Department of Electrical and Computer Engineering

Iowa State University Computer Engineering Program Student Outcomes Assessment Tools

Updated 2016

For more information, please see: D. T. Rover, D. Jacobson, A. E. Kamal and A. Tyagi, "Implementation and Results of a Revised ABET Assessment Process", in the proceedings of the American Society of Engineering Education Annual Conference, 2013 (http://www.asee.org/public/conferences/20/papers/7964/view).
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The Department of Electrical and Computer Engineering has implemented a multilevel assessment process for measuring student attainment of outcomes for the Computer Engineering program. It should be noted that the same process is used for the Electrical Engineering program and that the department's assessment and curriculum committees oversee both programs. A similar process is also followed for the Software Engineering program in the interests of sharing effective practices as appropriate. The multilevel assessment process for measuring student attainment of outcomes as described below and summarized in the table below:

1. Level 1 assessment uses high-level information from a cross-section of students in the program that can be used to identify trends and potential problems. Level 1 information corresponds to student competencies observed by supervisors (employers) in the workplace during student internships. This is done using workplace competency assessment surveys of employers. This workplace competency assessment is described below. The results of the surveys are mapped to ABET student outcomes (a) – (k); all outcomes are assessed at level 1.
2. Level 2 assessment is finer grained and more specific than level 1. Level 2 information corresponds to student performance as demonstrated through work submitted during the senior year in the senior design class (CPRE/EE 491 and CPRE/EE 492) and in the portfolio class (CPRE/EE 494). The student work consisting of various design project deliverables and portfolio items are reviewed and scored by faculty. Rubrics are used and cover all ABET student outcomes (a) – (k) except outcome (b), which is given special attention using level 3 assessment. The senior year is an opportune time to assess student learning in a summative manner.
3. Level 3 is finer grained and more specific than the other levels. It provides more in-depth examination of a student outcome earlier in the program at the time the student is learning about it. Level 3 information corresponds to student achievement on specific assignments in selected courses. The courses and assignments are selected based on their appropriateness to measure a particular student outcome. Student work is scored by the instructor using rubrics. There are level 3 results for ABET student outcomes (a), (b), (c), (e), (f) and (k). This level of assessment provides additional information about student achievement in selected required courses earlier in the program. This level is the primary assessment for outcome (b), since it is currently not assessed at level 2.

This process was introduced prior to the previous accreditation review. A summary of the approach was presented at the 2013 ASEE Annual Conference in the paper "Implementation and Results of a Revised ABET Assessment Process" (D. Rover, D. Jacobson, A. Kamal, and A. Tyagi, Proc. 2013 ASEE Annual Conference, June 2013).

As shown in Table 1 below, data are collected from three types of measurements (direct, indirect, and informal) and at three different levels (1: program, 2: demonstration and 3: learning).   The indirect and informal methods are based on student input from surveys, student forums, and informal feedback from faculty and students. Direct

measurements are obtained from four sources: senior design, the required portfolio class, selected required courses before the senior year, and workplace competency assessments completed by employers.

Table 1: The multilevel Student Outcomes assessment process

	Direct	Indirect	Informal
Program level *(Level 1)*	Workplace Competency assessment – Employer	Workplace Competency assessment – Student Student forums	Student input Faculty input
Demonstration level *(Level 2)*	Student Portfolios Senior Design	Student Portfolios	Student input Faculty input
Learning level *(Level 3)*	Several courses	Student forums	Student input Faculty input

Table 2 below shows the different tools used in assessing the Student Outcomes, the sources of the tools and the different characteristics of the tools, i.e., whether they are qualitative or quantitative, and whether they are direct, indirect or informal. These tools are used to assess the satisfaction of student outcomes at three different levels (program, demonstration, and learning) as shown above in Table 1.

Table 3 shows which tools are used to assess each of the SOs. The assessment plan is devised such that each SO (column) is assessed by at least one tool from each of the three levels (checkmarks in the column) in order to fulfill the philosophy of the development of the three levels, as described above. Each assessment tool (row) has at least one checkmark. Most course based assessments focus only on one or two SOs to provide a detailed learning level view of that SO from an appropriate course.

Table 2: Summary of Student Outcomes assessment tools

Assessment Tools	Level	Direct/Indirect/Informal					Source
		Direct	Indirect	Informal	Quant	Qual	
Senior design scoring	2	x			x		Faculty
Portfolio assessment	2	x			x	x	Faculty
Workplace competency assessment by employers	1	x			x		Employer
Course-based outcomes assessment by instructor	3	x			x	x	Faculty
Workplace competency self-assessment by students	1		x		x		Students
Student comments via forums	1,3		x			x	Students
Student input from research assessments	1,3	x	x		x	x	Students
Student input	1,2,3			x	x	x	Students
Faculty input	1,2,3			x	x	x	Faculty

The four types of direct measurements of student outcomes are used to provide both breadth of coverage (all of outcomes a-k) as well as depth of coverage (multiple measurements for each outcome). Table 3 shows the coverage map for the direct measures. As shown in the table, these tools are organized in three levels, which serve different purposes:

1. At Level 1, the workplace competency employer survey results provide a high level indication of how well our students are meeting the outcomes. Since the workplace competency assessment survey is not tied directly back to a learning experience, problems identified using the workplace competency assessment may be hard to attribute to a course.
2. At Level 2 of direct assessment, the senior design and the portfolio classes are used. These courses present an opportunity to evaluate student work that encompasses multiple outcomes (as shown in Table 3). While these courses do

not necessarily teach content that supports an outcome, the work produced by the students is evaluated to determine whether they have attained the outcome. If a problem is identified, the results will lead to an examination of student learning in prior courses.

3. The third level of direct assessment is designed to provide additional granularity. This is done by measuring each outcome in a course where that outcome is taught. We have developed a set of rubrics to assess each of the outcomes. Rubrics are applied in the courses identified as part of the course-based (Level 3) assessment (Table 3).

Table 3: Coverage map of the direct measures

Direct Assessment Tools	Student Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
Level 1: workplace competency survey from employers	√	√	√	√	√	√	√	√	√	√	√
Level 2: Senior design scoring by faculty	√		√	√	√	√	√				√
Level 2: Portfolio assessment by faculty								√	√	√	√
Level 3: Course-based outcomes assessment by faculty											
CPRE 281		√									
EE 230		√			√						
CPRE 288			√								
CPRE 381					√						√
CPRE 310	√										
CPRE 394						√					

There might be cases in which one or more of the three levels of direct measures have identified a problem, but we are unable to pinpoint exactly what is at fault. In this case the assessment committee identifies additional courses and rubrics where assessment can be done as shown in Figure 3 above. Table 4 identifies which courses contribute to each outcome. The rows highlighted in yellow indicate the courses used in level 3 assessment.

Table 4: Mapping between required courses and outcomes

Student Outcomes / Courses	a	b	c	d	e	f	g	h	i	j	k
EE 201	√	√									√
EE 230	√	√			√		√				√
CPRE 185	√	√	√	√	√		√	√	√	√	√
CPRE 281		√	√		√						√
CPRE 288	√	√	√	√	√	√	√	√	√	√	√
Com S 227	√		√								√
Com S 228											√
CPRE 294						√	√		√	√	
CPRE 308			√								√
CPRE 310	√										
CPRE 381		√									
Com S 309				√	√		√				√
Com S 311	√										
CPRE 394						√	√		√	√	
CPRE 491	√	√	√	√	√	√	√	√	√	√	√
CPRE 492	√	√	√	√	√	√	√	√	√	√	√
CPRE 494							√	√	√	√	√
ENGL 150, 250, 314							√				
Math & Science	√										
Gen Ed								√	√		

1. Level 1 Workplace Competencies

Below is a copy of a paper that describes the workplace competencies used for level 1 assessment. Also provided is a copy of the Workplace Assessment Alumni Survey (PEO; also used as part of Level 1 assessment by Employers of SO's applied for student interns who register in internship courses)

Assessing and Developing Program Outcomes through Workplace Competencies*

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The College of Engineering at Iowa State University (ISU) partnered with constituents and assessment professionals to identify and validate 14 observable and measurable competencies necessary and sufficient to measure program outcomes. Constituents identified the engineering and experiential workplaces as settings most likely to develop and demonstrate the competencies, and the traditional classroom as least likely. Engineering students in the experiential workplace are assessed on the competencies by their supervisors, providing feedback for curricular change. These results confirm that we must re-examine how we use the classroom to educate engineers and our belief that experiential education is critical to students' success.

Keywords: assessment; ABET; competencies; workplace assessment; internships

INTRODUCTION

MANY ENGINEERING PROGRAMS are well on their way to adopting the outcomes-based ABET Criteria 3, now well know as the 'ABET (a–k) Outcomes' [1]. Eight of the eleven Outcomes address 'an ability to . . .'; two address 'understanding'; and only one addresses 'knowledge.' The direct measurement of 'an ability to . . .' presents challenges very different from those of measuring knowledge and understanding. George Peterson, ABET Executive Director, stated, '. . . evaluating their outcomes are sophisticated activities with which most engineering educators have had little or no experience' [2].

There is no universal approach to implementing and assessing the ABET outcomes-based criteria. Each program must interpret the criteria as they fit for them. A cursory examination of the literature reveals numerous different approaches to implementing ABET criteria [3–5].

Mentkowski et al. [6] state:

● Abilities are complex combinations of motivations, dispositions, attitudes, values, strategies, behaviors, self-perceptions and knowledge of concepts and of procedures.
● A complex ability cannot be observed directly, it must be inferred from performance.

At Iowa State University (ISU), we realized that we did not know how to directly assess 'an ability'. We hypothesized that each of the Outcomes are multi-dimensional and represent some collection of workplace competencies necessary for the practice of engineering at the professional level.

We define workplace competencies as the application of knowledge, skills, attitudes and values, and behaviors, as identified by Ewell [7], in the engineering workplace. They are 'the result of integrative learning experiences in which skills, abilities and knowledge interact' to impact the task at hand [8]. As such, competencies are directly measurable through actions or demonstrations of the existence of those competencies in the individual.

The 2005–2006 ABET Engineering Criteria [1] confirm our hypothesis by stating that the program outcomes 'relate to the skills, knowledge, and behaviors that student acquire in their matriculation through the program.'

A list of such competencies could be endless. Which are the most important for students to become successful engineers? Rogers [9] stated that '. . . faculty must determine what competencies that the student must demonstrate in order to know that they have achieved the outcome.' She also stated that 'key stakeholders need to be involved in determining which competencies should be the focus from all the possible competencies for any given outcome.' We could not agree more.

Employers of Iowa State University graduating engineers are relying on behavioral-based interviewing in the recruitment, screening and selection processes of new hires. They seek to assess whether a student has demonstrated a specific set of competencies, the definition of which is based on the analysis of the successful practice of engineering in specific engineering positions. These screening criteria often contain a minimum set of competencies, such as communication, teamwork and continuous learning.

In Spring 1999, the Iowa State University College of Engineering and Development Dimensions International, Inc. (DDI), a global provider of competency-based performance management

tools and services [10], collaborated to identify workplace competencies that were linked to Criterion 3 Outcomes and Assessment.

IDENTIFYING WORKPLACE COMPETENCIES

Our initial objective was to create a set of repeatable and reproducible measurements for the ABET (a–k) Outcomes that could be applied across the broad spectrum of the engineering experiential education workplace. This process was previously reported by Hanneman *et al.*, [11] and is summarized here.

Experiential education can be broadly defined as a philosophy and methodology in which educators purposefully engage with learners in direct experience and focused reflection in order to increase knowledge, develop skills, and clarify values [12]. In the College of Engineering at Iowa State University, we use a much narrower definition for engineering experiential education. For us, it is work experience in an engineering setting, outside of the academic classroom, and before graduation. Iowa State engineering students work in either a cooperative education program (alternating periods of full-time academic college training and full-time work experience of approximately equal length) or an internship (a single work period of institutional supervised full-time employment of a summer or at least one semester) [13]. Thus, the experiential workplace for us is where students are working when on an internship or participating in a cooperative education program. Typically, over 80% of graduates of our accredited engineering programs have participated in engineering experiential education before they graduate. An internship or cooperative education experience is not required at ISU in our engineering programs, but is strongly encourage by faculty and advisors.

It was desired that measurements of the ABET (a–k) Outcomes should be applicable across all ten of our accredited programs and across the two forms of experiential education offered by the college. Additionally, we wanted the measurements to be clearly and independently defined, readily observable, immediately measurable, consistent with the visions and missions of our college and university, and aligned with existing employer assessment, development and performance management practices. The competencies were to be uniquely ISU's.

Over two hundred constituents (stakeholders) were invited in 1999 to participate in a process to create and validate metrics for the experiential education workplace. These constituents included representation from these groups:

- employers (supervisors, managers, practicing engineers, recruiters, and human resource, education, training and development representatives);

- faculty, staff, and administrators; alumnae/i;
- students who participated in experiential education; parents;
- international faculty from partnering institutions.

Significant effort was made to ensure that each accredited program in the college received appropriate representation from each of the stakeholder groups and to ensure a broad, diverse representation from the employer community. The group ultimately consisted of 212 stakeholders.

The constituents participated in DDI-facilitated focus sessions, using a 'Critical Incident' data gathering technique, following the DACUM strategy [14]. In these sessions, constituents provided hundreds of examples of successful and unsuccessful demonstrations of the eleven ABET (a–k) Outcomes by engineering students and graduates. DDI professionals analyzed these 'critical incident' stories and extracted fourteen dimensions or workplace competencies necessary and sufficient for the successful demonstration of the eleven Outcomes:

Engineering Knowledge	General Knowledge	Continuous Learning
Quality Orientation	Initiative	Innovation
Cultural Adaptability	Analysis & Judgment	Planning
Communication	Teamwork	Integrity
Professional Impact	Customer Focus	

Note that these are 'ISU Competencies' that resulted from dialogue with *our* constituents. Other programs or institutions might develop a different set of competencies.

Based on their experience, DDI provided definitions for each competency. Each definition is clear, concise and independent of all others. Specific to each definition is a set of observable and measurable Key Actions that a student may take that demonstrates their development of that ISU Competency. A complete listing of the ISU Competencies and Key Actions can be found at http://learn.ae.iastate.edu/assessment/competency-definitions.pdf. An example of one ISU competency, Continuous Learning, is given in Table 1.

This process resulted in a mapping of the fourteen ISU Competencies to the ABET (a–k) Outcomes. The matrix of this mapping is given in Table 2. In each cell with a number, a competency is mapped to a specific Outcome. The numbers refer to constituent ranking of each competency–outcome combination (see the following section on Validation). There is no mapping of a competency to an Outcome where there were no supportive 'critical incident' stories, despite the temptation to assign such a relationship.

This matrix confirms our hypothesis that the outcomes are multi-dimensional and complex. For example, 'Initiative' is linked to each Outcome with 'an ability'. Outcome (c), 'an ability to design a system . . .', requires the greatest

Table 1. The Continuous Learning workplace competency

Definition	Actively identifying new areas for learning; regularly creating and taking advantage of learning opportunities; using newly gained knowledge and skill on the job, and learning through application.
Key Actions	1. Targets learning needs Seeks and uses feedback and other sources of information to identify appropriate areas for learning.
	2. Seeks learning activities Identifies and participates in appropriate learning activities (e.g., courses, reading, self-study, coaching, experiential learning) that help fulfill learning needs.
	3. Maximizes learning Actively participates in learning activities in a way that makes the most of the learning experience (e.g., takes notes, asks questions, critically analyzes information, keeps on-the-job application in mind, completes required tasks).
	4. Applies knowledge or skill Puts new knowledge, understanding, or skill to practical use on the job; furthers learning through trial and error.
	5. Takes risks in learning Puts oneself in unfamiliar or uncomfortable situation in order to learn; asks questions at the risk of appearing foolish; takes on challenging or unfamiliar assignments.
Representative Career Activities	• Participating in applied projects that require new knowledge
	• Designing and/or performing experiments that require new knowledge
	• Designing products that require engineers to learn new subject areas
	• Questioning ethical professional responsibility when undertaking sensitive tasks
	• Engaging in discussions on professional responsibility
	• Taking courses outside of the 'hard sciences' while in the workplace
	• Using feedback from 'customers' to learn new material that will improve a product
	• Reading non-assigned books to learn new topics
	• Attending conferences and seminars
	• Learning local, state, and federal laws to understand impact on engineering practices
	• Learning new software programs to design a product or solve a problem
	• Participating in experiential education opportunities
Off-Key Actions	• Lets others determine learning goals and needs
	• Allows barriers and obstacles to interfere with learning
	• Only targets low-priority or current needs
	• Ignores own preferences, strengths, or developmental needs
	• Doesn't practice, reinforce, or apply learning
Over Actions	• Sets unrealistic goals or overextends
	• Over-emphasizes future needs and excludes current needs
	• Is overly confident or independent

Table 2. Matrix of ABET (a k) Outcomes vs. ISU Competencies*

ABET Criterion 3 Outcomes	Engineering Knowledge	General Knowledge	Continuous Learning	Quality Orientation	Initiative	Innovation	Cultural Adaptability	Analysis & Judgment	Planning	Communication	Team-work	Integrity	Professional Impact	Customer Focus
(a) An ability to apply knowledge of mathematics, science, and engineering	4.8		3.8		3.5			4.3						
(b) An ability to design and conduct experiments, as well as to analyze and interpret data	4.4		3.6	4.3	3.7	4.0		4.5	4.1		3.4			3.4
(c) An ability to design a system, component, or process to meet desired needs	4.4		3.8	4.1	3.9	4.3	3.0	4.5	4.2	4.0	3.8			4.2
(d) An ability to function on multidisciplinary teams					4.0		4.3	3.6	3.8	4.7	4.9	4.3	3.9	3.7
(e) An ability to identify, formulate, and solve engineering problems	4.7		3.8	3.9	4.1	4.2		4.4		3.7	3.6			3.6
(f) An understanding of professional and ethical responsibility		3.8	3.6	3.3			3.7	3.5				4.7		
(g) An ability to communicate effectively		3.8			3.7					4.9			4.2	4.0
(h) The broad education necessary to understand the impact of engineering solutions in a global & societal context	3.4	3.9	3.9				4.1	3.5						
(i) A recognition of the need for, and ability to engage in, life-long learning			4.6		4.1									
(j) A knowledge of contemporary issues		3.7	3.8				3.8	3.1						
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	4.3		4.2	3.6	3.7		2.6	4.0						

* Numbers refer to the average rating by constituents of the importance of the competency to demonstrating the outcome (5 = essential; 4 = very important; 3 = important; 2 = useful, but not essential; and 1 = unnecessary.) No rating was made for any competency-outcome combination where there was no 'Critical Incident' story.

Table 3. Constituents' view of the probability (%) that students/graduates will have the opportunity to develop and demonstrate competencies in various settings.

Setting	ISU Competency														
	Engineering Knowledge	General Knowledge	Continuous Learning	Quality Orientation	Initiative	Innovation	Cultural Adaptability	Analysis & Judgment	Planning	Communication	Teamwork	Integrity	Professional Impact	Customer Focus	Average
Engineering Workplace	88	71	87	87	92	78	73	89	87	90	90	90	92	88	86
Co-op/Internship Workplace	73	62	76	76	82	63	63	76	69	80	76	80	83	66	73
Classroom Capstone Design	76	47	69	72	73	63	55	73	75	71	75	72	60	53	67
Extracurricular Activities (Engineering Profession Related)	47	54	67	45	70	52	59	59	55	69	68	68	66	50	59
Classroom (Laboratory)	71	32	60	67	57	43	46	59	63	55	61	65	41	30	54
Extracurricular Activities (Non-engineering profession related)	25	69	56	35	63	44	59	49	51	65	64	66	60	47	54
Classroom (Traditional)	64	40	62	51	51	35	43	51	56	50	42	59	41	27	48

number of ISU Competencies. The 'Continuous Learning' and 'Analysis and Judgment' competencies are the most highly leveraged (associated with the greatest number of Outcomes) to the successful demonstration of the Outcomes.

VALIDATING THE RELATIONSHIP BETWEEN WORKPLACE COMPETENCIES AND ABET OUTCOMES

To validate the ISU Competency Matrix, a survey was sent to each of the original constituents. In this survey, we first asked them to carefully read the competency definitions and Key Actions and then to rate how important each competency is to a student's or a graduate's successful demonstration of each of the ABET Outcomes to which that competency is linked. The rating was on a Likert scale (5 = essential; 4 = very important; 3 = important; 2 = useful, but not essential; and 1 = unnecessary.)

Of the 212 constituents mailed a survey, 67 responded, a 32% return rate. The respondents represented industry and faculty from each of the engineering disciplines in the college. Each accredited program within the college had a minimum of six respondents that identified with the degree. Thirty-six percent represented faculty, fifty-eight percent of whom are Iowa State alumni. Sixty-four percent of respondents represented industry; sixty-nine percent of whom are Iowa State alumni. The results of their ratings are given in Table 2.

All competencies received an average rating of 3 (important) or better, confirming that the associations between the competencies and the Outcomes were valid. The only exception was the rating of Cultural Adaptability in its relationship to Outcome (k): 'an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.' That relationship received an average rating of 2.6. After review by the Employer Advisory Board for the ISU Engineering Cooperative Education, Internship and Summer Programs, the decision was made to keep this association at least through the initial pilot applications and analysis.

Finally, we asked of the constituents the degree to which the 14 ISU Competencies collectively cover ABET Criterion 3 Program Outcomes (a–k) and the degree (from 0 to 100%) to which all of the ISU Competencies cover the practice of engineering at the professional level. Coincidentally, the response average to both questions was 89%, from which we conclude that the ISU Competencies are sufficient for measuring our program outcomes.

This process resulted in a set of constituent-created and -validated, competency-based, ABET-aligned assessment tools for the engineering experiential education workplace. These tools will serve as the foundation for assessing our program outcomes.

CONFIRMING THE IMPORTANCE OF EXPERIENTIAL EDUCATION

As part of the validation survey, we asked that, after considering the Key Actions, constituents offer their assessment of the probability that a student and/or graduate would have the opportunity to take those actions to develop and demonstrate that competency in various settings. The settings were: the full-time engineering workplace, the cooperative education/internship workplace (experiential education); the traditional classroom, the classroom laboratory, the classroom capstone design, extracurricular activities (engineering profession related), and extracurricular activities (non-engineering profession related). The results are given in Table 3. The result for the Communication Competency is illustrated in Fig. 1.
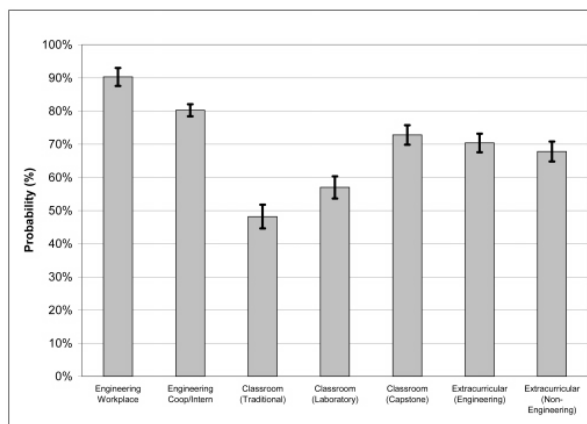
Fig. 1. Constituents' view of the probability (%) that students/graduates will have the opportunity to develop and demonstrate the Communication Competency in various settings.

For most of the competencies essential to the professional practice of engineering, the engineering workplace ranked the highest as the place best to develop and demonstrate the competencies, followed by internships. The classroom consistently ranked last. Engineering students spend a large portion of their academic experiences in the classroom, the least likely place for them to develop the skills, attitudes, values and behaviors necessary to be successful engineers, according to the constituents.

Competency assessment in experiential education

Engineering experiential education programs, such as cooperative education and internships, present the best place to directly observe and measure students developing and demonstrating competencies while engaged in the practice of engineering at the professional level. Measurements made by employers of student competencies present the best opportunity for feedback and curricular change with a cycle time that can address rapidly changing employer needs and expectations. Thus, engineering experiential education can and should be integral to the curricular continuous improvement process.

The ISU College of Engineering, through the office of Engineering Career Services, has implemented competency-based assessment tools for the engineering experiential education workplace, using Online Performance and Learning (OPAL[TM]) [15]. OPAL[TM] is DDI's web-based competency development and performance management software that provides assessment, development, coaching and learning tools. OPAL[TM] was customized to present the ISU Competencies, corresponding Key Actions, and assessment surveys. To receive academic credit for their work experience, each student is required to complete the standard self-assessment and to

ensure that their supervisor completes the same assessment of the student. This system has been in place since the fall of 2001. Over 90% of the ISU engineering students in the experiential workplace are evaluated by their supervisors.

A standard assessment survey consists of rating the student on the following question: 'When given the opportunity, how often does this individual perform the action?' The rating for each Key Action is on a Likert scale (1 = never or almost never; 2 = seldom; 3 = sometimes; 4 = often; 5 = always or almost always). A total of 61 Key Actions must be rated in the survey, which takes about 10 minutes to complete.

For each accredited engineering program in the College, the average value of each Key Action is computed from the student's self-assessment and separately from the supervisor's assessment. A ranking of the fourteen competencies (1 = highest mean score value, 14 = lowest mean score value) are made for students in each program. DDI recommends that individual departments look more carefully at patterns than a mean value. The overall results for the college [16] and one program [17] have been reported elsewhere.

The implementation of such an assessment system in a large practice-oriented engineering college presents an outstanding opportunity to collect very large volumes of competency-based assessment data and to study the correlation of these data to curricular processes and to the success of our graduates.

IMPLICATIONS FOR ENGINEERING EDUCATION PROGRAMS

There are number of important implications for engineering educators at Iowa State. Constituents

believe that the classroom is the least likely place to develop competencies necessary for the successful practice of engineering at the professional level. We must re-examine how we use the classroom in educating future engineers, broadening our focus to include competency development. Additionally, these results confirm our belief that experiential education is critical to students becoming successful in the engineering workplace. Finally, the engineering cooperative education and internship workplace provides a superb venue in which to assess student development and demonstration of the ISU Competencies and Criterion 3 Outcomes.

If competencies are the lens through which we view student learning outcomes, competencies must be integral to our engineering education programs. Competency-based learning involves redefining program, classroom, and experiential education objectives as competencies or skills, and focusing coursework on competency development. 'Competencies can have a stronger impact on student learning when they are linked and embedded within specific courses and across both general education and academic majors' [18]. Competencies are transparent; that is, all participants in the learning process can readily understand the learning goals. Competencies provide students with a clear map and the navigational tools needed to move expeditiously toward their goals [19].

At Iowa State University, some engineering programs are implementing competency-based learning and assessment. For example, the Department of Agricultural and Biosystems Engineering is implementing a competency-based education and assessment strategy [20], focused on student attainment of the Competencies, as demonstrated through portfolios and experiential education. They have identified the degree to which all engineering courses they offer address the 14 ISU competencies. The results of these assessments are being used to make curricular changes as part of their continuous improvement process.

CONCLUSIONS

Iowa State University's College of Engineering constituents helped us create and validate the use of workplace competencies to assess ABET Criterion 3 (a–k) Outcomes. Eight of the eleven Outcomes are directly stated as ability-based outcomes. Abilities are highly complex, multi-dimensional variables that cannot be measured directly and must be inferred from performance by direct observation. We re-defined the Outcomes as a collection of independent workplace competencies with measurable Key Actions.

Measuring the Outcomes as single variables can only provide information confirming that the demonstration of an Outcome is at a specified level, or whether the demonstration has improved or declined from a specified level. Measuring the Criterion 3 Outcomes with competencies provides specific information on what needs to be improved to enhance demonstration of specific Outcomes. This provides programs with specific, focused information on where and how to apply resources and, therefore, significantly enhances efficiency and efficacy of the curriculum continuous improvement process.

The experiential workplace (cooperative education and internships) provides a unique setting where the actions that define performance and competencies can be assessed while the student is actually engaged in the practice of engineering at the professional level.

The constituent-created ISU competencies provide the basis for an on-line measurement system that is well aligned with performance management and professional development systems in common practice in the engineering workplace. This system presents minimal burden to supervisors and mentors of engineering students and requires little education and training of the users.

The use of an on-line competency-based assessment system, such as OPAL^{TM}, provides large volumes of data to each program and to the college each semester, with little or no demand on faculty resources. A broad and representative sampling of student competency development is assured because of the high degree of student participation in experiential education and resulting supervisor assessment. Faculty can focus on data analysis, design and implementation of curricular changes, and analysis of the results of those changes.

Understanding the importance of developing workplace competencies in students provides an opportunity to re-invigorate and re-invent the engineering education process. Competencies provide students with a clear map and the navigational tools needed to become successful engineers and have a strong impact on student learning.

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1. SO's applied for student interns who register in internship courses)

Requestor Name	Date Received	Survey Name
Administrator, System	Wednesday, January 11, 2012	Engineering Alumnae ABET Survey 2011

Instructions
Use the scale below to rate how often you perform each action when given the opportunity.

When given the opportunity, how often does this person perform the action?
1 Never or almost never. This person hardly ever performs the action.
2 Seldom. This person often does not perform the action.
3 Sometimes. This person performs the action about half of the time.
4 Often. This person performs the action on most occasions.
5 Always or almost always. This person performs the action just about every time.
No Response: No opportunity to observe.

Analysis and Judgment (ISU Accreditation Aligned)
Identifying and understanding issues, problems, and opportunities; comparing data from different sources to draw conclusions; using effective approaches for choosing a course of action or developing appropriate solutions; taking action that is consistent with available facts, constraints, and probable consequences.

Identifies issues, problems, and opportunities
Recognizes issues, problems, or opportunities and determines whether action is needed.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Gathers information
Identifies the need for and collects information to better understand issues, problems, and opportunities.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Interprets information
Integrates information from a variety of sources; detects trends, associations, and cause-effect relationships.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Generates alternatives
Creates relevant options for addressing problems/opportunities and achieving desired outcomes.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Chooses appropriate action
Formulates clear decision criteria; evaluates options by considering implications and consequences; chooses an effective option.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Commits to action
Implements decisions or initiates action within a reasonable time.

◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Involves others
Includes others in the decision-making process as warranted to obtain good information, make the most appropriate decisions, and ensure buy-in and understanding of the resulting decisions.
◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Values diversity
Embraces and values diverse collection of inputs, values, perspectives, and thought paradigms in approaching the application of engineering to products and processes.
◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Communication (ISU Accreditation Aligned)
Clearly conveying information and ideas through a variety of media to individuals or groups in a manner that engages the audience and helps them understand and retain the message.

Organizes the communication
Clarifies purpose and importance; stresses major points; follows a logical sequence.
◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Maintains audience attention
Keeps the audience engaged through use of techniques such as analogies, illustrations, body language, and voice inflection.
◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Adjusts to the audience
Frames message in line with audience experience, background, and expectations; uses terms, examples, and analogies that are meaningful to the audience.
◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Ensures understanding
Seeks input from audience; checks understanding; presents message in different ways to enhance understanding.
◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Adheres to accepted conventions
Uses syntax, pace, volume, diction, and mechanics appropriate to the media being used.
◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Comprehends communication from others
Attends to messages from others; correctly interprets messages and responds appropriately.
◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Continuous Learning (ISU Accreditation Aligned)

Actively identifying new areas for learning; regularly creating and taking advantage of learning opportunities; using newly gained knowledge and skill on the job and learning through their application.

Targets learning needs
Seeks and uses feedback and other sources of information to identify appropriate areas for learning.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Seeks learning activities
Identifies and participates in appropriate learning activities (e.g., courses, reading, self-study, coaching, experiential learning) that help fulfill learning needs.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Maximizes learning
Actively participates in learning activities in a way that makes the most of the learning experience (e.g., takes notes, asks questions, critically analyzes information, keeps on-the-job application in mind, does required tasks).
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Applies knowledge or skill
Puts new knowledge, understanding, or skill to practical use on the job; furthers learning through trial and error.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Takes risks in learning
Puts self in unfamiliar or uncomfortable situation in order to learn; asks questions at the risk of appearing foolish; takes on challenging or unfamiliar assignments.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Cultural Adaptability (ISU Accreditation Aligned)
Being open to and making changes to accommodate the differences found in other cultures in order to interact effectively with individuals and groups from a different cultural background.

Demonstrate inclusive behavior
Establishes effective relationships with people of other cultures and backgrounds; shows genuine acceptance of people from backgrounds different from one's own.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Exhibits sensitivity
Exhibits sensitivity to and respect for the perspectives and interests of people of a different culture; attends to and tries to understand different perspectives and approaches.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Adapts behavior to other culture
Adjusts own approach to interactions, communications, and decision making to be

appropriate and effective within another culture without sacrificing own values.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Adapts products and processes to cultural concerns
Identifies, understands and incorporates cultural factors into the design of products and processes.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Customer Focus (ISU Accreditation Aligned)
Making customers and their needs a primary focus of one's actions; developing and sustaining productive customer relationships.

Seeks to understand customers
Actively seeks information to understand customers' circumstances, problems, expectations, and needs.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Educates customers
Shares information with customers to build their understanding of issues and capabilities.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Builds collaborative relationships
Builds rapport and cooperative relationships with customers.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Takes action to meet customer needs and concerns
Considers how actions or plans will affect customers; responds quickly to meet customer needs and resolve problems; avoids overcommitments.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Sets up customer feedback systems
Implements effective ways to monitor and evaluate customer concerns, issues, and satisfaction and to anticipate customer needs.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Engineering Knowledge (ISU Accreditation Aligned)
Having achieved a satisfactory level of knowledge in the relevant specialty areas of mathematics, science and engineering.

Knowledge of mathematics
Demonstrates a knowledge of the mathematical principles required to practice engineering in one's specialty area.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Knowledge of science

appropriate and effective within another culture without sacrificing own values.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Adapts products and processes to cultural concerns
Identifies, understands and incorporates cultural factors into the design of products and processes.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Customer Focus (ISU Accreditation Aligned)
Making customers and their needs a primary focus of one's actions; developing and sustaining productive customer relationships.

Seeks to understand customers
Actively seeks information to understand customers' circumstances, problems, expectations, and needs.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

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Implements effective ways to monitor and evaluate customer concerns, issues, and satisfaction and to anticipate customer needs.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Engineering Knowledge (ISU Accreditation Aligned)
Having achieved a satisfactory level of knowledge in the relevant specialty areas of mathematics, science and engineering.

Knowledge of mathematics
Demonstrates a knowledge of the mathematical principles required to practice engineering in one's specialty area.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Knowledge of science

Goes above and beyond
Takes action that goes beyond job requirements in order to achieve objectives.

◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Innovation (ISU Accreditation Aligned)
Generating innovative solutions in work situations; trying different and novel ways to deal with work problems and opportunities.

Challenges paradigms
Identifies implicit assumptions in the way problems or situations are defined or presented; sees alternative ways to view or define problems; is not constrained by the thoughts or approaches of others.

◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Leverages diverse resources
Draws upon multiple and diverse sources (individuals, disciplines, bodies of knowledge) for ideas and inspiration.

◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Thinks expansively
Combines ideas in unique ways or makes connections between disparate ideas; explores different lines of thought; views situations from multiple perspectives; brainstorms multiple approaches/solutions.

◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Evaluates multiple solutions
Examines numerous potential solutions and evaluates each before accepting any.

◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Ensures relevance
Targets important areas for innovation and develops solutions that address meaningful work issues.

◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Integrity (ISU Accreditation Aligned)
Maintaining social, ethical, and organizational norms; firmly adhering to codes of conduct and professional ethical principles.

Demonstrates honesty
Deals with people in an honest and forthright manner; represents information and data accurately and completely.

◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Keeps commitments
Performs actions as promised; does not share confidential information.

◯ 1   ◯ 2   ◯ 3   ◯ 4   ◯ 5   ◯ No Response

Behaves consistently
Ensures that words and actions are consistent; behaves consistently across situations. (
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Planning (ISU Accreditation Aligned)
Effectively managing one's time and resources to ensure that work is completed efficiently.

Prioritizes
Identifies more critical and less critical activities and tasks; adjusts priorities when appropriate.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Makes preparations
Ensures that required equipment and/or materials are in appropriate locations so that own and others' work can be done effectively.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Schedules
Effectively allocates own time to complete work; coordinates own and others' schedules to avoid conflicts.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Leverages resources
Takes advantage of available resources (individuals, processes, departments, and tools) to complete work efficiently.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Stays focused
Uses time effectively and prevents irrelevant issues or distractions from interfering with work completion.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Professional Impact (ISU Accreditation Aligned)
Creating a good first impression; commanding attention and respect; showing an air of confidence.

Dresses appropriately
Maintains professional, businesslike image.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Displays professional demeanor
Exhibits a calm appearance; does not appear nervous or overly anxious; responds openly and warmly when appropriate.
○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Speaks confidently
Speaks with a self-assured tone of voice.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Quality Orientation (ISU Accreditation Aligned)
Accomplishing tasks by considering all areas involved, no matter how small; showing concern for all aspects of the job; accurately checking processes and tasks; being watchful over a period of time.

Follows procedures
Accurately and carefully follows established procedures for completing work tasks.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Ensures high-quality output
Vigilantly watches over job processes, tasks, and work products to ensure freedom from errors, omissions, or defects.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Takes action
Initiates action to correct quality problems or notifies others of quality issues as appropriate.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Safety Awareness
Identifying and correcting conditions that affect employee safety; upholding safety standards.

Identifies safety issues and problems
Detects hazardous working conditions and safety problems; checks equipment and/or work area regularly.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Takes corrective action
Reports or corrects unsafe working conditions; makes recommendations and/or improves safety and security procedures; enforces safety regulations and procedures.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Monitors the corrective action
Monitors safety or security issues after taking corrective action and ensures continued compliance.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Teamwork (ISU Accreditation Aligned)
Actively participating as a member of a team to move the team toward the completion of goals.

Facilitates goal accomplishment
Makes procedural or process suggestions for achieving team goals or performing team functions; provides necessary resources or helps to remove obstacles to help the team accomplish its goals.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Involves others on team
Listens to and fully involves others in team decisions and actions; values and uses individual differences and talents.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Informs others on team
Shares important or relevant information with the team.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Models commitment
Adheres to the team's expectations and guidelines; fulfills team responsibilities; demonstrates personal commitment to the team.

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ No Response

Tip: To keep a copy of your responses, print them using the Print command in your browser's File menu. After sending your responses, you cannot retrieve them online.

[Cancel]   [Send]

2. Level 2 Assessment tools

Senior Design Rubrics

A subset of the Senior Design Committee serves as an assessment subcommittee to review student work from CPRE 491/492 (senior design courses). Subcommittee members review various design project documentation, including the final project report, presentation, poster, website, project plan and design document. Rubrics have been defined to assess SOs *a, c, d, e, f, g, k*. Each rubric consists of performance indicators for different attributes that satisfy the attainment of the student outcome. For each of the performance indicators, four levels of attainment are defined: (1) Unsatisfactory, (2) Developing, (3) Satisfactory, and (4) Exemplary. The description of each of these levels for each of the performance indicators is defined by the Senior Design Committee in consultation with the Assessment Committee.   The rubrics used are provided below:

Student outcome a: an ability to apply knowledge of mathematics, science, and engineering				
Performance Indicators	(1 pt) Unsatisfactory	(2 pts) Developing	(3 pts) Competent	(4 pts) Exceptional
Ability to apply knowledge of mathematics (e.g., statistics, probability, discrete mathematics)	Inability solve and identify relevant mathematical problems	Ability to solve but not able to identify the relevant mathematical problems	Ability to identify and solve the relevant mathematical problems	Ability to identify and solve relevant mathematical problems, and to explore formulations and solutions using alternate approaches.
Ability to apply knowledge of science (e.g., mechanics, semiconductor physics, electromagnetic, biology)	Inability solve and identify relevant scientific problems	Ability to solve but not able to identify the relevant scientific problems	Ability to identify and solve the relevant scientific problems	Ability to identify and solve relevant scientific problems, and to explore formulations and solutions using alternate approaches
Ability to apply knowledge of engineering (e.g., electronics, control systems, power systems, VLSI, communications and networks, software systems, computer architecture, embedded systems)	Inability solve and identify relevant engineering problems	Ability to solve but not able to identify the relevant engineering problems	Ability to identify and solve the relevant engineering problems	Ability to identify and solve relevant engineering problems, and to explore formulations and solutions using alternate approaches

Student outcome c: An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental , social, political, ethical, health and safety, manufacturability, and sustainability				
Performance Indicators	(1 pt) Unsatisfactory	(2 pts) Developing	(3 pts) Competent	(4 pts) Exceptional
Develops a design strategy based on project and client needs and constraints.	Lacks design strategy. Does not recognize client needs and constraints	Has some design strategy; Haphazard approach. Cannot design processes or individual pieces of equipment without significant amounts of help	Develops a design strategy. Comes up with a reasonable solution.	Develops a design strategy, including project plan and requirements. Suggests new approaches and improves on what has been done before
Thinks holistically: sees the whole as well as the parts	Has no knowledge of the design process. No holistic thinking	Has some knowledge of the design process. Has no concept of the process as a sum of its parts	Understands the design process. Makes an attempt to think holistically.	Articulates the design process and how areas interrelate. Thinks holistically: Sees the whole as well as the parts
Supports design procedure with documentation and references	No documentation	Design is done incompletely without the proper justification. Lacks documentation	Provides reasonable design procedure with documentation and references	Clearly lays out the design procedure with supporting analysis. Document relevant information. Provides market/literature survey
Considers all the relevant technical, nontechnical constraints and design tradeoffs.	Missing all relevant constraints	Considered technical constraints. Nontechnical constraints and design tradeoffs are missing.	Design strategy includes relevant technical constraints and design tradeoffs. Some relevant nontechnical constraints are missing.	Design strategy includes all the relevant technical and non technical constraints. Clearly shows the design tradeoffs

Student outcome d: An ability to function on multidisciplinary teams				
Performance Indicators	(1 pt) Unsatisfactory	(2 pts) Developing	(3 pts) Competent	(4 pts) Exceptional
Team Participation	Is absent from team meetings or work sessions >50% of the time. Does not contribute to group work at all or submits own work as the group's. Routinely fails to prepare for meetings.	Absent occasionally, but does not inconvenience group. Sometimes depends on others to complete the work; contributes less than fair share. Prepares somewhat for group meetings, but ideas are not clearly formulated	Routinely present at team meetings or work sessions. Is prepared for group meeting with some ideas.	Routinely present at team meetings or work sessions. Contributes a fair share to the project workload. Is prepared for the group meeting with clearly formulated ideas
Fullfill Team Roles Assigned	Does not perform any duties of assigned team role	Inconsistently performs duties that are assigned	Performs duties that are assigned	Performs all duties assigned and effectively assist others
Involves Others	Does work on his/her own; does not value team work. Does not consider the ideas of others	Sometimes keeps information to himself/herself; not very willing to share.	Most of the time listens and involves others in the team decisions and actions. Values individual differences and talents	Listens to and fully involves others in team decisions and actions; values and uses individual differences and talents. Shares credit for success with others.
Facilitates goal accomplishment	Does not contribute to team goals. Does not make an attempt to accomplish the team goals.	Sometimes depends on others to define team goals. Makes an attempt to finish the set goals.	Contribute to establishing team goals. Has plan to accomplish the set goals	Clearly establishes team goals. Provides necessary resources or helps to remove obstacles to help the team accomplish its goals.

Student outcome e: An ability to identify, formulate, and solve engineering problems				
Performance Indicators	(1 pt) Unsatisfactory	(2 pts) Developing	(3 pts) Competent	(4 pts) Exceptional
Ability to identify key points of the project. Ability to formulate an approach to solve.	Does not understand the problem. Cannot solve the problem	Understands the problem. Difficulty in coming up with an approach to solve the problem.	Understands the problem to be solved. Formulated an approach to solve the problem.	Problem to be solved is clearly stated and explained. Formulated the approach in such a way that various solutions strategies can be investigated.
Ability to analyze and solve	A solution is proposed without analysis and justification	A workable solution is proposed. Lacks analysis	Alternative approaches are considered. Analysis is complete but contains minor procedural errors.	Alternative approaches are considered. Each alternative approach is correctly analyzed for technical feasibility. Best possible solution is proposed
Prototyping , testing, evaluation and validation	Prototype is not developed. No validation.	Working/model prototype is build and demonstrated with performance issues. Prototype validation shows that some (important) design requirements are met, but some are missed.	Model prototype is presented demonstrating basic design principles. Prototype validation proves that most design requirements are met.	Working prototype is build and demonstrated. Validation proves that all design requirements are met

Student outcome f: an understanding of professional and ethical responsibility				
Performance Indicators	(1 pt) Unsatisfactory	(2 pts) Developing	(3 pts) Competent	(4 pts) Exceptional
Overall understanding	Lacks basic understanding	Some level of understanding of a subset of questions	Good understanding of all questions	Addresses questions with reasonable effort; indicates having read and engaged with assigned codes of ethics; indicates team discussion
Demonstrated strength of an area of responsibility	Little or no explanation of any elements related to the area, little or no use of elements, no impacts cited	Moderate grasp of responsibility, some relevant detail, not very purposeful or direct, some good impacts	Sound grasp of responsibility, details/examples relevant to the responsibility, responsibility applied purposefully, clear positive impacts	Impressive grasp of responsibility, insightful details/examples, strategic use of area in project, substantial documented impacts
Identified weakness of an area of responsibility	Vague description of opportunity; does not see benefits; no reference to codes; no plan or unclear; unreasonable to implement	Okay description of opportunity; vague benefits; some reference to codes; reasonable plan; may be possible to implement	Good explanation of opportunity; good definition of benefits and reference to codes; clear, strong plan; reasonable to implement	Superb explanation of opportunity; insightful on benefits and relevant codes; impressive plan; likely embraced by all and implemented

Student outcome g: An ability to Communicate Effectively				
Performance Indicators	(1 pt) Unsatisfactory	(2 pts) Developing	(3 pts) Competent	(4 pts) Exceptional
ORAL COMMUNICATION: Organization	Poor organization. No introduction. Summary and conclusions are not clear	Audience has difficulty following presentation because of some abrupt jumps; some of the main points and conclusion are unclear.	Satisfactory organization; clear introduction; main points are well stated, even if some transitions are somewhat sudden; clear conclusion.	Superb organization; clear introduction; main points well stated and argued, with each leading to the next point of the talk; clear summary and conclusion.
ORAL COMMUNICATION: Content	Boring slides; numerous mistakes; Main points are missing	No real effort made into creating a truly effective presentation; poor participation of team members.	Generally good set of slides; conveys the main points well. Adequate participation of team members.	Very creative slides; carefully thought out to bring out both the main points as well as the subtle issues while keeping the audience interested.
ORAL COMMUNICATION: Delivery	Delivery lacks confidence. Reads slides. No eye contact with audience	Low voice, occasionally inaudible; some distracting filler words and gestures; pronunciation not always clear.	Clear voice, generally effective delivery; minimal distracting gestures, but somewhat monotone.	Natural, confident delivery that does not just convey the message but enhances it; excellent use of volume and pace.
WRITTEN COMMUNICATION: Style	Spelling or grammar errors present throughout more than 2/3 of paper. style is inappropriate for audience; prescribed format is not followed	Text rambles, key points are not organized; spelling or grammar errors present throughout more than 1/3 of paper prescribed format is followed.	Articulates ideas; one or two grammar or spelling errors per page; prescribed format is followed.	Articulates ideas clearly and concisely; presented neatly and professionally; grammar and spelling are correct; uses good professional style; and conforms to prescribed format.
WRITTEN COMMUNICATION: Organization	Little evidence of organization or any sense of wholeness & completeness. Use poor transitions or fails to provide transitions.	Material generally well organized, but paragraphs combine multiple thoughts or section / subsections are not identified clearly.	Organizes material in a logical sequence to enhance reader's comprehension (paragraph structure, subheadings, etc.) with few lapses.	Organizes material in a logical sequence to enhance reader's comprehension (paragraph structure, subheadings, etc.). Provide transitions that eloquently serve to connect ideas.

WRITTEN COMMUNICATION: Use of graphs and tables	Figures presented are flawed: axes mislabeled, no data points, etc.	Uses graphs, tables, diagrams, but only in a few instances are they used to support, explain, or interpret information.	Most of the instances, Uses graphs, tables, diagrams to support points; to explain, interpret, and assess information; figures are all in proper format.	Throughout the report, Uses graphs, tables, diagrams to support points; to explain, interpret, and assess information; figures are all in proper format.

Student outcome k: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice				
Performance Indicators	(1 pt) Unsatisfactory	(2 pts) Developing	(3 pts) Competent	(4 pts) Exceptional
Techniques and skills (such as modeling, simulation, experimentation, measurement, and data analysis)	Lack technical skills to complete the project.	Has some knowledge but not adequate to complete the project	Has adequate knowledge to complete the project	Is capable of applying knowledge to derive an innovative and efficient design for the project
Selection and application of modern engineering tools and standards (such as Oscilloscope, Matlab, LabView, PSpice, and IEEE standards)	Not familiar with the tools and standards and is unable to select the right ones for the project.	Familiar with a few tools and standards but requires assistance in selecting and using them appropriately for the project	Is able to select and use tools and standards that may fit the project, with occasional guidance	Independent ability to choose and use tools and standards that are best for the project
Ability to acquire new knowledge and expertise	Is unable to learn new tools and skills	Is unable to learn new tools and skills unless with assistance	Given enough time, is able to learn new tools and skills	Is able to learn new tools and skills quickly and independently

Student Outcomes Assessment Using Student Portfolios
The portfolio is viewed as a purposeful collection of a student's work. All Electrical and Computer Engineering students submit a portfolio of student work in CPRE/EE 494 (Portfolio Assessment). Portfolios are introduced in CPRE/EE 166 (Professional Program Orientation), development begins in CPRE/EE 294 (Program Discovery), and is continued in CPRE/EE 394 (Program Exploration). A portfolio is a purposeful collection of student work that represents student interests, knowledge, skills and abilities. Portfolios are a means to document and communicate student work for faculty review and student outcomes assessment. The process of creating a portfolio also gives students the opportunity to reflect on their academic program. The portfolio is submitted electronically, typically as a link to a web site designed by the student.

The required elements of a portfolio are given in the course packet and included in an appendix. The main elements used for assessment are:
1. Career objective and resume
    2. General Education component and reflection
    3. Examples of prior work
    4. Technical work experience
    5. Senior design project
    6. Cumulative reflection

The general education reflection and cumulative reflection elements include specific questions to gather information relevant to particular student outcomes.

Portfolios are collected every semester and evaluated by the course instructor(s). A faculty group was formed to design and test rubrics to assess student outcomes (h), (i), (j), and (k) using portfolios.

Student outcome (h): the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context				
Performance Indicators	**Proficiency/Performance Scale**			
	1: Beginning	**2: Developing**	**3: Accomplished**	**4: Exemplary**
(h.A) Has the student been exposed to a sufficient variety of courses/situations that involve societal, global, economic and environmental aspects?	Almost no exposure to courses/situations involving societal, global, economic, or environmental contexts	Exposure to courses/situations related to only one aspect of societal, global, economic and environmental contexts	Exposure to situations/courses related to more than one aspect of societal, global, economic and environmental contexts	Balanced exposure to situations/courses related to all contexts - societal, economic, global and environmental
(h.B) Has the student discussed the influence of societal, global, and environmental issues in engineering problem formulation and solution?	The student does not discuss the impact of societal, global, and environmental issues in engineering problem formulation and solution.	The student realizes the impact of societal, global, and environmental issues in engineering problem formulation and solution.	The student discusses the impact of societal, global, and environmental issues in engineering problem formulation and solution, and gives a specific example.	The student discusses the impact of societal, global, and environmental issues in engineering problem formulation and solution, and gives multiple specific examples.

Student outcome(i): a recognition of the need for, and an ability to engage in life-long learning				
Performance Indicators	**Proficiency/Performance Scale**			
	1: Beginning	**2: Developing**	**3: Accomplished**	**4: Exemplary**
(i.A) **Description / discussion of use of external sources of information to complete class projects and other problem-solving tasks**	Cannot use materials outside of what is explained in class. Assumes that all learning takes place within the confines of the classroom.	Seldom brings information from outside sources to assignments. Completes only what is required.	Multiple examples of use of external sources of information, including library resources, professional journals, experts in field, and other students.	Demonstrates ability to learn independently – goes beyond what is required in completing an assignment.
(i.B) **Awareness of learning activities outside of the classroom, including participation in professional and technical societies, learning communities, industry experiences, etc.**	Shows little or no interest in outside learning resources, including professional and/or technical societies, learning communities, internships, etc.	Co-curricular and/or extra-curricular learning experience. Occasionally participates in the activities of local learning opportunities.	Multiple co-curricular and/or extra-curricular learning experiences. Active participation in local learning activities.	Participates and takes a leadership role in learning opportunities available to the student body.
(i.C) **Acknowledgement of how the college experience contributes to understanding the need to continuously update professional skills to solve new problems**	Has difficulty in recognizing own shortcomings.	Acknowledges the need to take responsibility for own learning.	Demonstrates connection between short/long term goals and life-long learning.	Demonstrates responsibility for creating one's own learning opportunities.

Student outcome (j) : a knowledge of contemporary issues				
Performance Indicators	**Proficiency/Performance Scale**			
	1: Beginning	**2: Developing**	**3: Accomplished**	**4: Exemplary**
(j.A) **Knowledge of current trends, complex problems, and career opportunities in your field of study**	Has difficulty identifying current topics related to problems and opportunities in the field of study.	Identifies and possibly describes at least one or two topics of interest related to the field.	Identifies and describes multiple current topics relevant to the student's major field of study.	Identifies and describes multiple current topics relevant to the student's major field of study; interprets and analyzes key topics of special importance.
(j.B1) **Awareness of contemporary issues facing society and various perspectives, such as engineering, economic, political, environmental, legal, professional, ethical, global, and/or cultural**	Has difficulty identifying an issue involving non-engineering and engineering factors.	Identifies and possibly describes a contemporary issue from at least one non-engineering perspective.	Identifies and describes a contemporary issue from multiple perspectives.	Identifies and describes a contemporary issue from multiple perspectives; explains relationships of various aspects.
(j.B2) **Inclusion of issues and various perspectives in problem-solving activities**	Has difficulty identifying an issue involving non-engineering and engineering factors.	Recognizes at least one non-engineering factor in an engineering problem.	Incorporates several perspectives in an engineering problem-solving activity.	Uses an interdisciplinary or systems thinking approach to problem solving.
(j.C) **Knowledge of engineering relevance to regional, national, or global problems**	Has difficulty describing a major problem or associating engineering with it.	Identifies one or more engineering aspects of a technical problem.	Describes and recognizes engineering knowledge or practice in relation to a major problem.	Discusses, interprets, and analyzes key engineering knowledge and practices as applied to a major problem.

Student outcome (k): an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice				
Performance Indicators	**Proficiency/Performance Scale**			
	1: Beginning	**2: Developing**	**3: Accomplished**	**4: Exemplary**
Description/discussion of the use of state-of-the-art equipment for engineering system design, control, and analysis	Gives 1 or more discussions that reference the use of standard equipment for engineering system design, control, or analysis	Gives 1 or more discussions that reference the use of standard equipment for engineering system design, control, or analysis; at least 1 concrete piece of evidence that supports the discussion of the equipment/tools used (e.g. project presentation showing data collected and analyzed)	Gives 2 or more discussions that reference the use of standard equipment for engineering system design, control, or analysis; at least 2 concrete pieces of evidence that support the discussion of the equipment/tools used (e.g. project presentation showing data collected and analyzed)	Gives 3 or more discussions that reference the use of standard equipment for engineering system design, control, or analysis; 3 or more concrete pieces of evidence that support the discussion of the equipment/tools used (e.g. project presentation showing data collected and analyzed)
(k.B) **Application of modern engineering analysis and design techniques to solve engineering problems**	Little or no discussion related to the importance of design techniques or analysis approaches	1 or more instances where a discussion demonstrates that a student is aware of the importance of specific design techniques or analysis approaches; 1 or more concrete examples that support the discussions about applying design techniques and engineering analysis (e.g. project presentation that gives some details on the technique or analysis approach taken)	2 or more instances where a discussion demonstrates that a student is aware of the importance of specific design techniques or analysis approaches; 2 or more concrete examples that support the discussions about applying design techniques and engineering analysis (e.g. project presentation that gives some details on the technique or analysis approach taken)	3 or more instances where a discussion demonstrates that a student is aware of the importance of specific design techniques or analysis approaches; 3 or more concrete examples that support the discussions about applying design techniques and engineering analysis (e.g. project presentation that gives some details on the technique or analysis approach taken)

3. Level 3 Coursework Assessment tools
Coursework Assessment Using Rubrics

The course-based assessment of Student Outcomes uses rubrics, which are developed by the Assessment Committee, in collaboration with instructors who usually teach courses in which the attainment of student outcomes are measured. To assess a certain Student Outcome, each rubric is based on identifying a number of performance indicators of different attributes that are necessary to satisfy the attainment of the Student Outcome. For each of the performance indicators, four levels of attainment are defined: (1) Unsatisfactory, (2) Developing, (3) Satisfactory, and (4) Exemplary. The definition of each of these levels for each of the performance indicators is defined by the Assessment Committee and the involved instructors.

Direct Assessment tool	Student Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
Level 3: Common Course based											
CPRE 281		√									
EE 230		√			√						
CPRE 288			√								
Level 3: Computer Engineering specific											
CPRE 381					√						√
CPRE 310	√										
CPRE 394						√					
Level 3: Electrical Engineering specific											
EE 224											√
EE 330 or EE 332	√										
EE 394						√					

CPRE 281 : Outcome b

Student outcome B: an ability to design and conduct experiments, as well as to analyze and interpret data				
Performance Indicators	(1 pt) Unsatisfactory	(2 pts) Developing	(3 pts) Satisfactory	(4 pts) Exemplary
Design Experiment	No plan for data collection; does not properly identify equipment needed for experiments	Experimental plan is incomplete, and partially correct; able to identify some equipment needed for experiments, but unable to identify their proper use	Experimental plan is correct but incomplete; needs some assistance in identifying equipment needed for experiments and their use	Experimental plan is correct and complete; does not need assistance in identifying equipment and their use in experiments
Conduct Experiment	Does not follow experimental procedure; does not know how to operate equipment and instruments properly; poor documentation of data; requires frequent supervision	Experimental procedure is partly followed; makes many mistakes in operating equipment; documentation is partly complete; requires some supervision	Experimental procedure is mostly followed; requires some guidance in operating equipment; documentation is mostly complete; requires little supervision	All experimental procedure are followed; does not require guidance or assistance in operating equipment; documentation is complete; does not require supervision
Analyze Data	Data collection is disorganized and incomplete; no identification of measurement errors	Data collection is partly complete and organized; identifies some measurement errors, but cannot analyze	Data collection is mostly complete and organized; identifies measurement errors but are not taken in analysis	Data collection is complete and well organized; measurement errors are identified and used in analysis
Interpret Data	Does not relate experimental data to theory; incorrect conclusions	Makes some relation of experimental data to theory; conclusions are partly correct	Mostly successful in relating experimental data to theory; conclusions are mostly correct and mostly complete	Experimental data is related to theory; conclusions are correct and complete

EE 230: Outcomes b, e

Student outcome b: An ability to design and conduct experiments, as well as to analyze and interpret data

Performance Indicators	Unsatisfactory (1)	Developing (2)	Satisfactory (3)	Exemplary (4)
Design experiments	No systematic plan, it would not allow experimenters to achieve any goals	It would allow experimenters to achieve some goals	The procedure would allow experimenter to achieve most goals	Well-designed experimental procedure would allow experimenter to achieve all goals
Conduct experiments	No ability Did not collect meaningful data	Some ability to conduct experiments and collected some meaningful data	Adequate ability, with some help Collected most of the needed data	Superior ability Collected all the appropriate data
Analyze data	No insight Missed the point of the experiment	Little insight Analyzed only the most basic points	Adequate insight Most data are analyzed correctly	Excellent insight Analyze data completely and apply the error analysis
Interpret data	Little or no attempt to interpret data	Interpreted some data correctly	Interpret most data correctly	Data completely and appropriately interpreted, not over-interpreted

EE 230: Outcomes b, e

Student outcome e: An ability to identify, formulate, and solve engineering problems

Performance Indicators	Unsatisfactory (1)	Developing (2)	Satisfactory (3)	Exemplary (4)
Ability to identify key points of the project and to formulate an approach to solve	Does not understand the problem. Cannot solve the problem	Understands the problem. Has difficulty in coming up with an approach to solve the problem	Understands the problem to be solved. Formulates an approach to solve the problem	Problem to be solved is clearly stated and explained. Formulates the approach in such a way that various solutions strategies can be investigated
Ability to analyze and solve	A solution is proposed without analysis and justification	A workable solution is proposed. Lacks analysis	Alternative approaches are considered. Analysis is complete but contains minor procedural errors	Each alternative approach is correctly analyzed for technical feasibility. Best possible solution is proposed
Prototyping, testing, evaluation and validation	Prototype is not developed. No validation	Working/model prototype is built and demonstrated with performance issues. Prototype validation shows that some (important) design requirements are met, but some are missed	Model prototype is presented demonstrating basic design principles. Prototype validation proves that most design requirements are met	Working prototype is built and demonstrated. Validation proves that all design requirements are met

CPRE 288: Outcome c

Student outcome c: An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental , social, political, ethical, health and safety, manufacturability, and sustainability				
Performance Indicators	(1 pt) Unsatisfactory	(2 pts) Developing	(3 pts) Competent	(4 pts) Exceptional
Makes design decisions.	Lacks design strategy. Does not recognize client needs and constraints	Has some design strategy; Haphazard approach. Cannot design processes without significant amounts of help.	Develops a design strategy. Comes up with a reasonable solution.	Develops a design strategy, including project plan and requirements. Suggests new approaches.
Sees how the part one is working on fits into the whole project.	Has no knowledge of the design process. No holistic thinking	Has some knowledge of the design process. Has no concept of the process as a sum of its parts	Understands the design process. Makes an attempt to think holistically.	Articulates the design process and how areas interrelate.
Documents work within reason. Helps with lab notebook and documents code.	No documentation	Design is done incompletely without the proper justification. Lacks documentation	Provides reasonable design procedure with documentation and references	Clearly lays out the design procedure with supporting analysis. Document relevant information.

CPRE 381: Outcomes e and k

Student outcome e: an ability to identify, formulate, and solve engineering problems				
Performance Indicator	1: Beginning - Unsatisfactory - Low level	2: Developing – Partly satisfactory – Medium level	3: Accomplished – Satisfactory – Medium-high level	4: Exemplary – Beyond satisfactory – High level
Ability to identify scope of implementation. Ability to enumerate implementation permutations and potential challenges.	Confusion with regards to the scope of the implementation Lack of understanding with regards to big picture challenges.	Understanding of problem scope. Limited understanding with regards to permutations and potential challenges.	Able to use appropriate discrete structures, and Identification of problem scope, with correct enumeration of implementation permutations and potential challenges. algorithms in solution.	Problem identification indicates superior understanding of implementation permutations and potential challenges.
Ability to create schematics and implement individual components.	Significant flaws in individual components. Lack of evidence of pre-implementation conceptual work, including schematics.	Individual components are in place, with minor problems leading to issues in full-system implementation. Schematics lack important detail.	Individual components are well-designed and correctly implemented.	Components are optimized beyond the requirements of the project. Superior full-system perspective enables insights regarding individual components
System integration, testing, and verification. Demonstration of correctness and ability to describe implementation.	Inability to correctly integrate system. No or severely limited full-system testing.	System is integrated with non-trivial flaws. Testing catches flaws without additional insight.	System passes major functional tests.	Additional infrastructure is provided to enable advanced testing and evaluation.

CPRE 381: Outcomes e and k

Student outcome k: an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice				
Performance Indicator	1: Beginning - Unsatisfactory - Low level	2: Developing – Partly satisfactory – Medium level	3: Accomplished – Satisfactory – Medium-high level	4: Exemplary – Beyond satisfactory – High level
Ability to design hardware using a Hardware Description Language (HDL)	Lack of HDL skills to accomplish any significant goals of the project.	Basic HDL capabilities. Can complete some individual modules, but has not gained enough expertise to complete project.	Adequate HDL skills to complete the project.	Superior HDL skills, leading to some design optimization in terms of efficiency or performance.
Application of an industry-strength HDL simulator (e.g. ModelSim) for design testing and verification	Lack of simulator familiarity, leading to lack of progress.	Familiarity with basic simulator functionality, hindering overall progress.	Ability to provide strong evidence that the design is fully tested in simulation	Use of automation to increase designer efficiency with regards to testing and verification.
Ability to develop and analyze programs at the assembly-level	Lack of assembly-level programming ability.	Can write small benchmarks and individual test-cases, but struggles with more complex applications.	Demonstrates ability to write complex applications.	Mastery of assembly-level programming allows for more in-depth component and full-system testing.

CPRE 310: Outcome a

Student outcome a: an ability to apply knowledge of mathematics, science, and engineering				
Performance Indicator	1: Beginning - Unsatisfactory - Low level	2: Developing – Partly satisfactory – Medium level	3: Accomplished – Satisfactory – Medium-high level	4: Exemplary – Beyond satisfactory – High level
Does the student use graphs effectively to represent the data and solve the problem of social network aggregation?	Unable to abstract out the discrete structures in the problem.	Able to use appropriate discrete structures, but uses inefficient algorithms in solution.	Able to use appropriate discrete structures, and effective algorithms in solution.	Able to use effective structures and algorithms and can point to alternate solutions, and compare their effectiveness.
Does the student design a precise and appropriate metric for measuring the "centrality" of a person in the network?	The student does not have a metric for defining centrality in a network.	The student has a metric which maybe ambiguous in some cases.	The student has a precise metric, but has not taken into account the cost of computing the metric while defining this.	The student has defined a metric keeping in mind the cost of computing the metric on a network.

EE/CprE 394: Outcome f

Student outcome f: An understanding of professional and ethical responsibility				
Performance Indicators	**Proficiency/Performance Scale**			
	1: Beginning	**2: Developing**	**3: Accomplished**	**4: Exemplary**
(f.A) Explain important ethical obligations associated with your discipline.	Cannot adequately recognize or explain an ethical issue.	1. Explain at least one major ethical obligation.	1. Explain at least one major ethical obligation. 2. Explain how the obligation applies to professional action. 3. Use a systematic argument to support the application.	1. Explain at least one major ethical obligation. 2. Explain how the obligation applies to professional action. 3. Use a systematic argument to support the application. 4. Give several specific examples of professional activities where the ethical obligation applies.
(f.B) Apply a systematic ethical framework to an ethical issue or situation in a disciplinary context.	Provide no basis for analysis (e.g., professional standards, code of ethics).	1. Clearly explain the issue or situation to be analyzed.	1. Clearly explain the issue or situation to be analyzed. 2. Show which professional duties apply to the issue or situation by citing a relevant code of ethics. 3. Resolve any conflicts among the applicable duties through a reasoned analysis.	1. Clearly explain the issue or situation to be analyzed. 2. Show which professional duties apply to the issue or situation by citing a relevant code of ethics. 3. Resolve any conflicts among the applicable duties through a reasoned analysis. 4. Show how an appropriate stance on the issue or situation follows from the analysis.
(f.C) Analyze a complex situation involving multiple conflicting ethical interests or principles to support an appropriate course of action.	Use incomplete information and provide no resolution.	1. Clearly explain the facts relevant to an ethical evaluation of the situation.	1. Clearly explain the facts relevant to an ethical evaluation of the situation. 2. Show what competing interests are at work in the situation. 3. Resolve disputes among the competing interests using a systematic ethical framework and/or professional standards.	1. Clearly explain the facts relevant to an ethical evaluation of the situation. 2. Show what competing interests are at work in the situation. 3. Resolve disputes among the competing interests using a systematic ethical framework and/or professional standards. 4. Justify an appropriate course of action and explain why it is the best among the available alternatives.

EE 332 or EE 330 : Outcome a

Student outcome a: An ability to apply knowledge of mathematics, science, and engineering

Performance Indicators	Unsatisfactory (1)	Developing (2)	Satisfactory (3)	Exemplary (4)
Apply knowledge of mathematics (e.g. statistics, probability, discrete mathematics)	Inability solve and identify relevant mathematical problems	Ability to solve but not able to identify the relevant mathematical problems	Ability to identify and solve the relevant mathematical problems	Ability to identify and solve relevant mathematical problems, and to explore formulations and solutions using alternate approaches
Apply knowledge of science (e.g. mechanics, semiconductor physics, electromagnetics, biology)	Inability solve and identify relevant scientific problems	Ability to solve but not able to identify the relevant scientific problems	Ability to identify and solve the relevant scientific problems	Ability to identify and solve relevant scientific problems, and to explore formulations and solutions using alternate approaches
Apply knowledge of engineering (e.g. electronics, control systems, VLSI, communications and networks)	Inability solve and identify relevant engineering problems	Ability to solve but not able to identify the relevant engineering problems	Ability to identify and solve the relevant engineering problems	Ability to identify and solve relevant engineering problems, and to explore formulations and solutions using alternate approaches

EE 224 Outcome k

Student outcome k: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice				
Performance Indicators	**Unsatisfactory (1)**	**Developing (2)**	**Satisfactory (3)**	**Exemplary (4)**
Techniques and skills (such as modeling, simulation, design methods, experimentation, measurement, and data analysis)	Lack technical skills to complete the project	Has some knowledge but not adequate to complete the project	Has adequate knowledge to complete the project	Is capable of applying knowledge to derive an innovative and efficient design for the project
Selection and application of modern engineering tools and standards (such as Test Equipment, HDL, Matlab, Cadence, LabView, Spectre, and IEEE standards)	Not familiar with the tools and standards and is unable to select the right ones for the project	Familiar with a few tools and standards but requires assistance in selecting and using them appropriately for the project	Is able to select and use tools and standards that may fit the project, with occasional guidance	Independent ability to choose and use tools and standards that are best for the project
Ability to acquire new knowledge and expertise (computer/WEB-based, publications, invention, and other resources)	Is unable to learn new tools and skills	Is unable to learn new tools and skills unless with assistance	Given enough time, is able to learn new tools and skills	Is able to learn new tools and skills quickly and independently