AC 2007-2716: VALIDATION PILOT FOR MEASURING ENGINEERING STUDENT ENGAGEMENT

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Reliability and Validity of the Engineering Faculty Survey of Student Engagement (E-FSSE): Validation of Surveys Measuring Student Engagement in Engineering

Abstract
The Engineering National Survey of Student Engagement (E-NSSE) and its faculty version, the Engineering Faculty Survey of Student Engagement (E-FSSE) are two new instruments designed to identify "best instructional practices" in engineering education and achieving certain learning outcomes desired of engineering graduates. This paper provides preliminary analysis in the validation process of the E-FSSE survey that began in October, 2006 (see E-FSSE Survey in Appendix I). Thus far, three of the nine universities in the validation project have completed the survey, via the web. This paper provides some preliminary analysis in the validation process and next steps. Several more validation steps are necessary before analysis is complete.

Introduction

In the wake of the National Academy of Engineering's "Educating the Engineer of 2020" report and the highly acclaimed National Academies' "Rising Above the Gathering Storm" report, today's engineering community is increasingly 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 the last several years, we have seen an influx of articles, dialogue, and meetings of engineering educators looking for ways to improve engineering education by introducing and strengthening their commitment to assessing specific approaches to teaching, learning, and student learning outcomes. The report, *Engineer of 2020 Project, Visions of Engineering in the New Century,* identifies the attributes and abilities engineers will need to perform well in a world driven by rapid technological advancements, national security needs, aging infrastructure in developed countries, environmental challenges brought about by population growth and diminishing resources, and the creation of new disciplines at the interfaces between engineering and science. To ensure that future engineers have these capabilities, they must be educated to be not only technically proficient, but also ethically grounded global citizens who can become leaders in business and public service.

Importance of Study

More recently, 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, "Assessment in Engineering Education: Evolution, Approaches, and Future Collaboration", 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]. Further, Bjorklund and Fortenberry assert that while researchers and educators have developed a number of classroom and college-wide assessments – oftentimes in preparation for an ABET accreditation visit – no national assessment exist to measure engineering student learning outcomes and the instructional practices that support those outcomes[2].

In response, CASEE has developed two surveys to assess the extent to which engineering students are engaging in identified "best instructional practices" and are achieving certain learning outcomes desired of engineering graduates. This paper describes the validation process of the E-FSSE survey and provides some preliminary analysis of that validation process.

Rationale

The CASEE questionnaires were developed in a systematic and rigorous manner, and are based on current and emerging research on student engagement, engineering education, practices of effective teaching and learning and engineering learning outcomes. The instruments were informed by the development of existing tools, yet the CASEE surveys are innovative in that they fill gaps in the assessment of engineering education. We have provided a well-developed research plan that has engaged a variety of engineering institutions in the piloting and on going refinement of the instruments. Our instruments have the potential to offer powerful formative feedback for individual engineering colleges and departments, as well to provide national baseline data on engineering education.

Study Participants and Methods

Measuring both student learning outcomes and teacher instructional practices is not straightforward task. Such questionnaires must be reliable—that is, the random error of responses must be minimized so that consistency of measurement is achieved. The questionnaire must also be valid—that is, it must be a true measure of what it purports to measure and must not be subject to bias. Validity can further be characterized as face, content, criterion, or construct validity. Distinct from traditional research in the physical sciences and engineering, educational research oftentimes endeavors to assess difficult-to-measure "constructs" (for example, attitude or satisfaction) rather than phenomena that can be physically observed (e.g., behaviors). Educational researchers, therefore, need to be especially diligent in establishing the validity of the measures they are using.

Questionnaire development and refinement

In the preliminary work for this project, we took great care in crafting clear, well-defined survey items with high face and content validity. We based the items on the scholarship of survey design and engineering education and, with their permission, items used in the NSSE [8], FSSE [9], and EC2000 [10] instruments. The NSSE instrument development team established, for example, through the use of focus groups, that each survey item has the same meaning for each respondent [6]. Similarly, we conducted two 90-minute focus groups (one with faculty and one with students) at each of five engineering colleges in February and March 2005 to establish that each of our survey items meant the same thing to each reader. 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 iterative 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.

In response to the critiques of self-reported data, and as noted on the NSSE website [7], "The validity and credibility of self-reports have been examined extensively. Self-reports are likely to be valid under five general conditions. They are: (1) when the information requested is known to the respondents; (2) the questions are phrased clearly and unambiguously; (3) the questions refer to recent activities; (4) the respondents think the questions merit a serious and thoughtful response; and (5) answering the questions does not threaten, embarrass, or violate the privacy of the respondent or encourage the respondent to respond in socially desirable ways." Our survey items meet these criteria, and are expected to be valid.

Final drafts of the instruments were completed at the end of June 2005. The current iteration of the survey drafts are approximately seven pages each and include items regarding demographic information and the student outcomes and teaching practices. Table 2 list the nine colleges of engineering that have agreed to participate in the pilot administrations of the CASEE faculty and student questionnaires.

Sampling

In October, 2006 email messages were sent to contact persons in the dean's office in each of the nine engineering colleges that initially agreed to participate. These institutions were selected to participate in the pilot administration of the survey because of their leadership and interest in the field of engineering education, their geographic diversity, and their willingness to administer the surveys college-wide. Five large, doctoral-granting research universities were selected to maximize the number of potential responses for this pilot of the questionnaire. Two primarily masters degree-granting universities were invited to participate to ensure the participation of a variety of institution types. For the same reason, a specialized and primarily baccalaureate degree granting institution was included.

Table 2: Institutions Participating in this Study

Institution	**Public/Private**	**Region**	**Focus**	**MSI***
Cal State LA	Public	West	Comprehensive	Yes
FAMU/FSU	Public	South	Comprehensive/Research	Yes
Georgia Tech	Public	South	Research	No
Montana State	Public	West	Research	No
Penn State	Public	East	Research	No
Purdue	Public	Mid-west	Research	No
University of Wisconsin	Public	Mid-west	Research	No
Rose-Hulman	Private	Mid-west	Baccalaureate	No
Rowan	Private	East	Comprehensive	No

*MSI = minority serving institution

As each participating engineering college has received IRB approval, email messages are sent to faculty that includes a letter from the office of the dean of the college describing the study, asking individuals to complete the anonymous survey, and providing a link to the on-line survey. The dean's office in each college will send out a follow-up email to all engineering faculty one to two weeks after the first solicitation. Follow-up solicitations were sent out to increase the number of survey respondents.

Of the nine participating colleges, three have received IRB approval thus far and have started filling out the E-FSSE. The preliminary data collected from those three schools are being used in this report.

The faculty sample includes all engineering faculty at participating institutions. "engineering faculty" includes all adjunct, assistant, associate, and full professors who teach at least one undergraduate course during the academic year. We are focusing on faculty with teaching responsibilities as many survey items ask about teaching practices. Faculty members with "research only" appointments are not well suited to answer many of the questions posed in the survey. Table 3 illustrates the total number of faculty at each institution that will be asked to complete the survey.

Table 3: Sample population by Location

Engineering College	**Faculty***
Cal State LA	42
FAMU/FSU	100
Georgia Tech	418
Montana State	70
Penn State	384
Purdue	321
University of Wisconsin	200
Rose-Hulman	82
Rowan	34
Total	1,651

*Preliminary estimate of total faulty in each college

Evaluation of the questionnaire

The instruments are being translated into on-line questionnaires using the commercial provider FormSite www.formsite.com, which offers various tools for survey development and results presentations. The site offers secure data input. Data from the on-line surveys were initially stored on the FormSite server and then downloaded to our server for analysis using SPSS. Data was examined in SPSS to identify any discrepancies, problems, or outliers. In analyzing the results of the pilot, survey response rates are reported and descriptive analyses of variables conducted. After the pilot, questions with highly skewed responses or high non-response rates will be removed or rewritten.

Validity Measures

Validity of measures was tested using a principle components extraction method with varimax rotation to statistically test whether scale items fit together and performed an exploratory factor analysis which analyzes the results from grouped questions that were answered similarly by faculty into independent factors. For more detail on factor analysis see references [11], [12], and [13].

For the principal components analysis, the Eigenvalue limit was set at one. We calculated component scores by scoring questions from one to five (five always representing maximum learning outcome or teacher instruction), summing them, and expressing the total as a percentage of the maximum possible score for the component. If a respondent omitted half or more of the questions in a component we excluded these data from analysis. Questions that best described student outcomes desired by the engineering community were retained, thus maximizing our chances of achieving content validity. Evidence of construct validity was sought by calculating Pearson's correlation coefficients matrix containing components for the overall student learning outcomes and teaching instructional practices scales.

Reliability Measures

To make sure the reliability of measures was stable, repeatable, and consistent across respondents, Cronbach’s alpha, an index of reliability associated with the variation, was used. By calculating Cronbach's alpha coefficient we estimated the internal consistency or reliability of each component. A Cronbach’s alpha index above 0.7 for each component is generally accepted by experts.

Results

Of the 102 respondents in the current sample of responses from three engineering colleges, the F-NSSE questionnaire was completed by 80 (78.4 percent) faculty members. The median (interquartile range) completion rate for questions was 96.5 percent (95.7 to 97.1 percent). Scale scores were calculated for a median (interquartile range) of 97.7 percent (94.5 to 98.1 percent) of responses.

Survey participants responded very well to the questions from the survey. At the end of the survey, participants were asked to make suggestions or comments about the survey. No new questions were identified by faculty members.

Validity

Validity was measured in three steps: First, as highlighted in “Linking Student Learning Outcomes to Instructional Practices—Phase I,” this project is grounded in the ABET engineering outcomes criteria and builds upon that grounding with the demonstrated knowledge base of the National Survey of Student Engagement as well as contemporary engineering education literature and the EC2000 study instruments [3]. Second, as highlighted in Bjorkland and Fortenberry [5], we conducted focus groups using a set of our survey items with both faculty and students at five engineering colleges. During the focus group, participants discussed the survey items to confirm the clarity and meaning of questions. Third we did a principle component analysis and exploratory factor analysis, which analyzes the results from all questions and then groups questions that were answered similarly by faculty members into independent factors. The results from exploratory factor analysis were used to indicate potentially bad questions (gave inconsistent results or seemed to be independent of the rest of the questions) and provided a set of independent categories. We also rechecked construct validity by calculating the intercomponent correlations.

The principal components analysis of the 80 completed questionnaires identified that the 15 learning components and 10 instructional practices each was judged to be coherent and to represent two separate scales related to student learning outcomes and teacher instructional practices. Appendix II lists the questions in each scale with their Cronbach alpha coefficients, the means and standard deviations of the scale scores, and the variance explained by each scale. Tables 4 and 5 list each scale and the corresponding number of questions with each.

Table 4: Student Learning Outcome Scale

	Number of Corresponding Questions
STUDENT OUTCOMES	
1. An ability to apply knowledge of mathematics, science, and engineering	3
2. An ability to design and conduct experiments, as well as to analyze and interpret data	4
3. An ability to design a system, component, or process to meet desired needs	3
4. An ability to function on multi-disciplinary teams	6
5. An ability to identify, formulate, and solve engineering problems	4
6. An understanding of professional and ethical responsibility	5
7. An ability to communicate effectively	4
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context	2
9. A recognition of the need for, and an ability to engage in life-long learning	5
10. A knowledge of contemporary issues	4
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	4
12. An ability to manage a project (including a familiarity with business, market-related, and financial matters)	5
13. A multidisciplinary systems perspective	3
14. An understanding of and appreciation for the diversity of students, faculty, staff, colleagues, and customers	4
15. A strong work ethic	6

Table 5: Instructional Practices Scales

	Number of Corresponding Questions
INSTRUCTIONAL PRACTICES	
1. Encouraging student-faculty interaction	7
2. Developing reciprocity and cooperation among students	5
3. Communicating high expectations	3
4. Providing prompt feedback	3
5. Using active learning techniques	4
6. Emphasizing time on task	15
7. Respecting diverse talents and ways of thinking	9
8. Building on correct pre-existing understandings; dispelling false preconceptions	5
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	2
10. Encouraging students' motivation to learn	5

Reliability

Cronbach's alpha was used to check the reliability of the intercorrelations of the constructs resulting from the factor analysis. The appendix lists the questions in each scale and their constructs with their Cronbach alpha coefficients, the means and standard deviations of the scale scores, and the variance explained by each scale. The learning component scale has satisfactory internal reliability with Cronbach's alpha coefficients greater than 0.70 for all learning components and greater than 0.80 for 10 of the 15 learning components. Only 3 of the 10 instructional practices components had Cronbach's α coefficients greater than 0.70 indicating that intercorrelation was not very good.

Discussion

The acceptability of the questionnaire to engineering faculty is shown by the high response rates for each question (median 96.5%) and the high proportion of responses for which we could calculate scale scores. We achieved response rates of over 50% from the three engineering programs who have thus far participated in the piloting of this survey after being on-line for three weeks. This shows that the instrument can successfully be administered via the web and probably by postal mail to a broad range of engineering faculty.

Content validity was ensured during questionnaire development through an extensive review of the relevant literature [4] and by adapting items used in the National Survey of Student Engagement (NSSE), Faculty Survey of Student Engagement (FSSE), and EC200 Study instruments. Content validity was initially shown by the outcome of the 10 focus groups conducted at five engineering colleges. Further evidence of content validity came from the outcome of the principal components analysis. The interscale correlations show that each scale is correlated with and hence related to student learning outcomes and teacher instructional practices, the scales assess different aspects of student learning outcomes and teacher instructional practices, a finding which argues in favor of construct validity. Future evaluations of this questionnaire should further examine construct and criterion validity.

The survey appears to have satisfactory internal reliability for at least one of its scales, the Learning Component scale, with the Cronbach's alpha index above 0.7 for each component which is generally accepted by experts. The Instructional Practices scale did not yield such good results indicating that it maybe necessary to add questions to improve reliability of each component. Also, conflicting styles of teaching application by professors may have lead to differences in score on the scale. To further determine the reliability of the instruments, we anticipate a second administration of the surveys in 2007-08 to make sure faculty with similar characteristics respond in approximately the same way from year to year.

Conclusions and Further Work

The current analysis indicates that this questionnaire has satisfactory reliability and validity but more data and test are needed to complete the validation process. This paper serves as the foundation for the results and conclusions from the analysis of our survey data and future applications of the survey. As indicated, the results presented here are preliminary. Further development of the questionnaire with a larger population is desirable. We are continuing to receive data from the participating engineering programs. Data collection will be completed for both faculty and students by May, 2007.

Potential Impact on New Engineering Faculty

The E-NSSE and F-NSSE instruments can make two potential contributions to the professional development of new engineering faculty: First, data collected from the E-NSSE may assist those faculty with less experience in making knowledgeable judgments of student behavior and student learning styles in preparing more effective teaching goals (the goals that direct choices of content and teaching method). This will ultimately increase their satisfaction, help them to gain greater confidence in their ability to achieve further teaching goals, and deepen their dedication to teaching. Second, engineering administrators can use information gathered from the F-NSSE to better mentor new faculty member by: (1) seeing how faculty are incorporating innovations in instruction and curriculum development; (2) helping to lay the groundwork for discussions about the assumptions and values that underlie the role of new faculty members; (3) diagnosing faculty member's strength and weaknesses; (4) developing professional development programming that addresses identified teaching and learning issues; and (5) making fairer comparisons among faculty.

The data collected from the E-NSSE and F-NSSE will provide all faculty members (both new and experienced) with: (a) tools to make them more effective teachers and (b) data which can inform classroom-based instructional research.

Table 6 below provides a project timeline for the next phases of this validation process. Additionally, a subsequent pilot administration of the surveys to further investigate the psychometric properties of the instruments will be undertaken. The specific analyses we anticipate conducting include:

Reliability

Test-retest reliability – We will ask a group of respondents to complete the survey twice in a relatively short time period (e.g., one week) in order to determine test-retest reliability.

Stability – We will run two sample t-tests comparing data from the first year pilot and the second year pilot for respondents with similar characteristics to check for differences in responses to each item from one year to the next. Items that have coefficients less than .6 would indicate those differences. They would not be considered stable and would be removed from the instruments.

Validity

Construct validity – In the second year of the grant, we will compare student survey responses and their end of the semester and cumulative GPAs.

Convergent validity – We will compare sample data to E-NSSE data from at least one participating institution.

Data collection, analysis and refinement of the E-NSSE and E-FSSE surveys are still in progress. Over the next few months we plan to perform a factor analysis of the results for the E-NSSE, a final revision of the current questions and creation of questions to target other categories that were not adequately addressed by the current version of the survey.

Table 6: Project Timeline

Task 2a: Analyze Results of Faculty Pilot	Dec 2006 -Feb 2007
2.1 Descriptive analysis of the variables	
2.2 Principle components factor analysis	
2.3 Check reliability of scales derived from factor analysis (using Cronbach's alpha)	
2.4 Multiple regression analysis to examine the relationships between independent and dependent variables	
Task 1b: Pilot Student Instruments	Mar – Apr 2007
Task 2b: Analyze Results of Student Pilot	May – Jul 2007
Task 3: Refine the Survey Instruments	Jul – Aug 2007
3.1 Delete redundant or extraneous items	
3.2 Item analysis	
3.3 Factor analyses using reduced model (including reliability tests)	
3.4 Reformat instruments	
3.5 Prepare for large-scale testing of the survey instruments	

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[1] Olds, B., Moskal, B., and Miller, R. "Assessment in Engineering Education: Evolution, Approaches, and Future Collaborations," *Journal of Engineering Education,* Vol. 94, No.1, 2005, 13-25

[2] Bjorklund, Stefani A., and Fortenberry, N.L. "Final Report: Measuring Student and Faculty Engagement in Engineering Education," CASEE Report 5902001-20050705

[3] Cupp, S.M., Moore, P. D., and Fortenberry, N.L. "Linking Student Learning Outcomes to Instructional Practices – Phase 1." *2004 ASEE Annual Conference and Exposition, Salt Lake City, UT*, Session 1630. Washington, DC: American Society for Engineering Education, 2004.

[4] Moore, P. D., Cupp, S. M. and Fortenberry, N.L. "Linking Student Learning Outcomes to Instructional Practices – Phase II." *Annual Frontiers in Education Conference,* Boulder, CO: ASEE/IEEE, 2003.

[5] Bjorklund, S. A., and Fortenberry, N. L.. "Linking Student Learning Outcomes to Instructional Practices -- Phase III." *2005 ASEE Annual Meeting and Exposition, Portland, OR*,, Session 3630. Washington, DC: American Society for Engineering Education, 2005.

[6] Ouimet, J.A., Bunnage, J.B., Carini, R.M., Kuh, G.D. & Kennedy, J. (2004). Using focus groups to establish the validity and reliability of a college student survey. *Research in Higher Education*. 45:233-50.

[7] National Survey of Student Engagement. "Frequently Asked Questions About NSSE's Psychometric Properties." Web page, April 2005 [accessed 6 May 2005]. Available at http://www.indiana.edu/~nsse/nsse_2002/faqpsych.htm.

[8] National Survey of Student Engagement. "NSSE 2006 Standard Version." Web page, January 2007 [accessed 17 January 2007]. Available at http://nsse.iub.edu/html/sample.cfm

[9] Faculty Survey of Student Engagement. "FSSE 2006." Web page, January 2007 [accessed 17 January 2007]. Available at http://fsse.iub.edu/html/fsse_survey_options.cfm

[10] EC2000. "Engineering Change: A study of the impact of the EC2000." Web page, January 2006 [accessed 17 January 2007]. Available at http://www.ed.psu.edu/cshe/abet/ec2000.html

[11] Crocker, L. and Algina, J. "Introduction to Classical and Modern Test Theory." Fort Worth: Hold, Rinehart and Winston, Inc, 1986.

[12] Kachigan, S. K. "Statistical Analysis." New York: Radius Press, 1986.

[13] Kim, J. and Mueller, C.W. "Factor Analysis—Statistical Methods and Practical Issues." Beverly Hills: Sage Publication, 1978.

APPENDIX I

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

1a. 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) ________________________

2. Is your faculty appointment primarily in teaching or research?

☐ Very heavily in research
☐ In both, but mostly research
☐ In both, but mostly teaching
☐ Very heavily in teaching

3. Think about **graduating seniors** 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	☐	☐	☐	☐	☐
d-2.	Work in teams where knowledge from many engineering disciplines must be applied	☐	☐	☐	☐	☐

Graduating seniors' ability to:		No ability	Some ability	Adequate ability	More than adequate ability	High ability
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	☐	☐	☐	☐	☐
j-1.	Manage a team's time to meet deadlines when leading a project	☐	☐	☐	☐	☐

Graduating seniors' ability to:		No ability	Some ability	Adequate ability	More than adequate ability	High ability
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 last five years.

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

   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)	☐	☐	☐	☐	☐
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	☐	☐	☐	☐	☐

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.)	☐	☐	☐	☐	☐	☐	☐	☐

	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	☐	☐	☐	☐	☐	☐	☐	☐

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

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 II

Student Outcomes

Component 1: An ability to apply knowledge of mathematics, science, and engineering
Cronbach's α coefficient= .832; mean scale score = 10.09 ; SD =2.11 ; % Variance = 4.435

#	Questions
3a-1.	Use basic scientific principles to analyze the performance of processes and systems
3a-2.	Use basic engineering principles to analyze the performance of processes and systems
3a-3.	Formulate and evaluate mathematical models describing the behavior and performance of systems and processes

Component 2: An ability to design and conduct experiments, as well as to analyze and interpret data
Cronbach's α coefficient=.856; mean scale score =12.76 ; SD =2.80 ; % Variance =7.85

3b-1.	Design an experiment
3b-2.	Analyze evidence or data from an experiment
3b-3.	Interpret results of an experiment
3b-4.	Use evidence to draw conclusions or make recommendations

Component 3: An ability to design a system, component, or process to meet desired needs
Cronbach's α coefficient=.783 ; mean scale score =10.20 ; SD =2.36 ; % Variance =5.58

3c-1.	Identify essential aspects of the engineering design process
3c-2.	Apply systematic design procedures to open-ended problems
3c-3.	Design solutions to meet desired needs

Component 4: An ability to function on multi-disciplinary teams
Cronbach's α coefficient=.909 ; mean scale score =21.39 ; SD =5.30 ; % Variance =28.11

3d-1.	Work in teams where knowledge and ideas from many disciplines (business, public policy, engineering, etc.) must be applied
3d-2.	Work in teams where knowledge from many engineering disciplines must be applied
3d-3.	Collaborate with others when working on multidisciplinary teams
3d-4.	Communicate effectively with others when working on multidisciplinary teams
3d-5.	Effectively manage conflicts that arise when working on multidisciplinary teams
3d-6.	Do their fair share of the work when working on multidisciplinary teams

Component 5: An ability to identify, formulate, and solve engineering problems
Cronbach's α coefficient=.894 ; mean scale score =13.24 ; SD =3.24 ; % Variance =10.49

3e-1.	Identify problems for which there are engineering solutions
3e-2.	Formulate a range of solutions to an engineering problem
3e-3.	Test potential solutions to an engineering problem
3e-4.	Use feedback from an experiment to improve solutions to an engineering problem

Component 6: An understanding of professional and ethical responsibility
Cronbach's α coefficient=.919 ; mean scale score =14.44 ; SD =4.53 ; % Variance =20.48

3f-1.	Identify potential ethical dilemmas in engineering practice
3f-2.	Estimate the potential for ethical dilemmas due to budget or time constraints

3f-3. Address ethical issues when working on engineering problems
3f-4. Apply an engineering code of ethics
3f-5. Apply technical codes and standards

Component 7: An ability to communicate effectively
Cronbach's α coefficient=.913 ; mean scale score =14.08; SD =3.31; % Variance =10.96
3g-1. Convey technical ideas in writing
3g-2. Convey ideas verbally
3g-3. Convey ideas in formal presentations
3g-4. Convey ideas in graphs, figures, etc.

Component 8: The broad education necessary to understand the impact of engineering solutions in a global and societal context
Cronbach's α coefficient=.889 ; mean scale score = 4.90 ; SD = 1.78; % Variance =3.15
3h-1. Estimate the impact of engineering solutions in a societal context (in a particular culture, community, state, nation, etc.)
3h-2. Estimate the impact of engineering solutions in a global context

Component 9: A recognition of the need for, and an ability to engage in life-long learning
Cronbach's α coefficient=.771; mean scale score =9.94; SD =2.80; % Variance =7.85
7l. Do you explicitly encourage students to set and pursue their own learning goals
7m. Do you make students aware of new opportunities for intellectual growth and professional development
7n. Do you explicitly encourage students to engage in critical, reliable, and valid self-assessment
7o. Do you explicitly encourage students to apply new knowledge gained to the practice of engineering

Component 10: A knowledge of contemporary issues
Cronbach's α coefficient=.924 ; mean scale score =10.49 ; SD =3.28 ; % Variance =10.73
3l-1. Consider contemporary issues (economic, environmental, political, aesthetic, etc.) at the local, national, and world levels
3l-2. Consider contemporary technical issues in your discipline at the local, national, and world levels
3l-3. Estimate how engineering decisions and contemporary issues can impact each other
3l-4. Use knowledge of contemporary issues to make engineering decisions

Component 11: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
Cronbach's α coefficient=.867; mean scale score =14.31; SD =3.31; % Variance =10.98
3i-1. Apply engineering techniques (e.g., processes, methods) in engineering practice
3i-2. Apply engineering skills (e.g., experimentation, machining, programming) in engineering practice
3i-3. Apply engineering tools (e.g., software, lathes, oscilloscopes) in engineering practice
3i-4. Integrate engineering techniques, skills, and tools to solve real-world problems

Component 12: An ability to manage a project (including a familiarity with business, market-related, and financial matters)
Cronbach's α coefficient=.893 ; mean scale score =13.95 ; SD =4.08 ; % Variance =16.63
3j-1. Manage a team's time to meet deadlines when leading a project
3j-2. Determine equipment and personnel needed when managing a project
3j-3. Create and follow a budget when managing a project
3j-4. Address the business, financial, and market related matters associated with project engineering
3j-5. Apply interpersonal skills in managing people

Component 13: A multidisciplinary systems perspective
Cronbach's α coefficient=.789 ; mean scale score =9.10 ; SD =2.51 ; % Variance =6.29
3k-1. Integrate knowledge and skills learned in engineering disciplines other than their specific majors
3k-2. Recognize the need to consult an expert from a discipline other than their own when working

on a project
3k-3. Recognize the limitations or validity of other professional engineers' opinions

Component 14: An understanding of and appreciation for the diversity of students, faculty, staff, colleagues, and customers

Cronbach's α coefficient=.777; mean scale score =14.27; SD =3.59; % Variance =12.94

5g. Recognize the unique skills, abilities, and contributions of all students in your engineering courses
5h. Recognize the need for diverse perspectives in solving engineering problems
5i. Comfortable working with engineering clients and colleagues from diverse racial/ethnic backgrounds
5j. Comfortable working with engineering clients and colleagues of the opposite gender

Component 15: A strong work ethic

Cronbach's α coefficient=.346; mean scale score =17.62; SD =2.86; % Variance =8.16

5a. Do not do their best work
5b. Turn in completed assignments on time
5c. Seek ways to improve a design, even after it's been turned in
5d. Take initiative in learning processes
5e. Do their share of tasks on time, when working in teams
5f. Are dependable (in terms of coursework)

Instructional Practices

Component 1: Encourage student-faculty interaction

Cronbach's α coefficient=.594; mean scale score = 24.35 ; SD =2.64 ; % Variance = 6.983

Survey Item Numbers	Questions
11&12a.	You interact with students in the classroom
11&12b.	You interact with students outside of class (office hours, advising, committees, etc.)
11&12c.	You are enthusiastic about teaching engineering
11&12d.	You are enthusiastic about engineering research
11&12e.	You know your students by name
11&12f.	You use email to communicate with students
11&12g.	You discuss grades or assignments with individual students

Component 2: Develop reciprocity and cooperation among students

Cronbach's α coefficient=.753; mean scale score =16.17 ; SD =2.64 ; % Variance =6.99

11&12h.	Students work cooperatively with other students on course assignments
11&12i.	Students teach and learn from each other
11&12j.	Students work in groups
11&12k.	Students give each other feedback on their work or ideas
11&12l.	Students interact with each other outside of class

Component 3: Communicate high expectations

Cronbach's α coefficient=.300 ; mean scale score =10.59 ; SD =1.20 ; % Variance =1.45

11&12u.	Students know what I expect from them in terms of coursework
11&12v.	I spend class time discussing the course's educational objectives
11&12w.	I expect high quality work from most students

Component 4: Give students feedback

Cronbach's α coefficient=.649 ; mean scale score =10.51 ; SD =1.37 ; % Variance =1.87

11&12m.	You give students frequent feedback on their work
11&12n.	You give students detailed feedback on their work
11&12o.	You give students prompt feedback on their work

Component 5: Use active learning techniques

Cronbach's α coefficient=.804 ; mean scale score =11.87; SD =2.41 ; % Variance =5.80

7a.	Do you guide students' learning activities rather than lecturing or demonstrating the course material
7b.	Are students active participants in the teaching and learning process
7c.	Do students ask questions in class
7d.	Do students contribute to class discussions

Component 6: Emphasize time on task

Cronbach's α coefficient=.555 ; mean scale score =9.70; SD =2.71; % Variance =7.37

8a.	Number of weekly that you expect to take less than 2 hours to complete
8b.	Number of weekly homework assignments that you expect to take between 2 and 5 hours to complete
8c.	Number of weekly homework assignments that you expect to take more than 5 hours to complete
9a.	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)?
9b.	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)?
10a.	Lecture
10b.	Teacher-led discussion
10c.	Teacher-student shared responsibility (seminar, discussion, etc.)
10d.	Student computer use

10e. Small group activities
10f. Student presentations
10g. In-class writing
10h. In-class problem sets
10i. Testing and evaluation
10j. Experiential (labs, field work, hands-on activities, etc.)

Component 7: Respect diverse talents and ways of thinking

Cronbach's α coefficient=.463 ; mean scale score =16.68; SD =2.74; % Variance =7.51

6a. Course included discussion about acceptance of and respect for differences (of opinion, background, etc.).
6b. Engineering students and you discussed diversity issues.
6c. You emphasized the importance of diversity in the engineering workplace.
6d. You observed the use of offensive words, behaviors, or gestures directed at students because of their backgrounds or identities.
6e. You observed certain engineering students being ignored or excluded (from projects, discussions, etc.) because of their backgrounds or identities.
6f. Students harassed or discriminated against you because of your background or identity.
6g. Your course's content reflects contributions of all engineers, including women and people of color, etc..
6h. You tailor lessons because some students learn in different ways than others.
6i. Students of all backgrounds/identities participate in class (in discussion, in-class assignments, team projects, etc.).

Component 8: Build on correct preexisting understandings, dispel false preconceptions

Cronbach's α coefficient=..632 ; mean scale score = 14.07 ; SD = 2.43; % Variance =5.90

7e. Do you explain new concepts by making explicit links between what students already know and the new material
7f. Do you teach students to apply fundamentals to problems they haven't seen before
7g. Do you encourage students to use what they already know to construct new understandings
7h. Do you use pretests or other measures to assess students' pre-existing understandings of basic math, science, or engineering principles
7i. Do students come to the course with misconceptions about specific areas of course content

Component 9: Provide factual knowledge, facilitate understanding of facts and ideas in context of a conceptual framework and organizing knowledge that facilitates retrieval of application

Cronbach's α coefficient=.518; mean scale score =5.97; SD =1.37; % Variance =1.87

7j. Do you introduce new concepts with simple, common sense examples or metaphors
7k. Do you introduce new concepts by requiring students to engage in hands-on activities, class discussions, etc.

Component 10: Encourage students' motivation to learn

Cronbach's α coefficient=.709 ; mean scale score =16.99 ; SD =2.26 ; % Variance =5.12

11&12p. You provide positive feedback to students that they can do well in engineering courses
11&12q. You structure engineering assignments, projects, or examinations so that most students can be successful
11&12r. You help students find meaning, value, and interest in engineering course material
11&12s. Your engineering courses have an open and positive atmosphere
11&12t. Students feel like valued members of the engineering community at your university