCE. He is a Fellow, ASCE, a Fellow, ASTM, member of ASEE, and a member of NSPE. Before coming to Purdue in 1991, he held faculty and administrative positions at the University of Kentucky.

Robert K. Tener, P.E. is Assistant Professor of Civil Engineering at Purdue University. Besides teaching, he directs the internship program in Purdue's Construction Engineering and Management program and serves as liaison between Purdue and senior leaders in the engineering and construction industry nationally. Before coming to Purdue, he served a first career in the U.S. Army Corps of Engineers, retiring in the grade of Colonel. He is a Fellow, ASCE, a Member of ASEE, and serves on the national Education Committee of the Associated General Contractors of America, Inc.