



## **Examining the use of engineering internship workplace competency assessments for continuous improvement**

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# **EXAMINING THE USE OF INTERNSHIP WORKPLACE COMPETENCY ASSESSMENTS FOR CONTINUOUS IMPROVEMENT.**

## **Abstract**

This study explored how workplace competency assessment data collected by College of Engineering programs from internship students and their supervisors between fall 2001 through fall 2011, are applied toward continuous improvement practices. The continuous improvement process is integral to the accreditation and evaluation of the engineering curriculum. This mixed methods study examined three separate practices using internship workplace competency assessment ratings in the continuous improvement process. The study examined how assessment rankings of the internship students' workplace competency strengths and weakness have changed from the 2001-05 assessment terms in the past accreditation cycle, to the 2006-11 assessment terms of the most recent accreditation cycle. It examined competency achievement percentages related to the ABET Criterion 3 (a-k) outcomes across the same timeline, and investigated how workplace competency assessment data are used to support continuous improvement for program curricula in the College of Engineering. The intent of the study was to gain better understanding of how the workplace competency assessment data has benefited the continuous improvement process that enhances student learning. The results can also provide suggestions to programs in the early stages of developing new program evaluation techniques.

## **Introduction**

The College of Engineering (COE) at Iowa State University (ISU) has used on-line assessment surveys since fall 2001 to collect workplace competency assessment (WCA) data to quantify internship students' demonstration of 15 workplace competencies linked to the ABET Criterion 3 (a-k) outcomes [1]. This study examined how engineering programs at ISU utilize WCA data for continuous improvement activities as part of the ABET accreditation criterion for achievement of student learning outcomes. Data collected from engineering internship student's self-assessments and their supervisors' assessments provide important information that is beneficial for continuous improvement (CI) practices. Understanding how WCA data supports the continuous improvement process for curriculum development can help improve practices for curriculum development, and competency assessment methods for program accreditation.

This study examined three topics on student internship WCA. The first part investigated changes in strengths and weaknesses for WCA ratings from assessment across terms from the 2001-05 accreditation cycle, to terms from the current 2006-11 accreditation cycle, monitoring both the COE and program data results. The second part examined the results of achievement percentages for competencies related to ABET Criterion 3 (a-k) learning outcomes across the COE and programs, and the final part consisted of results from an online focus group survey, that investigated how WCA data are currently used to support CI for program curricula in the COE. The intent of this study was to gain a better understanding of how the WCA data benefits the CI process that enhances student learning. Results of this study can benefit programs that are in the early stages of developing new program evaluation techniques.

## **Experiential Learning**

Traditional competency assessment methods have lost popularity among employers with only 13% believing that college transcripts are useful in determining students' achievement of important program learning outcomes, while over 67% identify internships and community-based projects as useful in "evaluating the graduates' potential for success" [2, p. 18], and half of the employers target them as the place where institutions should devote the most resources for assessment [2].

Experiential learning environments provide places where "knowledge is created through the transformation of experience" [14, p. 41], while enhancing their learning experience [13]. It is an authentic assessment environment that more closely simulates later types of learning situations, and is "one of the truest forms of active learning" [16, p. 80] where students can demonstrate their knowledge and skills, and receive valuable feedback from the experience [15]. Experiential learning encourages four modes of learning – experiencing, reflecting, thinking, and acting –where the learner can engage in all four modes based on the learning situation and what is being learned [13]. Kolb [14] explained the four modes as: (1) concrete experiences leading to (2) observations and experiences, which enable (3) forming abstract concepts, and (4) concluding with testing in new situations; all of which enhance learning.

## **Self-assessment**

With the incorporation of the learner-centered curricula, and the implementation of the ABET Criterion 3 (a-k) outcomes; student self-assessment has become integral for assessments and evaluations. As an indirect assessment method, it provides a formative learning environment where students can reflect on their experiences, can be used for performance evaluation to identify their strengths and weaknesses, and provides them with areas to improve by identifying gaps between achievements and outcomes. Research has shown that self-assessment raised students' achievement levels significantly [6][17], and accuracy is "reasonably stable when compared with the stability of actual performance" [10, p. 648]. Although, inconsistencies on the benefits of self-assessment were noted in the results of a Sitzmann et al. [18] study which found that only 32% of studies on self-assessment identify it as an indicator of learning, and rating inflations were problematic in instances where older students believed self-assessments would affect their grades [7]. In this study, data were not related to grades or individual performance. Workplaces today are continually expanding and advancing technologically. Employers use competency assessments to determine if their employees can apply prior knowledge, skills and abilities (KSA) beyond the acquisition of that knowledge or skillset.

## **Competency-based Learning**

Changes toward competency-based learning have been defined as "the redefining of program, classroom, and experiential education objectives as competencies or skills, and focusing coursework on competency development" [5, p. 2]. Environments that challenge students to apply their knowledge and skills to perform tasks in an experiential learning setting are considered the most effective environments in which to learn [11]. Most learning experiences are concentrated within the walls of classrooms, which constituents ranked as the least likely environment, with less than 50% probability, for students to have opportunity to demonstrate

competencies. Engineering workplaces ranked highest, at 90% probability, as the most likely place for demonstration of communication skills; engineering coops and internships ranked second at 80% probability [4]. Experiential education is the only opportunity that provides a direct observation of the undergraduate students demonstration of the ABET (a-k) Criterion 3 outcomes while in a professional engineering environment [11]. All other opportunities provide “at best, a simulation of engineering practices” [11, p. 2].

## Program Outcomes

A student’s completion of coursework requirements is no longer the primary measure for academic success; it is now measured by achievement of program learning outcomes [5]. Assessment on achievement of learning outcomes has been adopted as a method to evaluate overall program effectiveness and improve student learning. Program outcomes provide expectations for the knowledge, skills, and abilities (KSA) that students should possess by completion of their undergraduate program. Proficiency in these KSA is vital to future success for graduating students [4]. The ABET Criterion 3 (a-k) Student Learning Outcomes [1] define outcome requirements for accreditation. The COE at ISU determined that the 11 ABET Criterion 3 (a-k) outcomes were too difficult to measure directly [4], and divided these outcomes into 15 workplace competencies (Table 1), that quantify measurement of the ABET (a-k) Outcomes. Each outcome represented “some collection of workplace competencies necessary for the practice of engineering at the professional level” [4, p. 2]. Each workplace competency maps to the ABET Criterion 3 (a-k) Student learning outcomes, with two to eight key actions linked to each outcome. Sixty-four keys actions are used to define the 15 workplace competencies.

**Table 1.** Workplace competencies

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

The key actions are designed to validate experiential learning in an engineering work environment through clear, definable, instantly measureable, and readily observable metrics that are consistent with the visions and missions of Iowa State University and the College of Engineering. They “align with existing employer assessment, development and performance management practices” [4, p. 124]. Providing measurable key actions to address the ABET (a-k) outcomes allowed the COE to quantify how well internship students were able to demonstrate their acquired knowledge, skills and abilities during their undergraduate education experiences, which helps answer constituent questions about student preparedness for graduation and entry into the workplace.

Each workplace competency is mapped to specific ABET Criterion 3 Outcomes based on “critical incident” feedback from the 212 constituents that participated in the COE focus sessions to define the workplace competencies [5]. From this information, a weighted value for the importance to demonstrate the competency was determined based on the average value from a Likert scale (5 = essential; 4 = very important; 3 = important; 2 = useful; and 1 = unnecessary).

Each ABET (a-k) outcome is linked to multiple workplace competencies (see Table 2). Where there is no number shown, Constituents did not provide examples of a “critical incident” for that workplace competency under the ABET Outcome. For example, ABET Outcome (a) is linked to workplace competencies Analysis and Judgment, Continuous Learning, Engineering Knowledge, and Initiative

**Table 2.** Relationship between workplace competencies and ABET (a-k) outcomes \*

ABET Criterion 3 Outcome	Workplace Competency													
	Analysis & Judgment	Communication	Continuous Learning	Cultural Adaptability	Customer Focus	Engineering Knowledge	General Knowledge	Initiative	Innovation	Integrity	Planning	Professional Impact	Teamwork	Quality Orientation
(a) an ability to apply knowledge of mathematics, science, and engineering (weight factor)	4.2		3.8			4.8		3.5						
(b) an ability to design and conduct experiments, as well as to analyze and interpret data	4.5		3.6		3.3	4.4		3.7	4.0		4.1		3.4	4.2
(c) an ability to design a system, component, or process to meet desired needs	4.5	3.9	3.8	3.0	4.2	4.4		3.9	4.3		4.1		3.8	4.1
(d) an ability to function on multidisciplinary teams	3.6	4.7		4.3	3.6			4.0		4.3	3.8	3.9	4.9	
(e) an ability to identify, formulate, and solve engineering problems	4.3	3.6	3.8		3.5	4.6		4.1	4.2				3.5	3.9
(f) an understanding of professional and ethical responsibility	3.5		3.6	3.7				3.8		4.8				3.2
(g) an ability to communicate effectively		4.9			4.0			3.8	3.7			4.3		
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context	3.4		3.9	4.1		3.3	3.9							
(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	3.1		3.8	3.7			3.7							
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	4.0		4.1	2.6		4.3		3.7						3.6

Numbers refer to the average rating provided by constituents for the importance of the workplace competency to demonstration of the outcome (5 = essential; Key: 4 = very important; 3 = important; 2 = useful; and 1 = unnecessary. ) Where not rating is given constituents did not define a "critical incident" for it. Adapted from Brumm, Hanneman, and Mickelson (2006).

## **Continuous Improvement**

Since implementation of ABET Engineering Criteria 2000 (EC2000), focus has been directed toward student learning instead of the process of teaching. Universities must focus on a more product-oriented approach, as stakeholders require “knowledgeable, effective students who possess skills and talents valued by the public and private corporations” [9, p. 40]. Continually improving the undergraduate students’ KSA’s translates to more competent and qualified employees at the point of hire, allowing employers to focus on training for proprietary knowledge and skills. Employer assessment of the internship student’s workplace competencies can provide timely, direct, and reliable feedback for CI ensuring up-to-date information for continually changing employer needs and expectations. Brumm, Hanneman and Mickelson [4] explain that engineering experiential education “can and should be integral to the curricular continuous improvement process” [4, p. 127].

Critical voices to the CI process, Bessant, Caffyn, and Gallagher [3] note, it focuses heavily on tools implemented in the process, but lacks concentration on behavioral elements. They describe a correlation between organizations performance level of CI and their development of routines for improving the process, stating strong organizational behavior in the CI process is important to the successful achievement of the goals to be attained [4]. By developing a model for learning, practicing, and mastering the behaviors for CI, higher levels of success can be achieved [4]. Often, CI practices are used for assessment, but are not carried through to evaluation of outcome achievement.

Individual programs bear responsibility for their CI process. Annual reports distributed by the COE provide data from National Council of Examiners for Engineering and Surveying (NCEES) Fundamental of Engineering (FE) examination results, and workplace competency assessment survey results (<https://opal.eng.iastate.edu/>). The Director of Assessment and support staff provide assistance to interpret the results, which answers the call by the Academy for Assessment of Student Learning Outcomes at the Higher Learning Commission (HLC) for programs to be committed to teaching, student learning, assessment practices, and to CI of student learning. Assessment practices must satisfy or surpass CI objectives, provide accountability for existing program outcomes and promoted by the program to be successful [12].

### **Purpose of the Study**

This study investigates how internship students’ WCA data are utilized in the continuous improvement process for engineering program evaluation and curriculum development. First, the study examines how rankings that identify the strengths and weaknesses of workplace competency assessments have changed from the 2001-05 accreditation cycle to the most recent 2006-11 cycle. The central focus of this research is to observe improvements gained over time. The second element identifies changes to the outcome achievement percentages over the same accreditation cycles to measure overall improvements to the ABET Criterion 3 (a-k) outcomes because of improvement in the workplace competencies. To conclude, the study investigates how data collected from student self-assessment, supervisor assessment, and alumni feedback, trends in competency

strengths and weaknesses, and ABET Outcome achievement percentages contribute to program evaluation and curriculum development within the College of Engineering at Iowa State University. Through better understanding how WCA data is currently used in the continuous improvement process for program evaluation of student achievement of the program learning outcomes, and dissemination of the methods, “better practices” can be established. The ability to extract competency information from experiential learning opportunities presented through internships offers a valuable resource for confirmation of student learning outcome achievement necessary for program accreditation reviews.

### **Research Questions**

The overarching question central to this study asks, “How have workplace competency assessment data been applied to continuous improvement of engineering program curricula?” To learn how data from workplace competency assessment surveys have enhanced the CI process, more in-depth questions were drafted:

- How has the relationship of Top 5 strengths (T5) and bottom 5 weaknesses (B5) in workplace competencies changed from the 2001-05 accreditation cycle to the 2006-11 accreditation cycle?
- How do competency strengths and weaknesses influence curricula decisions?
- Does evidence suggest that curriculum changes have an impact on workplace competencies?
- How have engineering programs utilized workplace competency self-assessment ratings toward continuous improvement of the program curricula?
- How have engineering programs utilized workplace competency supervisor-assessment ratings toward continuous improvement of the program curricula?
- How have alumni survey data been used to collect WCA data for engineering program curriculum development?
- What practices have been developed for continuous improvement of the curriculum through evaluation of the WCAs?
- What factors are considered in the analysis of the WCA data toward recommended curriculum changes?
- How have aggregated College of Engineering WCA ratings data supported the program curriculum development process?
- How have achievement outcomes percentages calculated from self- and supervisor WCA ratings supported continuous improvement for the curriculum development process?

### **Methods**

This is a 3-part mixed methods study involving qualitative and quantitative analysis focused around the workplace competency assessment data collected by the COE at ISU between fall 2001 through fall 2011 internship terms. The first part investigated changes in strengths and weaknesses for WCA ratings from assessment across terms from the 2001-05 accreditation cycle, to terms from the current 2006-11 accreditation cycle, while observing both the COE and program data results. The second part examined the results of achievement



percentages for competencies related to ABET Criterion 3 (a-k) learning outcomes across the COE and programs, and the final part consists of results from a focus group survey, investigating how WCA data are currently used to support CI for program curricula in the COE. The intent for this study is to gain a better understanding of how the WCA data benefits the CI process that enhances student learning. Data collected through the online survey resulted from questions directed toward engineering program faculty, staff, and administrators that are currently or have previous experience using WCA data for program curriculum development in the College of Engineering at Iowa State University (ISU).

### **Relationships between WCA Rating Strengths and Weaknesses Over Time**

Near the completion of an internship, the college asks the internship students and their supervisors to complete an online survey rating the level of competency the students have demonstrated for the key actions which identify the 15 workplace competencies. The workplace competency assessment survey asks the question “When given the opportunity, how often does this person perform the action?” Respondents choose one of six options on a Likert-type scale; 1 – Never or almost never, 2 – Seldom, 3 – Sometimes, 4 – Often, 5 – Always or almost always, or the option for no response – NR. Student and supervisor WCA ratings for an internship term are averaged by workplace competency and COE program, and ranked to identify the strengths and weaknesses, from 1 (strongest) to 15 (weakest) to provide the Top 5 (T5) and Bottom 5 (B5) competencies. Top 5 and Bottom 5 rankings are calculated and the data is presented to the COE programs to track trends which are useful to help analyze students’ preparedness in the 15 workplace competencies and ultimately for entry into the workplace.

Tracking the top-5 and bottom-5 competencies was initially proposed by DDI as a method to monitor competency strength and weakness trends over time as an alternative for programs that do not consistently have a large quantity of students involved in internships. The practice has continued since the fall 2001 assessment term. Individual results, available only to students, provide formative feedback that can help undergraduates improve weaker knowledge, skills, and abilities prior to entering the workplace. Tracking the T5/B5 results over time is useful for continuous improvement practices for program curriculum development by identifying trends in strengths and weaknesses, which support curriculum development. The T5/B5 information must be kept in perspective. Gaps between the highest- and the lowest-ranking competencies are in many cases in one-tenth of one point or less. With 80% of engineering students participating in internships or cooperative work experiences, and 5,440 students having responded to the workplace competency assessment survey since 2001, these results can be considered strongly representative of the undergraduate engineering population [4].

### **Achievement Percentage Calculations**

Achievement percentages result from applying the 15 workplace competency ratings to the ABET Criterion 3 (a-k) outcomes. The overall demonstrated level of achievement for each ABET outcomes has been defined by calculating the supervisor or student competency rating for each workplace competency and multiplying it by the weighted factor (WF) determined for each competency. Weighted scores for each workplace competency were

defined by the constituents [4]. The numerator is divided by the total sum from the WF scores multiplied by 5, where 5 is the highest achievement ranking on a 5-point Likert scale for demonstration of a workplace competency.

$$\text{Achievement \%} = \frac{\sum (\text{Competency rating}) * (\text{WF})}{\sum (5) * (\text{WF})} \times 100\%$$

The COE has identified 85% achievement as the target level, but engineering programs have the autonomy to define their own acceptable level of achievement.

### **Survey of Program Assessment Committee**

Survey participants comprised 15 faculty and administrators from College of Engineering programs, who are current or past members of the ABET Committee. Participants were contacted because of their experience using internship workplace competency assessment surveys and working with WCA data. Ten of the 15 individuals completed the on-line survey questions. Members were surveyed to identify how internship students' self-assessment and their supervisor's assessment of the interns' demonstration of workplace competencies are utilized for continuous improvement of engineering program curricula. All participants (n=10) have roles in their programs' continuous improvement process, with several holding multiple roles. Seven of the respondents were COE ABET Committee members with one respondent being a former member of the ABET Committee.

Six respondents were active in the program curriculum committee, and six were active on the outcomes assessment committee. Six respondents were ABET Self-study authors or co-authors. Four respondents were departmental associate chairs for undergraduate education (or equivalent), and one respondent was a department chair. Six of the respondents are experienced or highly experienced working with WCA data, two are somewhat experienced, and one respondent had minimal experience.

### **Survey Design**

To determine how Criterion 4 continuous improvement objectives [1] are being addressed, a focus group consisting of faculty and administration members from each department within the College of Engineering was organized. The objective focused on the processes used in engineering programs to assess needs for changes to curricula based on the information provided by the WCA data. Results collected from this study are arranged to provide details defining practices for evaluation and analysis of the assessment data as it applies to curriculum development for achievement of program learning outcomes.

The on-line survey consisted of seven sections totaling 47 questions: Program Information (3), General Questions (6), Self-assessment (7), Supervisor assessment (10), Alumni assessment (5), workplace competency assessment data (15), and 1 opportunity for open comments. Questions were structured on a 5-point Likert-type scale, plus an option to choose "NB", defining no basis to respond to the question. The scale options ranging from low to high were Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree.

## Quantitative Results

Overall T5 and B5 ratings were averaged to identify changes occurring in strengths and weaknesses from the 2001-05 accreditation cycle to the 2006-11 cycle. Top five competencies for supervisor assessment rankings remained consistent from the 2001-05 to the 2006-11 accreditation cycles. Results shown in Table 3 illuminate the College of Engineering aggregate supervisor (Su) and student (Se) assessment rankings for the 2001-05 and 2006-11 assessment cycles. Top five competencies for student self-assessment rankings were consistent between the 2001-05 assessment and 2006-11 sessions. Integrity strongly ranked as the top competency for both respondents across both accreditation cycles. Quality Orientation, Professional Impact, and Cultural Adaptability consistently ranked in the remaining top 4 positions, all averaging above 4.40 in each accreditation cycle. Engineering Knowledge held position 5 in the 2001-05 accreditation cycle, it was replaced by Teamwork in the 2006-11 cycle.

**Table 3.** College of Engineering competency rankings by accreditation cycle

Accreditation Cycle	COE 2001-05				COE 2006-11			
	Su		Se		Su		Se	
n	1838		2103		2075		2924	
Competency	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Analysis and Judgment	<u>4.37</u>	<u>11</u>	4.33	9	<u>4.36</u>	<u>12</u>	4.33	9
Communications	<u>4.22</u>	<u>14</u>	<u>4.20</u>	<u>12</u>	<u>4.25</u>	<u>14</u>	<u>4.18</u>	<u>13</u>
Continuous Learning	4.40	10	4.34	7	4.44	7	4.33	8
Cultural Adaptability	<b>4.50</b>	<b>5</b>	<b>4.53</b>	<b>2</b>	<b>4.52</b>	<b>4</b>	<b>4.47</b>	<b>3</b>
Customer Focus	<u>4.25</u>	<u>13</u>	<u>4.14</u>	<u>14</u>	<u>4.31</u>	<u>13</u>	<u>4.17</u>	<u>14</u>
Engineering Knowledge	4.43	7	4.32	10	4.47	6	4.35	7
General Knowledge	<u>4.31</u>	<u>12</u>	4.34	8	<u>4.36</u>	<u>11</u>	4.32	10
Initiative	4.40	8	<u>4.20</u>	<u>13</u>	4.39	10	<u>4.23</u>	<u>12</u>
Innovation	<u>4.14</u>	<u>15</u>	<u>4.06</u>	<u>15</u>	<u>4.16</u>	<u>15</u>	<u>4.13</u>	<u>15</u>
Integrity	<b>4.85</b>	<b>1</b>	<b>4.79</b>	<b>1</b>	<b>4.77</b>	<b>1</b>	<b>4.73</b>	<b>1</b>
Planning	4.45	6	4.40	6	4.41	9	4.36	6
Professional Impact	<b>4.53</b>	<b>3</b>	<b>4.43</b>	<b>5</b>	<b>4.53</b>	<b>3</b>	<b>4.43</b>	<b>5</b>
Quality Orientation	<b>4.56</b>	<b>2</b>	<b>4.48</b>	<b>3</b>	<b>4.54</b>	<b>2</b>	<b>4.50</b>	<b>2</b>
Safety Awareness *	4.40	9	<u>4.21</u>	<u>11</u>	<b>4.49</b>	<b>5</b>	<b>4.47</b>	<b>4</b>
Teamwork	<b>4.50</b>	<b>4</b>	<b>4.45</b>	<b>4</b>	4.42	8	<u>4.24</u>	<u>11</u>

Note: Rankings shown in bold are top five scores; rankings underlined are bottom five scores.

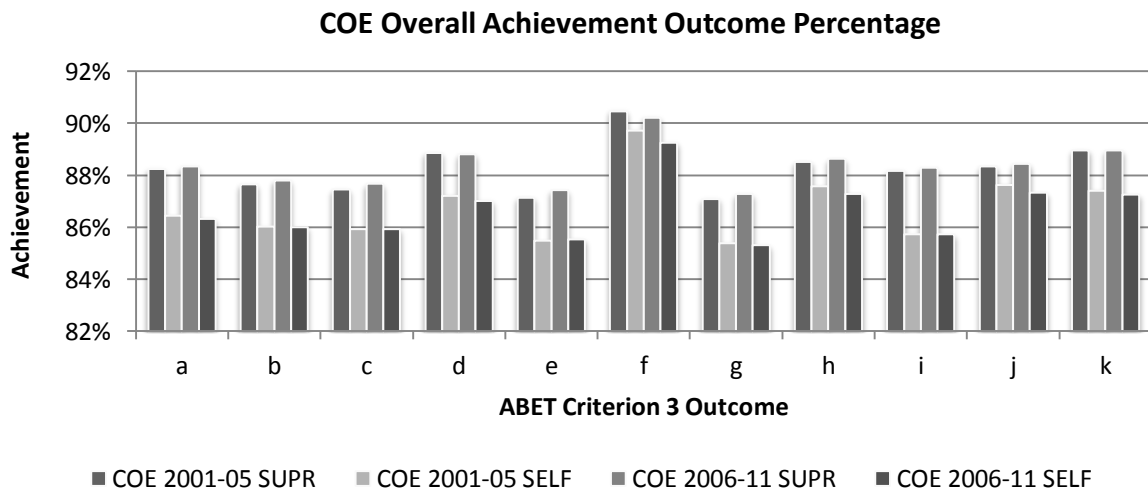
Bottom five results were also consistent. Innovation consistently ranked lowest for supervisor and self-assessment rankings across all sessions, with Communication, Customer Focus, and Initiative ratings consistently ranked low across both sessions. General Knowledge, Safety Awareness, and Analysis & Judgment alternated as lower ranking

competencies. In comparison of 2001-05 and 2006-11 competencies by programs, Aerospace, Agricultural, Civil, Construction, Electrical, and Industrial showed improvement in 50% or more of the competencies. A comparison of overall ratings between supervisor and student assessments, Supervisor ratings were consistently higher than student self-assessment ratings in every program, with exception of Industrial. Ratings for Industrial were split between higher supervisor and self-assessment ratings. Safety Awareness was not included until the 2004 term, therefore respondent numbers for Safety during the 2001-05 assessment terms are Su: n=845 and Se: n=973. Respondents for the 2006-11 are listed in Table 2.

### Achievement Percentages for ABET Outcomes

When comparing the change in overall achievement percentage by program from the 2001-05 assessment terms to the 2006-11 terms, self-assessment ratings improved in 50% of the programs ( $n = 10$ ) with scores ranging from 84.9% to 87.7%, while supervisor ratings improved in 70% of the programs, Aerospace, Agricultural, Civil, Chemical, Construction, Electrical, and Industrial, with percentages ranging from 87.5% to 90.5%. All ABET outcome percentages improved with percentages ranging from 0.1% to 0.8%, except outcome 'd' which dropped a negligible 0.1 percentage points, from the 2001-05 to 2006-11 accreditation cycles. All programs achieved at or above 83.4% for the 2001-05 assessment terms, and 86.4% for the 2006-11 terms. The overall COE outcome percentage improved 0.5%, improving from 88.2% to 88.7%.

The results (Figure 1) exhibited that self-assessment achievement percentages have consistently tracked supervisor ratings, measuring slightly lower in every instance. Results using the Mann-Whitney  $U$  test ( $\alpha = 0.05$ ) showed with 95% confidence, there was a



**Figure 1.** Percentages for College of Engineering overall achievement outcomes

statistical difference in mean values between the 2001-05 and 2006-11 achievement percentages for Agricultural ( $p < 0.001$ ), Civil ( $p < 0.001$ ), Chemical ( $p < 0.001$ ), Computer ( $p = 0.002$ ), Industrial ( $p = 0.013$ ), Materials ( $p = 0.030$ ), and Mechanical ( $p = 0.049$ ).

Achievement percentages improved in the 2006-11 assessment terms for Aerospace, Agricultural, Civil, Chemical, Construction, Electrical, and Industrial. Computer, Materials, and Mechanical dropped slightly.

### **Qualitative Survey Results**

Where applicable, results reflect administrative and faculty responses. Administrative respondents include classifications marked for Administration, Department chair, associate chair, and similar departmental positions. Faculty respondents include professors, associate and assistant professors, instructors, and similar personnel. Although many roles within the college overlap, respondents acting in an administrative position as noted in the survey reflect administrative responses. Responses that resulted in a neutral (N) or no basis for an answer (NB) have been omitted from the results. All other answers are reflected in the responses. Ten respondents completed this survey, in all cases where  $n=10$  the value for “ $n$ ” is omitted. Responses are identified when response rates vary or there is need to clarify.

#### **Using 2001-05 and 2001-06 Assessment Data for Continuous Improvement**

All respondents consider 2001-05 WCA data favorable in preparing for the most current accreditation cycle; responses were very helpful (3), helpful (5), and somewhat helpful (2). When using 2001-05 data in evaluations for continuous improvement actions for the 2006 accreditation cycle, 100% had positive feedback: somewhat helpful (6), helpful (2), and very helpful (2). Fifty –six percent of respondents agreed that WCA data from the 2001-2006 accreditation cycle provided valuable information for continuous improvement actions in program curriculum development ( $n=9$ ).

Eighty percent of respondents agree (Agree: 5; Strongly Agree: 3) that WCA data from the 2006-11 sessions were valuable in preparation for the 2012 Accreditation, and 70% agree WCA data provide valuable information in evaluating program curricula.

#### **Comparing Self and Supervisor WCA Ratings**

When asked if discrepancies between self- and supervisor assessments provide programs with valuable information about students’ understanding of workplace competencies, 22% agreed, and 22% disagreed; in situations where self-assessment scores were consistently higher than supervisor assessment scores, 22% felt further investigation is warranted and 33% ( $n=9$ ) did not feel the need to investigate. One-third of respondents ( $I=9$ ) felt the gap between self-assessments and supervisor assessments was important for understanding self and supervisor WCA relationships (Agree: 3; Disagree: 2).

#### **Achievement Rating Thresholds**

When defining an acceptable values for WCA ratings, based on the 5.0 Likert scale, 40% considered 3.5 to be acceptable, 20% respondents chose 3.0, and 10% response at 3.25. Twenty percent posted higher levels; one at 4.0 and one at 4.25. Based on acceptable achievement percentage target values for ABET Criterion 3 (a-k) outcomes, one-half chose the target value of 75% achievement level to be acceptable ,and the other 50% believe the

threshold should be a higher value of 80% (3) or 85% (2). The Department of Agricultural and Biosystems Engineering have previously been defined an 80% target for achievement of the ABET Criterion 3 (a-k) outcomes.

### **Achievement Data**

The COE provides achievement data to each program for use in program evaluation. Forty-four percent of respondents agree that comparing program and COE achievement percentage data provides a useful benchmark for programs to evaluate student achievement of ABET outcomes. Twenty-two percent of respondents disagree ( $n=9$ ). Eighty-eight percent determined data comparing program competency ratings to COE ratings for individual key actions to be important or somewhat important, 22% found it to be of little importance. Faculty and administrator responses were identical (1-Little importance, 3-Somewhat important, 1-Important).

### **Student Self-assessment on Demonstration of Workplace Competencies**

Forty percent of respondents agreed that internship students are fully instructed on the importance of the WCA data for program accreditation purposes, while 20% disagree. When asked if students are instructed on the importance of WCA for curriculum development, 30% agreed and 20% disagreed. Positive numbers increased when asked if students are adequately prepared with a strong understanding of workplace competencies prior to the start of their internship; 50% of the respondents agreed or strongly agreed, and two respondents disagreed.

Ninety percent of respondents agree that student self-assessment of workplace competencies is useful for continuous improvement of the program curriculum, and 50% were in agreement (Agree: 2; Strongly Agree: 3) that student self-assessment of workplace competencies is a trusted assessment for evaluating achievement of the COE learning outcomes, and 20% disagreed. Numbers fell with polarized opinions when asked if self-assessment is a valuable and reliable method for evaluation of achievement percentages for program learning outcomes with 20% in agreement (Agree: 1; Strongly Agree: 1) while 20% were in disagreement (2).

### **Supervisor Assessment of Student Demonstration of Workplace Competencies**

There were mixed results when asked if supervisors are informed of the importance of WCA data for program accreditation preparations; 20% responding did not agree, and one agreed. When asked if supervisors are informed of the importance that WCA has for program curriculum development: 10% disagreed, and 20% agreed.

Ten percent of respondents felt that their program worked closely with employers to encourage feedback on student WCA through the workplace competency assessment surveys; 30% disagreed. Seventy percent disagree (6) or strongly disagree (1) that their programs have defined an acceptable response rate for assessing intern students demonstration of workplace competencies. One responder explained; “our response rate has been higher than 80%, so we haven’t had to set a value.”

Support wanes, with 20% in agreement that supervisors are provided adequate instruction on assessing student intern's workplace competencies. Ninety percent are in agreement (Agree: 6; Strongly Agree: 3) that supervisor assessment feedback on students strengths and weaknesses is useful for continuous improvement of the program curriculum. Eighty percent are in agreement (Agree: 4; Strongly Agree: 4) that supervisors have the best opportunity to provide accurate feedback on student demonstration of workplace competencies, and 90% are in agreement (Agree: 5; Strongly Agree: 4) that supervisor assessments are more heavily weighted than student self-assessments. All respondents agree (6) or strongly agree (4) that supervisor assessment is a trusted method for rating student demonstration of workplace competency key actions. One responder noted, "We use it because we have virtually nothing else from the external clients". Employer involvement in the continuous improvement process is less strong. Less than half (4) agree that supervisors demonstrate strong support of student WCA as part of the continuous improvement process. One responder equates a "good response rate" as positive support of the process. Another voiced concerns; "we make huge assumptions about not only the training of the supervisors, but more importantly (and virtually impossible to measure) the seriousness with which they fill out the forms."

### **Alumni Feedback**

Forty-four percent of respondents agree that alumni are currently asked to complete an online WCA survey as part of the continuous improvement process for curriculum development; 56% disagreed. When asked if they feel that alumni are made aware of the importance of their participation in WCA for future curriculum development forty-four percent agree or strongly agree. One respondent disagreed ( $n=9$ ). Twenty percent of respondents agree (1) or strongly agree (1) that alumni WCA data are an important to the program continuous improvement process for curriculum development; one disagreed ( $n=10$ ).

When asked if alumni feedback on preparedness in workplace competencies is used in the continuous improvement process for curriculum development, 33% agreed. Thirty-three percent believe they are experiencing satisfactory results, and 22% strongly disagreed when asked if alumni response rates on their preparedness in the workplace competencies was satisfactory.

### **Impact of curriculum development changes on student's demonstration of workplace competencies**

Forty-four percent of respondents were in agreement (Agree: 1; Strongly Agree: 3) when asked if curriculum changes have had a measurable impact on the improved demonstration workplace competencies in the workplace; while one did not agree. Sixty-seven percent agree that raw data provided in spreadsheets by the COE are useful for the continuous improvement process ( $n=9$ ).

### **Influence of workplace competency strengths and weaknesses in curriculum development decisions**

Competency strengths and weaknesses provide valuable information about trends related to WCAs. Understanding these trends can help in the continuous improvement process. Fifty-six percent of respondents agreed that discrepancies between self and supervisor assessment rankings for the “Top 5” (T5) and “Bottom 5” (B5) competencies are monitored within their program to watch for these trends to determine if action should be taken in preparing students, and one disagreed. When asked if supervisor T5/B5 competency rankings help measure current competency achievement ratings, 33% agree and one strongly agree, while one disagreed. Fifty-six percent of respondents agreed that T5/B5 competency data received from self-assessment provides important feedback related to the student competency achievement ratings ( $n=9$ ). Seventy percent agree (6) or strongly agree (1) that T5/B5 competency data received from supervisor assessments provide important feedback for student competency achievement ratings ( $n=10$ ). When asked if overall COE data for individual key actions is useful information for determining strong and weak competency areas, 67% of respondents agreed.

## Conclusion

The purpose of this study was to learn how engineering programs are currently using data obtained from workplace competency assessments toward the continuous improvement process. Three elements of workplace competency assessment were investigated; competency strengths and weaknesses, competency achievement ratings linked to the ABET Criterion 3 (a-k) Outcomes, and practices for using workplace competency assessment data in the engineering programs continuous improvement practices.

## Competency Strengths and Weaknesses

Top 5 and Bottom 5 rankings for workplace competency assessments provide programs a method to track trends across time on how successfully internship students can demonstrate competency of learning outcomes in the workplace, which provides information useful toward evaluation of the program curriculum. Strengths can be used to verify that students can successfully transfer the knowledge, skills and abilities they have learned into a work environment, demonstrating migration toward higher levels of expertise [8][13][16]. Trends in weaknesses can be used to address areas of concern, and support program curricula evaluations. Important take-aways from this research include the following:

- With aggregate ratings of all workplace competencies ranging above the 4.0 mark, and gaps between the highest strength and lowest weakness were commonly less than one-half of one point, verifying there is little reason for concern, with all competencies falling at or above the minimum program defined competency threshold target points.
- Supervisor ratings for workplace competency assessments in the 2006-11 assessment terms were slightly higher than student self-assessments across all programs, ranging from 0.000 to 0.018 points; and across all competencies the results were consistent, ranging from 0.02 to .17 higher. This eliminates the concern of inflation in self-assessment ratings at the program and college levels.
- The slight improvement also indicates that students performed at a slightly higher rate than in past assessment terms from the 2001-05 accreditation cycle.



## ABET Outcome Achievement Percentages

When observing competency achievement percentage improvements for supervisor percentage ratings from the 2001-05 to the 2006-11 assessment terms based on the accreditation cycles the following determinations were made.

### *By ABET Outcome:*

- Improvement was observed in 70% of the program achievement percentages between the 2001-05 and 2006-11 assessment terms, with over half of those showing a significant improvement in percentage ratings. Computer, Material, and Mechanical showed a slight drop in achievement percentages across the ABET (a-k) outcomes.
  - 90% of programs improved in demonstrating (a) an ability to apply mathematics, science and engineering principles.
  - 80% programs improved in demonstrating (g) an ability to communicate effectively.
  - 70% programs improved in the demonstration of outcomes: (h) understanding the impact of engineering solutions in a global and societal context, (i) recognizing the need for life-long learning, (j) knowledge of contemporary issues, and (k) Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.
  - 60% programs improved the demonstration of outcomes: (b) Ability to design and conduct experiments, analyze and interpret data, (c) Ability to design a system, component, or process to meet desired needs, (e) Ability to identify, formulate and solve engineering problems, and (f) Understanding of professional and ethical responsibility.
  - 50% programs improved in the demonstration of outcome (d) ability to function on multidisciplinary teams. Additional research is needed to determine the associations of this.
  - 50% or more COE programs at ISU have shown improvement of achievement percentage for all 11 outcomes. Improvement in outcomes h-k demonstrates improved strengths among engineering students in their discipline topics.
- When addressed by program, 50% (Agricultural, Chemical, Civil, Electrical, and Industrial) improved in all 11 (a-k) ABET Outcomes. One (Construction) improved in 9 outcomes; one (Aerospace) improved in 6 outcomes, one (Materials) improved in 2 outcomes, and two (Computer and Mechanical) improved in 1 outcome.
- When addressed by overall COE Results, the programs included in the COE combined demonstrated improvement in 9 of the 11 ABET Outcomes (a, b, c, e, g, h, i, j, and k) from the 2001-05 to the 2006-11 accreditation cycles. Collectively this encompasses all workplace competencies with the exception of Integrity. This is because integrity only appears in two competencies: (d) an ability to function on multi-disciplinary teams, and (f) an understanding of professional and ethical responsibilities. These two outcomes would be less likely to have opportunities to demonstrate by the nature of internships. Eight of ten programs did show improvement in outcome (g) when isolating individual competencies.

A survey comprised of 47 questions targeted toward self-assessment ratings, supervisor assessment ratings, alumni feedback, accreditation, strength and weakness data, and use of a-k outcome achievement data were visited. Ten of 15 respondents (67%) completed the full survey, with one respondent completing only the general questions and opting out due to lack of long-term experience with the WCA data. In summary, results from the survey identify the following key points:

- WCA ratings are useful to programs in supporting evaluation of student competency in each of the workplace competencies. As part of an overall continuous improvement plan, WCA data can be used to monitor trends in competencies over time through T5 and B5 assessment data, and provide valued information on achievement of ABET Outcomes. This information holds value when programs are preparing self-study reports for accreditation.
- Data from the WCA results are not heavily weighted for use in program curriculum changes to address areas of deficiency in student learning outcomes.
  - Programs rely more heavily on data from multiple sources like in-class assessments, the NCEES Fundamentals of Engineering (FE) exam, and capstone projects for the evaluation process.
- Confidence in student self-assessment for demonstration of workplace competencies are perceived to be not as reliable as the supervisor assessment.
- Supervisor assessment ratings are deemed to be more reliable as a measure of the students' demonstration of competency in the workplace.
- Respondents lack confidence that WCA surveys are treated with full respect and, therefore, provide validity to the ratings.

Constraints limiting the level of information provided in the data were raised as a drawback. Respondents identified that the ability to mine data for additional demographic information could provide programs with valuable data on competency success in areas such as: gender, class ranking, traditional vs non-traditional programs, learning community or student organization participation, and others.

Five respondents suggested that additional WCA information could enhance the continuous improvement process. Items not currently provided to the programs that could improve the feedback include:

“Supervisor comments would be very helpful”

“Comparison of current accreditation cycle data to prior accreditation data”

“Analysis of (individual) key actions (if programs would use it).”

“Temporal data on how workplace competency changes over time”

“When evaluating student interns, keep track of student year (junior, senior, sophomore)”

One respondent reinforced the value of the Online Performance and Learning (OPAL®) program, a competency development and management software [4] developed by

Development Dimensions International (DDI) that provides assessment, development, coaching and learning tools for students; stating that it provides much more than workplace competency assessment of internship and cooperative students. This statement refers to the value that OPAL® has as a resource the College of Engineering provides in self-management tools where students can develop a greater depth of knowledge and skills to improve in workplace skills and competencies. Assessment is only one component of the OPAL® system.

### **Future Direction for Research**

Additional research in the current assessment terms will continue to provide a greater understanding in the following areas:

- To determine if trends in strengths and weaknesses have changed among programs.
- To provide more in-depth understanding how modifications to program curricula may have influenced student demonstration of workplace competencies.
- Continuing longitudinal study to determine if the relationship between supervisor and self-assessment of internship workplace competencies have changed from the most recent accreditation cycle from past cycles.
- Study individual respondent data from internship students and supervisors, while maintaining a high level of confidentiality for respondents, in order to facilitate more in-depth research into demographics associated with the competencies. Note that an alternate assessment instruments for on-line workplace competency assessment surveys that would be required.

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