NATIONAL ACADEMY OF ENGINEERING
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Measuring Student and Faculty Engagement in Engineering Education

CASEE

Center for the Advancement of Scholarship on Engineering Education

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NATIONAL ACADEMY OF ENGINEERING
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CENTER FOR THE ADVANCEMENT OF SCHOLARSHIP ON ENGINEERING EDUCATION
DR. NORMAN L. FORTENBERRY, DIRECTOR

August 29, 2005

Dear Colleague:

The Center for the Advancement of Scholarship on Engineering Education (CASEE) represents an effort, collaborative across stakeholder communities, to improve the alignment of the knowledge and skills possessed by future and current engineers and the knowledge and skills sought within engineers by various stakeholders of engineering education. This effort is pursued through research on, as well as development and deployment of, innovative policies, practices, and tools designed to enhance the efficiency and effectiveness of systems for the formal (spanning all age and grade levels), informal, and lifelong education of engineers. I write to make you aware of several opportunities for you and members of your department to participate in on-going CASEE activities.

The ***Dane and Mary Louise Miller Symposium*** brings together key constituencies within the engineering community to share the latest emerging findings from engineering education research as well as findings on best practices in student and faculty development. This year's meeting again will immediately precede the Frontiers in Education Conference and will be held ***October 18 and 19, 2005, at the Radisson City Centre hotel in Indianapolis, Indiana***. Conference details and registration information can be found on the CASEE home page at <***http://www.nae.edu/CASEE***>.

The ***Annals of Research on Engineering Education (AREE)*** is an experiment in collaborative scholarship, which serves to link education researchers and practitioners across engineering domains and between engineering and other disciplines. The main focus of AREE is publishing structured summaries of education research relevant to engineering education drawn from a wide array of participating journals as well as essays by authors reflecting on the research process they have used. Our aim is to highlight what has been learned, reflect on how that learning occurred, and debate how best to advance engineering education research. We invite participation by members of the engineering education community, both education researchers and classroom practitioners. We are offering free access to AREE for a 12-month period beginning in October 2005. You may register to access AREE at <***http://www.areeonline.org/CMS/RegisterAccount.aspx/***>.

Enclosed with this letter is the final report of a three-phase NSF-supported project on ***"Measuring Student and Faculty Engagement in Engineering Education."*** One goal of the project was to create an integrated and synthesized set of pilot instruments to assess the current state of the instructional practices and student learning outcomes. The pilot instruments have been vetted with focus-groups of students and faculty held in early 2005 at Colorado School of Mines, Massachusetts Institute of Technology, The Pennsylvania State University, Purdue University, and the University of Texas at Austin. We invite your review and comment on the instruments and seek expressions of interest in participating in a future large-scale validation pilot of the instruments. Comments and expressions of interest can be sent to me at <***nfortenb@nae.edu***>.

Working together, we can "re-engineer" engineering education to achieve excellence!

Sincerely yours,

Norman L. Fortenberry

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Encl.

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Final Report:
"Measuring Student and Faculty Engagement in Engineering Education"

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Supported by a grant from the National Science Foundation (Grant No. DUE-0404802) this project included three main goals: 1) synthesizing a combined set of student learning outcomes for undergraduate engineering students; 2) drawing upon the literature to create a pilot database on the current education research linking desired student learning outcomes to specific educational best practices; and 3) adapting the NSSE, FSSE, and EC2000 Study instruments into a comprehensively integrated and synthesized set of pilot instruments, vetted with a cross-section of the engineering education community to assess the current state of the instructional practices and student learning outcomes. CASEE staff reviewed hundreds of conference proceedings, journal articles, manuscripts, etc. to complete goals 1 and 2. We then adapted the NSSE, FSSE, and EC2000 survey instruments, and using up-to-date and relevant literature on engineering and higher education, developed a number of survey items for a faculty and student questionnaires. CASEE staff conducted 10 focus groups at a total of five engineering colleges to ensure the items' readability and face validity. With feedback from the focus group participants, we refined the items and instruments, which are presented in Appendices A and B.

Today's engineering community is concerned with and attuned to improving the processes and outcomes of educating tomorrow's engineers. To that end, the Center for the Advancement of Scholarship on Engineering Education (CASEE), the first operating center at the National Academy of Engineering, conducts on-going research and implementation activities to foster excellence in engineering education. CASEE's initial focus has been on extending the research base on engineering education within engineering disciplines and translating research results into practice in classrooms, internship sites, and work sites.

In recent years, educators have been trying to improve engineering education by introducing and strengthening their commitment to assessing specific approaches to teaching, learning, and student learning outcomes. In their recent article, Olds, Moskal, and Miller describe the current movement toward the assessment of student learning outcomes within the engineering community, and assert that, as recently as 1997, the engineering community had relatively little experience in conducting outcomes assessment [1]. While researchers and educators have developed a number of classroom and college-wide assessments – oftentimes in preparation for an ABET accreditation visit – no national assessments exist to measure engineering student learning outcomes and the instructional practices that support those outcomes.

MEASURING STUDENT AND FACULTY ENGAGEMENT IN ENGINEERING EDUCATION

The project entitled "Measuring Student and Faculty Engagement in Engineering Education" was supported by a grant from the National Science Foundation (DUE-0404802), and had three goals:

1) Synthesize a combined set of student learning outcomes for undergraduate engineering students,
2) Draw upon the literature to create a pilot database on the current education research linking desired student learning outcomes to specific educational best practices, and

3) Adapt the National Survey of Student Engagement (NSSE), Faculty Survey of Student Engagement (FSSE) instruments as well as the instruments used in Penn State's study of impact of ABET's EC2000 into a comprehensively integrated and synthesized set of pilot instruments, vetted with a cross-section of the engineering education community to assess the current state of the instructional practices and student learning outcomes.

The integrated set of survey instruments are intended to assess the extent to which engineering faculty are engaging in identified "best instructional practices" and the extent to which engineering students are achieving certain learning outcomes desired of engineering graduates. This report describes the tasks of the project undertaken to achieve the three outlined goals, and the anticipated next steps for the project.

I. Task I: Synthesize Desired Student Learning Outcomes

ABET's "3a through k" criteria identify 11 learning outcomes expected of engineering graduates [2]. Based on a rigorous review of the literature, the first phase of our work revealed four additional student outcomes desired by the engineering education community. Although many more outcomes were mentioned in the literature, each of the four learning outcomes was cited at least 16 times, which also was the number of times the least cited ABET criterion was referenced in the same body of literature (see [3] for a complete description of Task 1 activities).

We suggest that an engineering graduate also ought to demonstrate 1) an ability to manage a project, including a familiarity with business, market-related, and financial matters, 2) a multidisciplinary systems perspective, 3) an understanding of and appreciation for the diversity of students, faculty, staff, colleagues, and customers, and 4) a strong work ethic [3]. Table 1 summarizes the 15 foundational student learning outcomes.

Table 1. 15 Foundational Technical and Non-Technical Student Outcomes

Engineering graduates must have:
ABET Criteria 3a-k
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 multidisciplinary 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 life-long learning and the ability to engage in it
j) A knowledge of contemporary issues
k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Table 1 (cont.). 15 Foundational Technical and Non-Technical Student Outcomes

Engineering graduates must have:
"Plus CASEE's four"
L) An ability to manage a project (including a familiarity with business, market-related, and financial matters)
M) A multidisciplinary systems perspective
N) An understanding of and appreciation for the diversity of students, faculty, staff, colleagues, and customers
O) A strong work ethic

II. Task II: Identifying Principles of Effective Teaching and Learning

During the second phase of this project, we identified 10 "best instructional practices" thought to contribute to the 15 student learning outcomes identified in Phase I. Although a number of authors used different wording for similar concepts, we used three sources as the primary tools for organizing the 10 principles and use their "language." The three sources (Chickering & Gamson [4], Bransford et al [5], and the American Psychological Association's "learner-centered psychological principles" [6]) were chosen based on their prominence in engineering education circles, how familiar engineering educators already are with these concepts, and of course, their appropriateness. The 10 principles of effective instruction include:

1) Encourage student-faculty interaction
2) Develop reciprocity and cooperation among students
3) Communicate high expectations
4) Provide prompt feedback
5) Use active learning techniques
6) Emphasize time on task
7) Respect diverse talents and ways of thinking
8) Build on correct pre-existing understandings; dispelling false preconceptions
9) Provide factual knowledge, facilitating understanding of the facts and ideas in context of a conceptual framework, and organizing knowledge that facilitates retrieval and application
10) Encourage students' motivation to learn

III. Task III: Linking Instructional Principles to Learning Outcomes

Task III of the project provided empirical evidence from, and identified the gaps in, higher education and engineering education literature that link instructional best practices with the 15 desired student outcomes in engineering education. The results are depicted in Table 2.

The first column of Table 2 lists the instructional principles described in this report. Columns two and three list student outcomes (ABET 3a through k and "CASEE's plus four") associated with each instructional practice. More specifically, the second column lists outcomes, shown in the literature[1], that result from students engaging in teaching and learning strategies associated with each instructional principle. The third column lists outcomes we might expect to

[1] See [8] for references to specific studies noted in the literature linking "best" instructional practices to desired student outcomes.

result from students engaging in teaching and learning strategies associated with each instructional principle, however, no evidence was found to substantiate these assumptions. For example, engineering education research has shown that student-faculty interaction contributes to students' gains in design and professional skills [7]; however, one could expect that through interacting with faculty, students ought to make gains in all of the identified outcomes. As noted in Table 2, many opportunities exist for scholars to conduct novel and needed research examining the extent to which these principles and outcomes are related, and exactly which instructional best practices contribute to students achieving each of the identified outcomes.

Table 2. Instructional Principles Related to Student Outcomes

Instructional Principles	**RELATED STUDENT OUTCOMES (ABET 3A-K) AND "CASEE'S PLUS FOUR"**	
	EVIDENCE FOUND IN ENGINEERING EDUCATION RESEARCH	EXPECTED RELATIONSHIP
1. Encouraging student-faculty interaction	3b, 3c, 3f, 3k	All
2. Developing reciprocity and cooperation among students	3g, L	3d, 3g, L, N
3. Communicating high expectations		All
4. Providing prompt feedback	3b, 3c, 3f	All
5. Using active learning techniques	3b, 3c, 3d, 3e, 3g, 3k	All (except 3j)
6. Emphasizing time on task		All
7. Respecting diverse talents and ways of thinking	3a*, 3b	All (especially N)
8. Building on correct pre-existing understandings; dispelling false preconceptions	3a*	All (especially those related to design)
9. Providing factual knowledge, facilitating understanding of the facts and ideas in context of a conceptual framework, and organizing knowledge that facilitates retrieval and application		All (especially those related to design)
10. Encouraging students' motivation to learn		All (especially 3i)

*****Correlation based on the assumption that learning a concept can be equated to the ability to correctly apply it.

While we endeavored to conduct a thorough review of the available literature, we certainly may have overlooked some relevant studies. Nonetheless, the dearth of research in engineering education investigating the effects of the 10 instructional principles on the 15 desired student outcomes suggests the primary finding of Task III was that ample opportunities exist for scholars to conduct novel and needed research examining the extent to which these principles and outcomes are related, and exactly which instructional best practices contribute to students achieving each of the identified outcomes.

For a thorough description of Task III of this project, refer to our paper in the 2005 American Society for Engineering Education (ASEE) proceedings [8].

IV. Task IV: Developing Survey Items

Using the information gathered in Tasks I – III, and by adapting some of the items used in the National Survey of Student Engagement (NSSE), Faculty Survey of Student Engagement (FSSE), and EC2000 Study instruments[2], we developed two survey instruments (faculty and student versions). The CASEE instruments differ from the NSSE and FSSE instruments in that their content focuses specifically on engineering education. They are distinguished from the EC2000 instruments as the EC2000 instruments concentrate only on the 11 EC2000 3a-k student outcomes criteria and a substantially smaller set of instructional practices. Included at the end of this report in Appendices A and B, CASEE's surveys "Measuring Student and Faculty Engagement in Engineering Education" also include items regarding demographic information. Appendix C includes a table matching instructional practices and student outcomes to specific survey items.

V. Task V: Focus Groups and Survey Refinement

Survey items were developed for two separate instruments, a faculty instrument and a student instrument, based on the outcomes of Tasks I - III. CASEE staff then facilitated two 90-minute focus groups (a faculty group and a student group) on each of five CASEE-affiliated campuses (Colorado School of Mines, Massachusetts Institute of Technology, The Pennsylvania State University, Purdue University, and the University of Texas at Austin) in February and March 2005. A total of 63 faculty and 44 students reviewed the instruments.

Focus group participants received a set of survey items to review prior to participating in the focus groups. During the focus groups, participants 1) discussed the meaning of each item to ensure that every reader interpreted the item in the same way and 2) suggested additional items and alternative ways to word certain items. Refining the items was an iterated process. CASEE staff refined the items as suggested by focus group participants between visits at each campus. There was a great deal of discussion in the first few focus groups and, as the items were refined, subsequent focus group participants believed the items were clear and relevant to the instruments' intent.

[2] For more on NSSE and FSEE see the National Survey of Student Engagement Web site at <http://www.indiana.edu/~nsse/>. The Center for the Study of Higher Education at The Pennsylvania State University has been conducting a longitudinal study of the impact of the revised engineering accreditation criteria (known as EC2000) on achievement of 11 student learning outcomes known within the engineering community as "3a-k." This study, focused on seven engineering disciplines, seeks to nationally survey students, faculty, alumni, employers, and administrators. More information is available at <http://www.ed.psu.edu/cshe/abet/ec2000.html>.

VI. Task VI: Dissemination and Project Continuation

During the last phase of this project, we have been concentrating on disseminating the completed research and introducing a variety of audiences to our surveys and the processes by which we developed them. To that end, we presented one paper at the 2005 ASEE conference in Portland [8] and will present two papers at the FIE [9] and ABET [10] conferences in October 2005. Additionally, we will mail a summary of our final report to every engineering department head in the U.S.

CASEE intends to pilot the student and faculty instruments at one engineering college during the spring 2006 semester in order to determine the extent to which the survey items are reliable and valid and to refine the instruments before conducting a large-scale pilot at several universities. We will continue to make available the project's details and progress at national conferences and on the CASEE Web site. At the conclusion of this project, CASEE intends to make the survey instruments available to engineering colleges nationwide, with the expectation that the instruments will provide baseline data to help individual engineering colleges and the national engineering community continue our quest for excellence.

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APPENDIX A:
A Survey Measuring Student and Faculty Engagement in Engineering Education (Faculty Version)

Center for the Advancement of Scholarship on Engineering Education (CASEE)

Instructions: Please mark your answers in the boxes. If you are asked to specify an answer, please clearly print your answer on the line provided.

1. How many years have you been teaching as an engineering faculty member? ____ years

2. In what engineering discipline are you employed? (If you hold a joint appointment, please indicate that area as well.)

- ☐ Aerospace Engineering
- ☐ Chemical Engineering
- ☐ Civil Engineering
- ☐ Computer Engineering
- ☐ Electrical Engineering
- ☐ Industrial Engineering
- ☐ Mechanical Engineering
- ☐ Other (please specify) _____

3. Think about <u>graduating seniors</u> in your program. Please rate their ability, on average, to do the following:

Graduating seniors' ability to:		**No ability**	**Some ability**	**Adequate ability**	**More than adequate ability**	**High ability**
a-1.	Use basic scientific principles to analyze the performance of processes and systems	☐	☐	☐	☐	☐
a-2.	Use basic engineering principles to analyze the performance of processes and systems	☐	☐	☐	☐	☐
a-3.	Formulate and evaluate mathematical models describing the behavior and performance of systems and processes	☐	☐	☐	☐	☐
b-1.	Design an experiment	☐	☐	☐	☐	☐
b-2.	Analyze evidence or data from an experiment	☐	☐	☐	☐	☐
b-3.	Interpret results of an experiment	☐	☐	☐	☐	☐
b-4.	Use evidence to draw conclusions or make recommendations	☐	☐	☐	☐	☐
c-1.	Identify essential aspects of the engineering design process	☐	☐	☐	☐	☐
c-2.	Apply systematic design procedures to open-ended problems	☐	☐	☐	☐	☐
c-3.	Design solutions to meet desired needs	☐	☐	☐	☐	☐
d-1.	Work in teams where knowledge and ideas from many disciplines (business, public policy, engineering, etc.) must be applied	☐	☐	☐	☐	☐

Graduating seniors' ability to:		No ability	Some ability	Adequate ability	More than adequate ability	High ability
d-2.	Work in teams where knowledge from many engineering disciplines must be applied	☐	☐	☐	☐	☐
d-3.	Collaborate with others when working on multidisciplinary teams	☐	☐	☐	☐	☐
d-4.	Communicate effectively with others when working on multidisciplinary teams	☐	☐	☐	☐	☐
d-5.	Effectively manage conflicts that arise when working on multidisciplinary teams	☐	☐	☐	☐	☐
d-6.	Do their fair share of the work when working on multidisciplinary teams	☐	☐	☐	☐	☐
e-1.	Identify problems for which there are engineering solutions	☐	☐	☐	☐	☐
e-2.	Formulate a range of solutions to an engineering problem	☐	☐	☐	☐	☐
e-3.	Test potential solutions to an engineering problem	☐	☐	☐	☐	☐
e-4.	Use feedback from an experiment to improve solutions to an engineering problem	☐	☐	☐	☐	☐
f-1.	Identify potential ethical dilemmas in engineering practice	☐	☐	☐	☐	☐
f-2.	Estimate the potential for ethical dilemmas due to budget or time constraints	☐	☐	☐	☐	☐
f-3.	Address ethical issues when working on engineering problems	☐	☐	☐	☐	☐
f-4.	Apply an engineering code of ethics	☐	☐	☐	☐	☐
f-5.	Apply technical codes and standards	☐	☐	☐	☐	☐
g-1.	Convey technical ideas in writing	☐	☐	☐	☐	☐
g-2.	Convey ideas verbally	☐	☐	☐	☐	☐
g-3.	Convey ideas in formal presentations	☐	☐	☐	☐	☐
g-4.	Convey ideas in graphs, figures, etc.	☐	☐	☐	☐	☐
h-1.	Estimate the impact of engineering solutions in a societal context (in a particular culture, community, state, nation, etc.)	☐	☐	☐	☐	☐
h-2.	Estimate the impact of engineering solutions in a global context	☐	☐	☐	☐	☐
i-1.	Apply engineering techniques (e.g., processes, methods) in engineering practice	☐	☐	☐	☐	☐
i-2.	Apply engineering skills (e.g., experimentation, machining, programming) in engineering practice	☐	☐	☐	☐	☐
i-3.	Apply engineering tools (e.g., software, lathes, oscilloscopes) in engineering practice	☐	☐	☐	☐	☐
i-4.	Integrate engineering techniques, skills, and tools to solve real-world problems	☐	☐	☐	☐	☐

Graduating seniors' ability to:		No ability	Some ability	Adequate ability	More than adequate ability	High ability
j-1.	Manage a team's time to meet deadlines when leading a project	☐	☐	☐	☐	☐
j-2.	Determine equipment and personnel needed when managing a project	☐	☐	☐	☐	☐
j-3.	Create and follow a budget when managing a project	☐	☐	☐	☐	☐
j-4.	Address the business, financial, and market related matters associated with project engineering	☐	☐	☐	☐	☐
j-5.	Apply interpersonal skills in managing people	☐	☐	☐	☐	☐
k-1.	Integrate knowledge and skills learned in engineering disciplines other than their specific majors	☐	☐	☐	☐	☐
k-2.	Recognize the need to consult an expert from a discipline other than their own when working on a project	☐	☐	☐	☐	☐
k-3.	Recognize the limitations or validity of other professional engineers' opinions	☐	☐	☐	☐	☐
l-1.	Consider contemporary issues (economic, environmental, political, aesthetic, etc.) at the local, national, and world levels	☐	☐	☐	☐	☐
l-2.	Consider contemporary technical issues in your discipline at the local, national, and world levels	☐	☐	☐	☐	☐
l-3.	Estimate how engineering decisions and contemporary issues can impact each other	☐	☐	☐	☐	☐
l-4.	Use knowledge of contemporary issues to make engineering decisions	☐	☐	☐	☐	☐

4. Please respond to questions 4 through 10. based on <u>one particular upper-level undergraduate engineering course section</u> you are teaching or have taught in the past five years.

a. Please indicate the level of students in that course.
- ☐ Mainly juniors
- ☐ Mainly seniors

b. Approximately how many students are enrolled in that course?
- ☐ Less than 20
- ☐ 21 - 40
- ☐ 41 - 60
- ☐ More than 60

c. Indicate the category that best describes that course (select all that apply).
- ☐ Required engineering course
- ☐ Capstone course
- ☐ Elective/optional engineering course
- ☐ Other (specify) _____

d. In what year did you most recently teach that course? ____

5. Approximately what percent of students in your selected course section:		**1 –24 percent**	**25 – 49 percent**	**50 - 74 percent**	**75 percent or higher**	**I Don't Know**
a.	Do not do their best work?	☐	☐	☐	☐	☐
b.	Turn in completed assignments on time?	☐	☐	☐	☐	☐
c.	Seek ways to improve a design, even after it's been turned in?	☐	☐	☐	☐	☐
d.	Take initiative in learning processes?	☐	☐	☐	☐	☐
e.	Do their share of tasks on time, when working in teams?	☐	☐	☐	☐	☐
f.	Are dependable (in terms of coursework)?	☐	☐	☐	☐	☐
g.	Recognize the unique skills, abilities, and contributions of all students in your engineering courses?	☐	☐	☐	☐	☐
h.	Recognize the need for diverse perspectives in solving engineering problems?	☐	☐	☐	☐	☐
i.	Comfortable working with engineering clients and colleagues from diverse racial/ethnic backgrounds?	☐	☐	☐	☐	☐
j.	Comfortable working with engineering clients and colleagues of the opposite gender?	☐	☐	☐	☐	☐

6. How often did the following occur in your selected course section?		**Almost never**	**Occasionally**	**Often**	**Almost always**
a.	Course included discussion about acceptance of and respect for differences (of opinion, background, etc.).	☐	☐	☐	☐
b.	Engineering students and you discussed diversity issues.	☐	☐	☐	☐
c.	You emphasized the importance of diversity in the engineering workplace.	☐	☐	☐	☐
d.	You observed the use of offensive words, behaviors, or gestures directed at students because of their backgrounds or identities.	☐	☐	☐	☐
e.	You observed certain engineering students being ignored or excluded (from projects, discussions, etc.) because of their backgrounds or identities.	☐	☐	☐	☐
f.	Students harassed or discriminated against you because of your background or identity.	☐	☐	☐	☐
g.	Your course's content reflects contributions of all engineers, including women and people of color, etc.	☐	☐	☐	☐
h.	You tailor lessons because some students learn in different ways than others.	☐	☐	☐	☐
i.	Students of all backgrounds/identities participate in class (in discussion, in-class assignments, team projects, etc.).	☐	☐	☐	☐

7. In your selected course, how often:		**Almost never**	**Occasionally**	**Often**	**Almost always**
a.	Do you guide students' learning activities rather than lecturing or demonstrating the course material?	☐	☐	☐	☐
b.	Are students active participants in the teaching and learning process?	☐	☐	☐	☐

7. In your selected course, how often:		**Almost never**	**Occasionally**	**Often**	**Almost always**
c.	Do students ask questions in class?	☐	☐	☐	☐
d.	Do students contribute to class discussions?	☐	☐	☐	☐
e.	Do you explain new concepts by making explicit links between what students already know and the new material?	☐	☐	☐	☐
f.	Do you teach students to apply fundamentals to problems they haven't seen before?	☐	☐	☐	☐
g.	Do you encourage students to use what they already know to construct new understandings?	☐	☐	☐	☐
h.	Do you use pretests or other measures to assess students' pre-existing understandings of basic math, science, or engineering principles?	☐	☐	☐	☐
i.	Do students come to the course with misconceptions about specific areas of course content?	☐	☐	☐	☐
j.	Do you introduce new concepts with simple, common sense examples or metaphors?	☐	☐	☐	☐
k.	Do you introduce new concepts by requiring students to engage in hands-on activities, class discussions, etc.?	☐	☐	☐	☐
l.	Do you explicitly encourage students to set and pursue their own learning goals?	☐	☐	☐	☐
m.	Do you make students aware of new opportunities for intellectual growth and professional development?	☐	☐	☐	☐
n.	Do you explicitly encourage students to engage in critical, reliable, and valid self-assessment?	☐	☐	☐	☐
o.	Do you explicitly encourage students to apply new knowledge gained to the practice of engineering?	☐	☐	☐	☐

8. In a typical week, how many homework assignments do you require students to complete in your selected course section?		**Number of Homework Assignments**			
		1-2	3-4	5-6	More than 6
a.	Number of weekly that you expect to take less than 2 hours to complete	☐	☐	☐	☐
b.	Number of weekly homework assignments that you expect to take between 2 and 5 hours to complete	☐	☐	☐	☐
c.	Number of weekly homework assignments that you expect to take more than 5 hours to complete	☐	☐	☐	☐

9. Time students spend preparing for your selected course section

		Hours per Week						
		2 or less	**3-4**	**5-6**	**7-8**	**9 - 10**	**11 - 12**	**More than 12**
a.	In a typical 7-day week, about how many hours do you expect your students to spend preparing for class (studying, reading, writing, doing homework or lab work, analyzing data, and other activities related to your course)?	☐	☐	☐	☐	☐	☐	☐
b.	In a typical 7-day week, about how many hours do you think your students actually spend preparing for class (studying, reading, writing, doing homework or lab work, analyzing data, and other activities related to your course)?	☐	☐	☐	☐	☐	☐	☐

10. In your selected course, on average, what percent of class time is spent on the following (total should equal 100%)?

		Percent of Time							
		0	**1-9**	**10 - 19**	**20 - 29**	**30 - 39**	**40 - 49**	**50 - 74**	**75 or more**
a.	Lecture	☐	☐	☐	☐	☐	☐	☐	☐
b.	Teacher-led discussion	☐	☐	☐	☐	☐	☐	☐	☐
c.	Teacher-student shared responsibility (seminar, discussion, etc.)	☐	☐	☐	☐	☐	☐	☐	☐
d.	Student computer use	☐	☐	☐	☐	☐	☐	☐	☐
e.	Small group activities	☐	☐	☐	☐	☐	☐	☐	☐
f.	Student presentations	☐	☐	☐	☐	☐	☐	☐	☐
g.	In-class writing	☐	☐	☐	☐	☐	☐	☐	☐
h.	In-class problem sets	☐	☐	☐	☐	☐	☐	☐	☐
i.	Testing and evaluation	☐	☐	☐	☐	☐	☐	☐	☐
j.	Experiential (labs, field work, hands-on activities, etc.)	☐	☐	☐	☐	☐	☐	☐	☐

For the next set of questions, please <u>mark two boxes per row</u> to indicate how important certain instructional practices are to you and how often you engage in those practices.

		11. How important is it to you that				12. How often do			
		Not Important	Somewhat Important	Important	Very Important	Never	Occasionally	Often	Almost Always
a.	You interact with students in the classroom	☐	☐	☐	☐	☐	☐	☐	☐
b.	You interact with students outside of class (office hours, advising, committees, etc.)	☐	☐	☐	☐	☐	☐	☐	☐
c.	You are enthusiastic about teaching engineering	☐	☐	☐	☐	☐	☐	☐	☐
d.	You are enthusiastic about engineering research	☐	☐	☐	☐	☐	☐	☐	☐
e.	You know your students by name	☐	☐	☐	☐	☐	☐	☐	☐
f.	You use email to communicate with students	☐	☐	☐	☐	☐	☐	☐	☐
g.	You discuss grades or assignments with individual students	☐	☐	☐	☐	☐	☐	☐	☐
h.	Students work cooperatively with other students on course assignments	☐	☐	☐	☐	☐	☐	☐	☐
i.	Students teach and learn from each other	☐	☐	☐	☐	☐	☐	☐	☐
j.	Students work in groups	☐	☐	☐	☐	☐	☐	☐	☐
k.	Students give each other feedback on their work or ideas	☐	☐	☐	☐	☐	☐	☐	☐
l.	Students interact with each other outside of class	☐	☐	☐	☐	☐	☐	☐	☐
m.	You give students frequent feedback on their work	☐	☐	☐	☐	☐	☐	☐	☐
n.	You give students detailed feedback on their work	☐	☐	☐	☐	☐	☐	☐	☐
o.	You give students prompt feedback on their work	☐	☐	☐	☐	☐	☐	☐	☐
p.	You provide positive feedback to students that they can do well in engineering courses	☐	☐	☐	☐	☐	☐	☐	☐
q.	You structure engineering assignments, projects, or examinations so that most students can be successful	☐	☐	☐	☐	☐	☐	☐	☐
r.	You help students find meaning, value, and interest in engineering course material	☐	☐	☐	☐	☐	☐	☐	☐
s.	Your engineering courses have an open and positive atmosphere	☐	☐	☐	☐	☐	☐	☐	☐
t.	Students feel like valued members of the engineering community at your university	☐	☐	☐	☐	☐	☐	☐	☐
u.	Students know what I expect from them in terms of coursework	☐	☐	☐	☐	☐	☐	☐	☐
v.	I spend class time discussing the course's educational objectives	☐	☐	☐	☐	☐	☐	☐	☐
w.	I expect high quality work from most students	☐	☐	☐	☐	☐	☐	☐	☐

13. What is your gender?

- ☐ Female
- ☐ Male

14. What is your ethnic background?

- ☐ African American/Black
- ☐ American Indian/Alaskan Native
- ☐ Asian
- ☐ European American/White
- ☐ Hawaiian or Pacific Islander
- ☐ Hispanic/Latino
- ☐ Other (please specify) _____

APPENDIX B:
A Survey Measuring Student and Faculty Engagement in Engineering Education (Student Version)

Center for the Advancement of Scholarship on Engineering Education (CASEE)

Instructions: Please mark your answers in the boxes. If you are asked to specify an answer, please clearly print your answer on the line provided.

1. What is your engineering major?

- ☐ Aerospace Engineering
- ☐ Chemical Engineering
- ☐ Civil Engineering
- ☐ Computer Engineering
- ☐ Electrical Engineering
- ☐ Industrial Engineering
- ☐ Mechanical Engineering
- ☐ Other (please specify) _____

2. When is your anticipated graduation date?

☐ Spring '06	☐ Spring '07	☐ Spring '08
☐ Summer '06	☐ Summer '07	☐ Summer '08
☐ Fall '06	☐ Fall '07	☐ Fall '08

☐ Other (please specify) _____

3. Thinking about in your in-class and out-of-class experiences, please rate your ability to do the following:		**No ability**	**Some ability**	**Adequate ability**	**More than adequate ability**	**High ability**
a-1.	Use basic scientific principles to analyze the performance of processes and systems	☐	☐	☐	☐	☐
a-2.	Use basic engineering principles to analyze the performance of processes and systems	☐	☐	☐	☐	☐
a-3.	Formulate and evaluate mathematical models describing the behavior and performance of systems and processes	☐	☐	☐	☐	☐
b-1.	Design an experiment	☐	☐	☐	☐	☐
b-2.	Analyze evidence or data from an experiment	☐	☐	☐	☐	☐
b-3.	Interpret results of an experiment	☐	☐	☐	☐	☐
b-4.	Use evidence to draw conclusions or make recommendations	☐	☐	☐	☐	☐
c-1.	Identify essential aspects of the engineering design process	☐	☐	☐	☐	☐
c-2.	Apply systematic design procedures to open-ended problems	☐	☐	☐	☐	☐
c-3.	Design solutions to meet desired needs	☐	☐	☐	☐	☐
d-1.	Work in teams where knowledge and ideas from many disciplines (business, public policy, engineering, etc.) must be applied	☐	☐	☐	☐	☐
d-2.	Work in teams where knowledge from many engineering disciplines must be applied	☐	☐	☐	☐	☐
d-3.	Collaborate with others when working on multidisciplinary teams	☐	☐	☐	☐	☐
d-4.	Communicate effectively with others when working on multidisciplinary teams	☐	☐	☐	☐	☐

3. Thinking about in your in-class and out-of-class experiences, please rate your ability to do the following:		**No ability**	**Some ability**	**Adequate ability**	**More than adequate ability**	**High ability**
d-5.	Effectively manage conflicts that arise when working on multidisciplinary teams	☐	☐	☐	☐	☐
d-6.	Do your fair share of the work when working on multidisciplinary teams	☐	☐	☐	☐	☐
e-1.	Identify problems for which there are engineering solutions	☐	☐	☐	☐	☐
e-2.	Formulate a range of solutions to an engineering problem	☐	☐	☐	☐	☐
e-3.	Test potential solutions to an engineering problem	☐	☐	☐	☐	☐
e-4.	Use feedback from an experiment to improve solutions to an engineering problem	☐	☐	☐	☐	☐
f-1.	Identify potential ethical dilemmas in engineering practice	☐	☐	☐	☐	☐
f-2.	Estimate the potential for ethical dilemmas due to budget or time constraints	☐	☐	☐	☐	☐
f-3.	Address ethical issues when working on engineering problems	☐	☐	☐	☐	☐
f-4.	Apply an engineering code of ethics	☐	☐	☐	☐	☐
f-5.	Apply technical codes and standards	☐	☐	☐	☐	☐
g-1.	Convey technical ideas in writing	☐	☐	☐	☐	☐
g-2.	Convey ideas verbally	☐	☐	☐	☐	☐
g-3.	Convey ideas in formal presentations	☐	☐	☐	☐	☐
g-4.	Convey ideas in graphs, figures, etc.	☐	☐	☐	☐	☐
h-1.	Estimate the impact of engineering solutions in a societal context (in a particular culture, community, state, nation, etc.)	☐	☐	☐	☐	☐
h-2.	Estimate the impact of engineering solutions in a global context	☐	☐	☐	☐	☐
i-1.	Apply engineering techniques (e.g., processes, methods) in engineering practice	☐	☐	☐	☐	☐
i-2.	Apply engineering skills (e.g., experimentation, machining, programming) in engineering practice	☐	☐	☐	☐	☐
i-3.	Apply engineering tools (e.g., software, lathes, oscilloscopes) in engineering practice	☐	☐	☐	☐	☐
i-4.	Integrate engineering techniques, skills, and tools to solve real-world problems	☐	☐	☐	☐	☐
j-1.	Manage a team's time to meet deadlines when leading a project	☐	☐	☐	☐	☐
j-2.	Determine equipment and personnel needed when managing a project	☐	☐	☐	☐	☐
j-3.	Create and follow a budget when managing a project	☐	☐	☐	☐	☐
j-4.	Address the business, financial, and market related matters associated with project engineering	☐	☐	☐	☐	☐
j-5.	Apply interpersonal skills in managing people	☐	☐	☐	☐	☐

3. Thinking about in your in-class and out-of-class experiences, please rate your ability to do the following:		**No ability**	**Some ability**	**Adequate ability**	**More than adequate ability**	**High ability**
k-1.	Integrate knowledge and skills learned in engineering disciplines other than your specific major	☐	☐	☐	☐	☐
k-2.	Recognize the need to consult an expert from a discipline other than your own when working on a project	☐	☐	☐	☐	☐
k-3.	Recognize the limitations or validity of other professional engineers' opinions	☐	☐	☐	☐	☐
l-1.	Consider contemporary issues (economic, environmental, political, aesthetic, etc.) at the local, national, and world levels	☐	☐	☐	☐	☐
l-2.	Consider contemporary technical issues in your discipline at the local, national, and world levels	☐	☐	☐	☐	☐
l-3.	Estimate how engineering decisions and contemporary issues can impact each other	☐	☐	☐	☐	☐
l-4.	Use knowledge of contemporary issues to make engineering decisions	☐	☐	☐	☐	☐

4. To what extent do you/are you:		**Not at all**	**Somewhat**	**Mostly**	**Always**
a.	Set and pursue your own learning goals	☐	☐	☐	☐
b.	Take new opportunities for intellectual growth or professional development	☐	☐	☐	☐
c.	Seek the latest information or advances in your field	☐	☐	☐	☐
d.	Engage in critical, reliable, and valid self-assessment	☐	☐	☐	☐
e.	Apply new knowledge gained to the practice of engineering	☐	☐	☐	☐
f.	Recognize the unique skills, abilities, and contributions of all students in your engineering courses	☐	☐	☐	☐
g.	Recognize the need for diverse perspectives in solving engineering problems	☐	☐	☐	☐
h.	Comfortable working with engineering clients and colleagues from diverse racial/ethnic backgrounds	☐	☐	☐	☐
i.	Comfortable working with engineering clients and colleagues of the opposite gender	☐	☐	☐	☐
j.	Know what you want to do after graduation (get a job, go to graduate school, etc.)	☐	☐	☐	☐
k.	Know what you need to do to attain the goals you have for after graduation	☐	☐	☐	☐
l.	Making progress towards achieving your post-graduation goals	☐	☐	☐	☐

For questions 5 through 10, think about the <u>current school year</u>.

5. In your engineering courses, how often:		**Almost never**	**Occasionally**	**Often**	**Almost always**
a.	Do you fail to do your best work?	☐	☐	☐	☐
b.	Do you turn in completed assignments on time?	☐	☐	☐	☐
c.	Do you seek ways to improve a design or project, even after it's been turned in?	☐	☐	☐	☐
d.	Do you take initiative in your learning process?	☐	☐	☐	☐
e.	Do you complete your share of tasks on time, when working in teams?	☐	☐	☐	☐
f.	Are you dependable?	☐	☐	☐	☐

6. How often did the following occur in your <u>engineering major</u>		**Almost never**	**Occasionally**	**Often**	**Almost always**
a.	My engineering courses emphasized acceptance of, and respect for, differences (of opinion, background, etc).	☐	☐	☐	☐
b.	My engineering instructors and I discussed diversity issues.	☐	☐	☐	☐
c.	My engineering instructors emphasized the importance of diversity in the engineering workplace.	☐	☐	☐	☐
d.	I observed the use of offensive words, behaviors, or gestures directed at students because of their backgrounds or identities.	☐	☐	☐	☐
e.	I observed other engineering students being ignored or excluded (from projects, discussions, lab work, etc.) because of their backgrounds or identities.	☐	☐	☐	☐
f.	I was harassed or discriminated against by others in my major because of my background or identity.	☐	☐	☐	☐
g.	My engineering courses' content reflects contributions of all engineers, including women and people of color, etc.	☐	☐	☐	☐
i.	Students of all backgrounds/identities participate in class (in discussion, in-class assignments, team projects, etc.).	☐	☐	☐	☐

7. How often did the following occur in the courses you took in your <u>engineering major</u>?		**Almost never**	**Occasionally**	**Often**	**Almost always**
a-1.	I interacted with instructors as part of my courses.	☐	☐	☐	☐
a-2.	I interacted with instructors outside of class (office hours, advising, committees, etc.).	☐	☐	☐	☐
a-3.	Instructors were enthusiastic about engineering research or practice.	☐	☐	☐	☐
a-4.	Instructors were enthusiastic about teaching engineering.	☐	☐	☐	☐
a-5.	Instructors knew my name.	☐	☐	☐	☐
a-6.	I used email to communicate with instructors.	☐	☐	☐	☐
a-7.	I discussed grades or assignments with my instructors.	☐	☐	☐	☐

7. How often did the following occur in the courses you took in your engineering major?		**Almost never**	**Occasionally**	**Often**	**Almost always**
b-1.	I worked cooperatively with other students on course assignments.	☐	☐	☐	☐
b-2.	Students taught and learned from each other.	☐	☐	☐	☐
b-3.	Classmates and I worked in groups.	☐	☐	☐	☐
b-4.	I discussed ideas with my classmates (individuals or groups).	☐	☐	☐	☐
b-5.	I got feedback on my work or ideas from my classmates.	☐	☐	☐	☐
b-6.	I interacted with classmates outside of class.	☐	☐	☐	☐
c-1.	Assignments and activities were clearly explained.	☐	☐	☐	☐
c-2.	Instructors made clear what was expected of students in the way of activities and effort.	☐	☐	☐	☐
c-3.	Instructors expected a lot of work from me.	☐	☐	☐	☐
c-4.	Instructors expected high quality work from me.	☐	☐	☐	☐
d-1.	Instructors gave me frequent feedback on my work.	☐	☐	☐	☐
d-2.	Instructors gave me detailed feedback on my work.	☐	☐	☐	☐
d-3.	Instructors gave me prompt feedback on my work.	☐	☐	☐	☐
e-1.	Instructors guided students' learning activities rather than lecturing or demonstrating the course material.	☐	☐	☐	☐
e-2.	Students were required to be active participants in the teaching and learning process.	☐	☐	☐	☐
e-3.	I asked questions in class.	☐	☐	☐	☐
e-4.	I contributed to class discussions.	☐	☐	☐	☐
f-1.	Instructors recognized that some students learn in different ways than others.	☐	☐	☐	☐
f-2.	Instructors conveyed material in more than one way (in writing, using diagrams, verbally, using real-life examples, etc.).	☐	☐	☐	☐
g-1.	Instructors explained new concepts by making explicit links between what students already know and the new material.	☐	☐	☐	☐
g-2.	I have learned to apply fundamentals to problems I haven't seen before.	☐	☐	☐	☐
g-3.	Engineering instructors gave pretests at the beginning of the semester or when introducing a new topic.	☐	☐	☐	☐
g-4.	I have had misconceptions about specific areas of some course material.	☐	☐	☐	☐
h-1.	Instructors used simple, common sense examples or metaphors to introduce new concepts.	☐	☐	☐	☐
h-2.	Instructors introduced new concepts by requiring students to engage in hands-on activities, class discussions, etc.	☐	☐	☐	☐
i-1.	I received positive feedback from instructors that I can do well in engineering courses.	☐	☐	☐	☐

7. How often did the following occur in the courses you took in your engineering major?		**Almost never**	**Occasionally**	**Often**	**Almost always**
i-2.	Engineering assignments, projects, or examinations have been too difficult for me to be successful.	☐	☐	☐	☐
i-3.	I found meaning, value, and interest in my engineering course material.	☐	☐	☐	☐
i-4.	My engineering courses had an open and positive atmosphere.	☐	☐	☐	☐
i-5.	I felt like a valued member of the engineering community at my university.	☐	☐	☐	☐
i-6.	I felt intimidated by some of my engineering instructors.	☐	☐	☐	☐

8. In a typical week, how many homework assignments of problem sets do you complete in your engineering major?		**Number of Homework Assignments**			
		1-2	3-4	5-6	More than 6
a.	Number of weekly homework assignments that take less than 2 hours to complete	☐	☐	☐	☐
b.	Number of weekly homework assignments that take between 2 and 5 hours to complete	☐	☐	☐	☐
c.	Number of weekly homework assignments that take more than 5 hours to complete	☐	☐	☐	☐

9. Time you spend preparing for an average junior or senior level engineering course		**Hours per Week**						
		2 or less	**3-4**	**5-6**	**7-8**	**9 - 10**	**11 - 12**	**More than 12**
a.	In a typical 7-day week, about how many hours **should** you spend preparing for **one average** engineering class (studying, reading, writing, doing homework or lab work, analyzing data, and other activities related to your course)?	☐	☐	☐	☐	☐	☐	☐
b.	In a typical 7-day week, about how many hours do you **actually** spend preparing for **one average** engineering class (studying, reading, writing, doing homework or lab work, analyzing data, and other activities related to your course)?	☐	☐	☐	☐	☐	☐	☐

10. In your engineering courses, on average, what percent of class time is spent on the following (total should equal 100%)

		Percent of Time							
		0	**1-9**	**10 - 19**	**20 - 29**	**30 - 39**	**40 - 49**	**50 - 74**	**75 or more**
a.	Lecture	☐	☐	☐	☐	☐	☐	☐	☐
b.	Teacher-led discussion	☐	☐	☐	☐	☐	☐	☐	☐
c.	Teacher-student shared responsibility (seminar, discussion, etc.)	☐	☐	☐	☐	☐	☐	☐	☐
d.	Student computer use	☐	☐	☐	☐	☐	☐	☐	☐
e.	Small group activities	☐	☐	☐	☐	☐	☐	☐	☐
f.	Student presentations	☐	☐	☐	☐	☐	☐	☐	☐
g.	In-class writing	☐	☐	☐	☐	☐	☐	☐	☐
h.	In-class problem sets	☐	☐	☐	☐	☐	☐	☐	☐
i.	Testing and evaluation	☐	☐	☐	☐	☐	☐	☐	☐
j.	Experiential (labs, field work, hands-on activities, etc.)	☐	☐	☐	☐	☐	☐	☐	☐

11. What are your plans for next year?

Continue undergraduate education:
- ☐ Full-time
- ☐ Part-time

Employment:
- ☐ In an engineering-related occupation full-time
- ☐ In an engineering-related occupation part-time
- ☐ Outside engineering full-time
- ☐ Outside engineering part-time

Graduate school:
- ☐ In an engineering-related discipline full-time
- ☐ In an engineering-related discipline part-time
- ☐ Outside engineering full-time
- ☐ Outside engineering part-time

☐ Other (specify) _____

12. By the end of this academic year, will you have taken the Fundamentals of Engineering (FE) Exam?

☐ Yes ☐ No (please go to # 13)

a. If you have taken the FE, did you pass?

☐ Yes ☐ No

13. What is your gender?

☐ Female

☐ Male

14. What is your ethnic background?

- ☐ African American/Black
- ☐ American Indian/Alaskan Native
- ☐ Asian
- ☐ European American/White
- ☐ Hawaiian or Pacific Islander
- ☐ Hispanic/Latino
- ☐ Other (please specify) _____

15. Did you begin college at your current institution or elsewhere?

☐ Started here ☐ Started elsewhere

16. Since high school, which of the following types of schools have you attended other than the one you are attending now?

- ☐ Vocational or technical school
- ☐ Community or junior college
- ☐ 4-year college other than this one
- ☐ None
- ☐ Other (please specify) _____

17. Thinking about this current academic term, how would you characterize your enrollment?

☐ Full-time ☐ Less than full-time

18. Are you a member of a sorority or fraternity?

☐ Yes ☐ No

19. Are you a student-athlete on a team sponsored by your institution's athletics department?

☐ Yes ☐ No

20. What have most of your grades been up to now at this institution?

☐ A	☐ B	☐ C
☐ A-	☐ B-	☐ C- or lower
☐ B+	☐ C+	

21. Which of the following best describes where you are living now, while attending college?

- ☐ Residence hall or other campus housing (not fraternity/sorority house)
- ☐ House, apartment, etc. within walking distance of the institution
- ☐ House, apartment, etc. within driving distance of the institution
- ☐ Fraternity or sorority house

22. What is the highest level of education that your parents completed? Mark one box per column.

Mother	Father	
☐	☐	Did not finish high school
☐	☐	Graduated from high school
☐	☐	Attended college but did not finish degree
☐	☐	Completed an associate's degree
☐	☐	Completed a bachelor's degree
☐	☐	Completed a master's degree
☐	☐	Completed a doctoral degree (Ph.D., M.D., J.D., etc.)

APPENDIX C:
Matching Instructional Practices and Student Outcomes to Survey Items
A Survey Measuring Student and Faculty Engagement in Engineering Education

Center for the Advancement of Scholarship on Engineering Education (CASEE)

	Corresponding Survey Item Numbers	
INSTRUCTIONAL PRACTICES	**Student Survey**	**Faculty Survey**
1. Encourage student-faculty interaction	7a (1-7)	11 & 12 (a-g)
2. Develop reciprocity and cooperation among students	7b (1-6)	11 & 12 (h-l)
3. Communicate high expectations	7c (1-4)	7 (u-w)
4. Give students feedback	7d (1-3)	11 & 12 (m-o)
5. Use active learning techniques	7e (1-4)	7 (a-d)
6. Emphasize time on task	8, 9, 10	8, 9, 10
7. Respect diverse talents and ways of thinking	6 (a-i); 7f (1-2)	6(a-i)
8. Build on correct preexisting understandings, dispel false preconceptions	7g (1-4)	7 (e-i)
9. Provide factual knowledge, facilitate understanding of facts and ideas in context of a conceptual framework and organizing knowledge that facilitates retrieval and application	7h (1-2)	7 (j-k)
10. Encourage students' motivation to learn	7i (1-6)	11 & 12 (p-t)
STUDENT OUTCOMES		
a. An ability to apply knowledge of mathematics, science, and engineering	3a (1-3)	3a (1-3)
b. An ability to design and conduct experiments, as well as to analyze and interpret data	3b (1-4)	3b (1-4)
c. An ability to design a system, component, or process to meet desired needs	3c (1-3)	3c (1-3)
d. An ability to function on multidisciplinary teams	3d (1-6)	3d (1-6)
e. An ability to identify, formulate, and solve engineering problems	3e (1-4)	3e (1-4)
f. An understanding of professional and ethical responsibility	3f (1-5)	3f (1-5)
g. An ability to communicate effectively	3g (1-4)	3g (1-4)
h. The broad education necessary to understand the impact of engineering solutions in a global and societal context	3h (1-2)	3h (1-2)
i. A recognition of the need for life-long learning, and an ability to engage in it	4 (a-e)	7 (l-o)
j. A knowledge of contemporary issues	3l (1-4)	3l (1-4)
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	3i (1-4)	3i (1-4)
L. Ability to manage a project and a familiarity with business, market-related, and financial matters	3j (1-5)	3j (1-5)
M. A multidisciplinary systems perspective with breadth of engineering sciences	3k (1-3)	3k (1-3)
N. An understanding and appreciation of the diversity of students, faculty, staff, colleagues, and customers	4 (f-i)	5 (g-j)
O. A good work ethic (a commitment to quality, timeliness, and continuous improvement)	5 (a-f)	5 (a-f)

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