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Assessing engineering students' demonstration of workplace competencies in experiential learning environments through internships and cooperative work experiences

Mark A. Laingen
Iowa State University

Assessing engineering students' demonstration of workplace competencies in experiential learning environments through internships and cooperative work experiences

by

Mark A. Laingen

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Program of Study Committee:
Steven A. Freeman, Major Professor
Thomas J. Brumm
Steven K. Mickelson
Mack C. Shelley II
Kevin P. Saunders

Iowa State University

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DEDICATION

Special thanks …

So many people deserve recognition for their support during my completion of this dissertation. No individual could possibly achieve this milestone without support. I dedicate this dissertation to Kimberly for her support, encouragement, understanding, patience, and motivation; all of which have made this journey possible. I also dedicate this dissertation to my sons, Bradley and Collin, who have always been supportive with words of encouragement during this process. They have been my motivation.

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ABSTRACT

This study investigated the relationships between supervisor assessments and internship students' self-assessments for 15 workplace competencies, demonstrated in an internship or cooperative work environment. The 15 workplace competencies were developed by Iowa State University in collaboration with over 200 constituents comprised of Iowa State University COE alumni, engineering employers, COE faculty, partnering international faculty, and COE students, to provide clear, independent, and assessable measures for the eleven learning outcomes identified in the ABET Criterion 3 (a-k) outcomes. The study investigated workplace competency assessment data collected over ten years, commencing with the fall 2001 internship assessment term and concluding with the fall 2011 assessment term. The study used three separate methodologies to analyze workplace competency assessments in the COE. Part 1 analyzed data across the fifteen workplace competencies, and across ten programs in the College of Engineering, that have been involved with the workplace competency assessment of internship and cooperative students from the beginning of data collection in 2001. Supervisor assessment ratings were compared to internship student self-assessment ratings across the ten-year span from 2001-11using the non-parametric equivalent of the paired *t*-test; the Wilcoxon singed rank test for paired data. Part 2 of the study investigated the relationship between supervisor and student self-assessment data across assessment terms related to the 2001-05 and 2006-11 ABET accreditation cycles. The third part investigated how data tracking workplace competency strengths and weaknesses and ABET outcomes achievement percentages have changed between the assessment terms across accreditation cycles. Part 3 included an on-line survey

sent to program curriculum committee members involved with workplace competency assessment data that investigated how the engineering programs are utilizing this data in support of continuous improvement of the program curricula. Results of the analysis demonstrate how paired supervisor assessment and student self-assessment ratings for assessment of the internship students’ demonstration of workplace competencies can be useful in evaluating student demonstration of competency in COE learning outcomes through the experiential learning environment, and support continuous improvement practices for program curriculum development.

CHAPTER 1. GENERAL INTRODUCTION

Introduction

This study investigated the relationships between supervisor assessment ratings and student self-assessment ratings for engineering students' demonstration of 15 workplace competencies while participating in an internship, consisting of a single work related term (semester, or semester plus summer, or summer), or cooperative work experience, consisting of a multiple work related term where responsibilities increase with experience on the job. For this study, the term "internship" was used to identify the results from both internship and cooperative experiential learning experiences. The study sought to validate student self-assessment of workplace competencies demonstrated during these experiential learning experiences. These experiences have provided students with practical work experience within their field of engineering, with opportunities to demonstrate the knowledge, skills and abilities that they have acquired during their undergraduate education. Their ability to demonstrate the knowledge, skills, and abilities acquired during their undergraduate education has been an important measure of their achievement of learning outcomes during the educational process. The ability to validate self-assessment as a reliable method for indirect assessment of learning outcomes is useful in assessing student preparedness for entry into the workplace, and for assessment of the engineering program curricula that are used to prepare the undergraduate engineering students. The study also sought to understand how student self-assessment and supervisor assessments were used in engineering programs' continuous improvement practices, which is also beneficial for program curriculum development.

Dissertation Organization

This study used a mixed methods approach that involved three separate articles that investigated the relationship between paired supervisor and student self-assessment data across programs, workplace competencies, and assessment terms as related to accreditation cycles. The research was divided into the following three articles:

- Article 1 used quantitative analysis that compared the relationship of supervisor and student self-assessment data collected from the 2001-11 workplace competency assessment surveys.
- Article 2 used quantitative analysis that compared the relationship of supervisor and student self-assessment data collected from the workplace competency assessment surveys across internship terms related to the 2001-05 and 2006-11 accreditation cycles.
- Article 3 used quantitative analysis of data collected from the 2001-11 workplace competency assessment surveys that identified workplace competency strengths and weaknesses, and addressed achievement percentages associated with the ABET Criterion 3 outcomes. Qualitative analysis was used to analyze data resulting from a survey given to COE program coordinators involved in the analysis of workplace competency data for development of the program curriculum.

Experiential Learning

Experiential learning provided through internship and cooperative work experiences combine classroom studies with supervised work experiences. Engineering internship and cooperative work experiences (internships) provide students with practical work experience, while offering them the opportunities to demonstrate the knowledge, skills and abilities (KSA) that they have learned during their undergraduate education. Demonstration of their KSA's is an important measure of their achievement in the educational process. Kolb (1984) described experiential learning as the construction of knowledge that involves a creative tension among four learning modes – experiencing, reflecting, thinking, and acting, where the learner engages in a continuous process that is responsive to the contextual situation and what is being learned (Kolb & Kolb, 2005). More than two-thirds of employers positively identified experiential learning (internships and community-based projects) as useful in evaluating the engineering graduates potential for success (AAC&U, 2008), compared to thirteen percent that believe college transcripts are useful for determining a students' level of achievement in important program learning outcomes. Half of the respondents targeted internships and community-based projects as the place where institutions should devote the most resources for assessment (AAC&U, 2008). Experiential learning is an environment that provides an authentic assessment setting more closely structured to simulate later learning environments (McKeachie, 2006), and one of the truest forms of active learning, where individuals are given autonomy for their education (Eisner, 2002), which enhances their learning experience (Kolb & Kolb, 2005), allowing the experience to becomes personalized (Wiggins & McTighe, 1998). Experiential learning environments involve four important phases: (1) tangible experiences, which lead to (2) observations and experiences, (3) forming abstract concepts, which concludes with (4) testing these experiences in new situations. These phases enhance the learning process (Kolb, 1984) through the transfer of prior knowledge and skills into new challenges, which is an essential skill toward the graduate's success in the workplace. Achieved expertise requires practice and drill to advance strong initial knowledge within a context (Bransford, Brown, Cocking, & Rodney, 1999). Experiential learning provides training across different contexts, which provides better transfer than learning within a single context. True understanding of a topic is flexible, can be connected to other applications, and generally transferred (Bransford et al., 1999).

An individual must have a strong understanding of a concept in order to be able to transfer that understanding into a new setting. Research conducted by Bransford et al. (1979) claimed that students have a better opportunity to learn a concept if they are provided opportunities to practice their knowledge and skills in a variety of applications.

Self-assessment

By engaging students in the responsibility for their learning, they are able to enhance their learning experience. Self-assessment engages the student in the learning process through personal reflection of their educational experience. To measure student preparedness for entry into engineering positions following graduation, it is important to understand the student's ability to demonstrate competency in key actions associated with workplace competencies during their undergraduate educational experience. Demonstrations of proficiency in key actions provides valuable information for both the student and the college. Assessment of workplace competency becomes more difficult to track after students have graduated and entered the workforce. Self-assessments obtained from alumni surveys continue to provide workplace competency data to the engineering programs after the student has graduated. Programs must rely on graduates to provide accurate feedback of their preparedness in workplace competencies. Graduate feedback provides key information to help programs define areas where student preparedness may have strengths and weaknesses.

This is important for continuous improvement of program curricula. The workplace is a dynamic environment that is continually expanding and advancing technologically. Employers use competency assessment to determine if graduates can apply the knowledge they have learned beyond the acquisition of that knowledge or skillset (Robinson & Robinson, 1999). Self-assessment is a valuable method for measuring these skill sets.

Understanding the relationship between student self-assessments and supervisor assessments will help us understand how self-assessment are used as a tool for assessment. Fitzgerald, White, and Gruppen (2003) reported in their study on the reliability of self-assessment that; “student’s self-assessment accuracy is reasonably stable when compared with the stability of actual performance” (p. 648). Assessment of workplace competencies results from demonstration of actual performance in the workplace, which suggests that self-assessment should measure performance competency with relative accuracy. Arnold, Willoughby, and Calkins’ (1985) longitudinal study of self-assessment in undergraduate medical education supports this theory, which confirmed student self-assessment skills increase slightly as their education increases. Confirming that the relationships between these mean values are statistically significant will support argument that self-assessment is a valid and consistent measure of internship assessment. It will also support argument that the self-assessment evaluations of graduated engineering students represent a reliable method of collecting competency data after the student has entered the workforce.

Understanding the level of consistency, that self-assessment can provide the engineering programs with support to continue assessment after the student has graduated. Post-graduation assessment of the engineering professional will support research designed to enhance the continuous improvement of the engineering programs. Continuous monitoring of the engineering programs will help the engineering programs prepare students for transition into the workplace. Feedback received from engineering graduates is valuable for the College of Engineering. Through tracking of their demonstration of workplace competencies, the graduate will gain important knowledge into their own progress in these key actions. This assessment also provides valuable analysis of their own strengths and deficiencies, which enhances their own personal continuous improvement and career development.

Continuous Improvement

Continuous improvement planning is a key component toward Accreditation Board for Engineering and Technology (ABET) accreditation preparations. Accreditation of each engineering department is essential for the continued success of any engineering program. Documentation of the continuous improvement process is essential for ABET accreditation.

Employers also benefit from this research. Continually improving the skills and abilities of the graduating engineering student translates to a more competent and qualified employee at the point of hire. A more highly trained engineer at the entry level means less time required in the employers initial training. Employers can focus more on the proprietary knowledge and skills that the student will need to be a more productive, efficient and effective employee for them.

Employer assessment of an internship student’s demonstration of workplace competencies provides feedback for continuous improvement in curriculum development. Brumm, Hanneman, and Mickelson (2006) support the employer assessment of a student’s workplace competency as an assessment method that has a quick cycle-time, which can address the constantly changing employer needs and expectation. “Engineering experiential education can and should be integral to the curricular continuous improvement process" (Brumm et al., 2006, p. 127). Experiential education provides a measure of employment expectations that cannot effectively be measured in a classroom environment. Continuous monitoring of workplace expectations permit programs to stay abreast of dynamic changes that occur in industries.

Program Assessment

ABET's development of the Engineering Criteria 2000 (EC2000) prompted a major transition in the assessment and continuous improvement process of engineering programs' pursuit for accreditation. The Engineering Accreditation Commission (EAC) designed Criterion 3 of ABET EC2000 to ensure that programs demonstrate that graduates from their programs have demonstrated competency in eleven specific outcomes known as the ABET (a-k) outcomes (ABET, 2010).

Continuous improvement of teaching and learning is a primary reason to perform assessments. Information must be directed at the audience of stakeholders most interested in the data and focus on the relevant information for that group. These stakeholders may be faculty, staff, students, employers, administrators and accreditors (Astin, 1991).

Assessing Workplace Competencies

Internship and cooperative workplace competency assessment (WCA) is a useful measure used by programs to determine if students are receiving the knowledge, skills and abilities identified as essential for transitioning into the engineering workplace. In workplaces that are continually expanding and advancing technologically, competencies help employers determine if graduates can apply the knowledge learned beyond the acquisition of that knowledge (Robinson & Robinson, 1999). Student success is no longer measured entirely by completion of coursework requirements. Success is now measured by achievement of program learning outcomes, which are defined as “statements that describe what students are expected to know or be able to do by the time of graduation from the program” (Brumm et al., 2006, p. 1). Proficiency of workplace competencies is essential to future success for graduating students. Workplace competency assessment is a continuous improvement loop that can be used by engineering programs to obtain direct assessment feedback from employers, and indirect assessment feedback from the internship students to determine how well students are prepared for entry into the workplace.

Competency–based Assessment

Effective assessment practices use direct and indirect techniques, and quantitative and qualitative collection measures that are appropriate to the objectives or learning outcome being measured. Workplace competency assessment involves a continuous improvement loop that can be used by engineering programs to obtain direct assessment feedback from employers, and indirect assessment feedback from the internship students to determine how well students are prepared for entry into the workplace. Assessment of the workplace competencies help to satisfy the ABET Criterion 4 requirements, that continuous improvement processes must be well established and documented in the program self-study for accreditation (ABET, 2010).

Workplace competencies were developed toward measurement of the eleven ABET Criterion 3 (a-k) outcomes (ABET, 2010) which identify criterion that students should be able to demonstrate competency in, by completion of their undergraduate studies:

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

As stated, the ABET Criterion 3 outcomes are difficult to measure. Seven of the outcomes begin with "the ability" to measure the outcome. Mickelson et al. (2007) define the breakdown of abilities as complex combinations of competencies, and competencies as the application of behavior and motivation to knowledge understanding, and skills. The COE collaborated with a constituency of over 200 ISU alumni, employers, faculty, partnering international faculty, and co-op and intern students, to assist in developing performance assessment tools comprised of 15 workplace competencies to provide measurable actions for the ABET Criterion 3 outcomes. The 15 workplace competencies are clarified through 64 key actions (Appendix A) that provide measurable ways to convert the (a-k) outcomes to measurable activities (Appendix B). The 64 key actions quantify the 15 workplace competencies through clear, definable, readily observable, and instantly measureable metrics that are "consistent with the visions and missions of our college and university, and align with existing employer assessment, development and performance management practices" (Brumm et al., 2006, p. 124).

Student Outcome Achievement

Program educational objectives define objectives that have been systematically confirmed by program constituents, and that graduates will be required to achieve for career and professional success. Student outcomes for each program are clearly defined to identify the expected knowledge, skills and abilities a student is required to achieve by their undergraduate graduation. Calculations used for measuring student outcome achievement are determined by using the ratings obtained through direct assessment measures having internship employment supervisors rate their intern on each of the 64 key actions that measure the 15 workplace competencies. 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” (Brumm, Hanneman, & Mickelson, 2006, p. 124). Indirect assessment is measured using intern student’s self-assessment of these same 64 key actions. The results of these ratings are calculated using the formula for percentage of achievement shown:

$$\%\text{ Achievement} = \frac{\sum \text{(competency ranking)(weighting factor)}}{\sum \text{(5)(weighting factor)}} \quad \text{X } 100\%$$

Programs within the college have determined a minimum attainment level for each of the outcomes used in determining an acceptable level of demonstration for each competency. The numerator is determined by taking the sum of actual rated demonstration values of the competency key actions for each of the ABET Outcomes, and dividing it by the denominator which is the sum of a perfect competency rating for each of the same key actions linked to the ABET Outcome. The ratio is converted to a percentage by multiplying the value by 100.

Glossary of Terms

Terms used in this study which require clarification are provided as follows:

- AACU- American Association of Colleges and Universities
- ABET- Accreditation Board for Engineering and Technology
- AER- used to identify the Aerospace Engineering program at ISU.
- AGR used to identify the Agricultural Engineering program at ISU.
- CHE- used to identify the Chemical Engineering program at ISU.
- CIV used to identify the Civil Engineering program at ISU.
- COE- College of Engineering
- Workplace competencies – 15 competencies (Appendix A) defined by the College of Engineering and their constituents to provide measurable solutions to the ABET Criterion 3 outcomes.
- CON used to identify the Construction Engineering program at ISU.
- CPR used to identify the Computer Engineering program at ISU.
- ELE used to identify the Electrical Engineering program at ISU.
- IND used to identify the Industrial Engineering program at ISU.
- MAT used to identify the Materials Engineering program at ISU.
- MEC used to identify the Mechanical Engineering program at ISU.
- OPAL®- Online Performance and Learning, software provided by Development Dimensions Incorporated (DDI) for workplace competency assessment

- Program Educational Objectives – the expected accomplishments of graduates during the first 3 years following graduation (ABET, 2009)
- Student Outcomes – what a student should know or be able to demonstrate by the time they graduate. (ABET, 2009)

Goal of the Study

This study investigated the relationships between self-assessment and supervisor assessment of workplace competencies. It assessed how the relationship between these demonstrations of workplace competencies have changed over time from fall 2001 to fall 2010, how the relationships vary between programs, and what changes have occurred overall at the college level. The study analyzed how this information is used to evaluate Iowa State University (ISU) competency-based program learning objectives, and how demonstrated strengths and weaknesses are being addressed within the program curriculum.

This research strived to identify the relationship between self-assessment and supervisor assessment for the demonstration of workplace competencies across ISU engineering programs, workplace competencies, accreditation cycles, and combined data for the College of Engineering from 2001 to 2011. The relationships are important to validate self-assessment as a reliable practice in the continuous improvement process for evaluation of the program curriculum.

Purpose of the Study

The overarching goal for this study was to investigate the relationship between COE undergraduate internship students' self-assessed ratings and employment supervisors' assessment ratings for the students' demonstration of workplace competencies related to undergraduate internships. The study investigated how these relationships between supervisor and student assessments compare across the 15 workplace competencies, and across COE programs. The workplace competencies provide measurable, observable, assessment methods to determine how well engineering students were prepared for entry into the workplace. Review of the literature does not provide information specifically related to this research. The study focuses on the central question “What relationships exist between self-assessment and supervisor assessment of engineering internship students’ demonstration of workplace competencies?”

Data collected in the workplace competency assessment survey (Appendix C) provide the COE programs with valuable information about the engineering students’ preparedness in the key action areas defining workplace competency. This study looked at three main focal points; the relationship between self-assessment and supervisor assessment of workplace competencies, how those relationships have changed over a period of time that corresponds with the ABET accreditation cycles, and how the information is being used in the engineering programs’ continuous improvement process for curriculum development. Within these points, there are many other questions raised and every effort made to answer them.

Need for the Study

Increasing the engineering students preparedness for the workplace through mastery of learning objectives is supported in the report by Hanneman and Gardner (2010) that explains how the change from a domestic to global workplace and the reduction of corporate training programs have shifted the development of skill back onto higher education programs. This shift has increased the need for a stronger demonstration of workplace competencies for the entry-level engineers. Hanneman and Gardner (2010) also point out that the increasing number of highly skilled and educated workers from China, India, South Korea and Europe are driving up expectations for a more highly trained worker at the point of hire. Demands for a skilled workforce also come from corporate pressures to fill positions that will be occurring from an aging workforce that are rapidly reaching retirement age. As engineers begin to retire, the need for a higher level of competency for entry positions will increase; as companies desperately try to fill the voids resulting from the loss of these experienced engineers. Hanneman & Gardner (2010) emphasize the urgency for this migration to workplace preparation prior to employment, and reinforce the value of experiential learning:

> In response to this shift in employer expectations, undergraduate education needs to recognize the urgency of pushing more students through the core curriculum into coursework, lab assignments, practicums, internships, etc. that position students in more challenging, more ambiguous learning environments where they can develop the abilities required to succeed after college. (Hanneman & Gardner, 2010, p. 3).

Research Questions

This research focused around the comparison of student intern self-assessment of their competency in the 64 key action areas and the supervisor assessment of the students' competencies. The questions that guide this research were:

Article 1: Evaluating Student Self-assessment and Supervisor assessment in the demonstration of achievement of workplace competencies

- What is the relationship between the demonstration of workplace competencies from student self-assessment and employer assessment?

- How do mean scores for self-assessment and employer assessment ratings of competencies relate across engineering departments?
    1. How do mean scores between self-assessment and supervisor assessment of the demonstration of workplace competencies relate by competency for each year?
    2. What differences exist between self-assessment and supervisor assessment values by competency?
    3. What is the relationship between Achievement results for self-assessment and supervisor assessment values for data from 2001-2010?

Article 2: Impacts of ABET accreditation cycles on the demonstration of workplace competencies

- How do mean self-assessment and supervisor assessment ratings relate over time from fall 2001 to spring 2010?
    1. How have workplace competency assessment results changed from fall 2001-2005 to spring 2006-2010 averages for each program in the College of Engineering? How have they changed across competencies during this time?
    2. Has the relationship (gap) between student self-assessment and supervisor assessment of the demonstration of workplace competencies changed over the fall 2001-2005 to spring 2006-2010 collection period? By competency and by program?
    3. How have the relationships between self-assessment and supervisor assessment of the Top-5 and Bottom-5 competencies changed?

Article 3: Case Study: Using Internship assessment data toward Continuous Improvement of the Engineering Curricula

- How have workplace competencies been applied to continuous improvement of departmental curricula within the College of Engineering?
    1. 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?
    2. How do competency strengths and weaknesses influence curricula decisions?
    3. Does evidence suggest that curriculum changes have an impact on workplace competencies?
    4. How have engineering programs utilized workplace competency self-assessment ratings toward continuous improvement of the program curricula?
    5. How have engineering programs utilized workplace competency supervisor-assessment ratings toward continuous improvement of the program curricula?
    6. How have alumni survey data been used to collect WCA data for engineering program curriculum development?
    7. What practices have been developed for continuous improvement of the curriculum through evaluation of the WCAs?
    8. What factors are considered in the analysis of the WCA data toward recommended curriculum changes?
    9. How have aggregated College of Engineering WCA ratings data supported the program curriculum development process?

10. How have achievement outcomes percentages calculated from self- and supervisor WCA ratings supported continuous improvement for the curriculum development process?

Methodology

This study used quantitative and qualitative, mixed methods analysis methods. Chapters 2 and 3 implement quantitative analysis of workplace competency data. Chapter 2 investigates the relationship between supervisor and student self-assessment ratings across 10 COE programs and 15 workplace competencies collected during internships and cooperatives between fall 2001 and fall 2011. These 10 COE programs were selected based on their involvement in workplace competency assessment research since it began in 2001. Chapter 3 investigates how the supervisor and student self-assessment relationships have changed across COE programs and assessment terms grouped by the 2001-05 and 2006-11 accreditation cycles.

Chapter 4 provides analysis on the strengths and weaknesses of the workplace competencies across the assessment terms as organized according to the accreditation cycles. This analysis strived to compare the change in strengths and weaknesses from the 2001-05 accreditation cycle to the most recent 2006-11 cycle. Chapter 4 is a 3-part mixed methods study that includes qualitative and quantitative analysis focused around the workplace competency assessment data collected by the COE at ISU between fall 2001 through fall 2011 internship and cooperative terms. The first part investigates 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 examines 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, 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).

Workplace Competency Assessment Sample

The samples consisted of undergraduate engineering students actively enrolled in an engineering program at ISU, who have recently completed a paid internships and cooperative work experiences at an employer's place of employment, and the supervisors that were directly involved with the students. The number of participants by college and program varies each semester based on the students enrolled in a summer internship or professional internship. Random sampling is not possible for this study. Surveys are completed by all respondents that have completed their internship, and the results averaged prior to distribution of the data. Those students' responses are included in survey results. With more than 80% of graduating engineering students having participated in experiential learning, and close to 100% of the these students having participated in the workplace competency assessment survey, data collected is highly representative of the engineering student population (Hanneman et al., 2002).

Workplace Competency Assessment Survey Instrument

The workplace competency assessment survey used to collect respondent data was administered through the Online Performance and Learning (OPAL®) software developed in partnership with Development Dimensions International Inc. (DDI, 2004), a global leader in talent management and assessment. The survey used for the assessment of internship students' demonstrations of workplace competencies consists of a quantitative Likert styled summative rating (Likert, 1932). Students taking the survey are asked to rate themselves in each of the 15 workplace competencies by answering the following question: "When given the opportunity, how often does this individual perform the action?" The respondent is given examples referred to as key actions that provide measurable outcomes for each of the competencies. These ratings are measured as: 1 = never or almost never; 2 = seldom; 3 = sometimes; 4 = often; 5 = always or almost always. Sixty-four Key Actions are rated in the survey. Mickelson et al. (2007) explain that this assessment is designed to measure the student's proficiency in the demonstration of workplace competencies. These competencies satisfy the need to measure a student's competency in the learning outcomes defined in the ABET (a-k) Criterion 3 program outcomes. The process results in a standardized data set that can be used for analysis purposes.

Data Collection

As part of their internship, students are required to complete a workplace competency assessment survey near the end of an internship, and the internship supervisor is asked to complete an identical assessment (Hanneman et al., 2002). Hanneman et al. (2002) explained: "To receive academic credit for the work term each student was required to complete the standard self-assessment and to ensure that the supervisor complete the same assessment of the student” (p. 5). Supervisor participation in the assessment survey is not mandatory, but is strongly recommended by the college that one supervisor respond for each intern they employ. It is possible for multiple supervisor to respond for a student if a student has been trained by more than one supervisor, although a respondent value of 100% is the maximum reported for each program. Although individual identification is recorded, it is used only to track direct feedback from supervisors that students can access to gain insight into their strengths and deficiencies; by contract with DDI Corporation (2004), individual respondent information is not provided for use by the college. Assessment data were collected from the online WCA surveys (Appendix C) and organized by year, internship session (Spring, Spring/Summer, Summer, Summer/Fall, and Fall), program (Aerospace, Agricultural, Civil, Chemical, Computer, Construction, Electrical, Industrial, Materials, and Mechanical), respondent type (supervisor or student self-assessment), and workplace competency (Analysis & Judgment, Teamwork, etc). The data consist of mean scores for 64 specific key actions (Appendix A) demonstrated during the internship, which are averaged into the 15 workplace competencies. Mickelson et al. (2007) note that assessment data on internship students’ demonstration of the workplace competencies that have been mapped to the ABET Criterion 3 (a-k) program outcomes, are used to provide critical feedback on the effectiveness of the program curricula in preparing undergraduate students for the practice of engineering.

Actual respondent numbers for each competency represents the aggregate number of program respondents (APPENDIX E) factor into each score. The overall response rates for student self-assessments (Se) are 5,440, and supervisor assessments (Su) are 4,239.

Aggregate respondent totals for 2006-11 include 2,075 supervisors, and 2,924 students. Aggregate respondent totals for 2001-05 include 2,164 supervisors, and 2,516 students.

Statistical Design

Data were collected from workplace competency assessment surveys and organized by year of internship, internship session (Spring, Spring/Summer, Summer, Summer/Fall, and Fall), program (Aerospace, Agricultural, Civil, etc.), respondent type (Supervisor or Student self-assessment), and workplace competency (Analysis & Judgment, Teamwork, etc.). The data consist of mean scores for 64 specific key actions demonstrated during the internship, which were averaged into the 15 workplace competencies. The total respondent number (*n*) for each competency represents the aggregate number of respondents factored into each score. This study consists of assessment terms for collection years 2001-11 (combined accreditation cycles), and the 2006-11 collection years (recent accreditation cycle).

Data analyses were performed using Minitab®-16 where two-tailed Wilcoxon signed rank tests for paired samples (Wilcoxon test) were used as the non-parametric equivalent of the paired samples parametric *t*-test. A level of Type I Error (α) ≤ 0.05 was employed to establish statistical significance, which establishes a maximum probability of 5% that the null hypothesis will be rejected incorrectly. An attained significance value of $p \leq \alpha$ demonstrates a statistically significant difference between the supervisor and self-assessment scores, which supports the conclusion of rejecting the null hypothesis. Test outcomes where $p > \alpha$ indicate that insufficient evidence exists to reject the null hypothesis.

Non-parametric testing was used because the data are collected and aggregated to provide mean rating values across the respondent group. The aggregated (Level 2) data do not provide information on distribution. Contractual agreements with the software distributor, Development Distribution Incorporated (DDI) does not allow access to the raw data where variance could be calculated, or to individual respondent information. The lack of access to variance information eliminates the ability to use parametric testing methods for this study. By ranking the absolute values of the differences between the paired data values using the Wilcoxon signed rank test, the results of a statistical test based on the number of negative and positive differences could be determined. Mean scores provided will also lessen the variances when compared to individual scores. The non-parametric statistics are calculated using a two-sided hypothesis test, which compares the mean values provided by hypothesizing that the difference between Supervisor WCA rankings (Su) and Student Self-assessment WCA rankings (Se) are not different. A drawback in using the Wilcoxon signed rank test is the lower power of the test compared to similar parametric tests. With the signed rank test, it is less likely that the null hypothesis is rejected when it is false. The smaller the Type I error level or alpha (α), the less likely it is to reject the null hypothesis (H_0). The lower power of the test using the signed rank test will also decrease a chance of detecting an effect when it exists. For this study an alpha level of 0.05 is used, which means the chance of finding an effect that does not really exist is 5%.

At a confidence level of 95% the probability of risk for a Type I error is not greater than 0.05. Therefore, if $p < 0.05$ the authors will reject the null hypothesis (H_0) because the probability of error is very low, and if $p > 0.05$ the authors will fail to reject the null hypothesis (H_0) because the probability of error exceeds an acceptable risk level for a Type I error. For the purpose of this study the judgment of failing to reject the null hypothesis or rejecting the null hypothesis is based entirely on the *p*-value being at or below the alpha level

($p <= 0.05$) or above ($p > 0.05$), as provided in the Minitab® calculations to 3 decimal places. No manipulation (rounding) of the data is used.

The Bonferroni method for multiple significance tests was used to conduct and interpret results for the test for multiple comparisons, which corrects the *p*-values for multiple repetitions of the same test. Using a significance value for alpha (α) of 0.05, this value is divided by the number of comparisons being tested. In this case there are a total of 10 tests; therefore, the alpha value is 0.05/10, or 0.005. Under these circumstances, a test is declared to be statistically significant if $p \leq 0.005$. All other differences are determined not to be statistically significant.

Focus Group Survey Sample

The on-line survey (Appendix D) investigates how workplace competency assessment (WCA) data are used within engineering programs in support of the continuous improvement process for accreditation and curriculum development. Forty-seven total questions are divided into 7 separate sections with multiple questions for each: 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. The focus group is comprised of 15 faculty, staff 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. 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. Results of the survey provide insight into the value WCA data have provided for continuous improvement of the program curriculum and accreditation preparation. 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 (6) 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.

Assumptions

The following assumptions were made:

1. Students have acquired adequate training on the 15 workplace competencies and the related key actions.
2. Supervisors have monitored the internship activities with reasonable opportunity to observe student performance.
3. Both respondents have provided a fair and accurate assessment on the demonstration of the workplace competencies.

Limitations

Data from the workplace competency assessment surveys result from student and supervisor assessment of performance in the workplace based on the opportunity to demonstrate competency in each of the 15 workplace competencies at the completion of an internship conducted in the employer's workplace. Demonstration of competency requires observation by the supervisor at a level that provides accurate assessment.

This study was limited to workplace competency assessment data provided by COE's Engineering Career Services (ECS) from workplace competency assessment survey responses. The data were compiled into aggregate mean values, which eliminated the ability to mine data from individual respondents or their supervisory respondents. Workplace competency assessment survey questions were developed by Development Dimensions International, Inc. (DDI) in Philadelphia, PA. As part of the partnership agreement between DDI and ECS, data collected through the online performance and learning (OPAL) assessment survey could be used provided there is no link back to individual students. Inability to link the data to individual respondents limits the level of data mining that can be performed. Direct comparisons between respondent competency ratings and their supervisor ratings were not available for analysis.

Delimitations

The study was delimited by the following:

1. Data collected did not provide information on individual respondents or supervisors.
2. Data available from each assessment term were provided in mean values based on the number of respondents for the term.

3. The sample subjects were comprised of a small number of freshman students, sophomore and junior undergraduate engineering students that had recently completed an internship with an employer in their field of study.
4. The assessment tool was designed to measure a student's demonstration level of performance in each key action activity, based on the question: "when given the opportunity, how often does this individual perform the action?" This subjective form of performance assessment requires several criteria to occur: first, the opportunity must be present before the level of competency can be measured, and requires the assessor to have observed the subjects' demonstration of the activity to provide a knowledgeable assessment of their competency.

Self-assessment allows opportunities for inaccuracies of collected data. When a person provides feedback on their own strengths or weaknesses there is risk of scoring inaccuracies. Their knowledge level on the tasks they are performing can affect accuracy. In their study on longitudinal self-assessment accuracy, Fitzgerald et al. (2003) strived to gain a better understanding of self-assessment and to provide evidence that it is a stable measure of assessment over time; "self-assessment accuracy appears to be influenced by task familiarity; the more familiar the task, the more accurate the self-assessment" (p. 646). As students become more familiar with the key actions with the work they are doing, consistency in assessing demonstration of the competencies should improve. Assessors must fully understand the importance of accurate assessments to each survey question as a measure of valuable feedback to the college for continuous improvement of the curriculum for future engineering students. Inability to define the academic year of the intern limits the depth of research that can be done with this data. The inability to identify individuals within the study limits research in the following areas:

- establishing academic standing and its relationship on workplace competency
- understanding how maturity in the academic program affects the workplace competency outcomes
- understanding how GPA or class ranking impacts key action competencies
- understanding the relationship between courses taken and key action competency
- understanding how gender impacts key action competency

Inability to collect supervisor assessment of employed graduates limits the ability to measure the consistency of self-assessment after graduation. The ability to recognize individual workplace competencies would provide information relating to the personal maturity of the student through their academic years.

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CHAPTER 2. STUDENT SELF-ASSESSMENT AND SUPERVISOR ASSESSMENT RELATIONSHIPS FOR RATING DEMONSTRATION OF WORKPLACE COMPETENCIES IN ENGINEERING INTERNSHIPS.

A manuscript prepared for submission to the *International Journal of Engineering Education*

Mark A. Laingen, Thomas J. Brumm, Steven A. Freeman, & Mack C. Shelley II

Abstract

This study examined the relationship between supervisor assessment and student self-assessment ratings for 15 workplace competencies demonstrated while participating in an internship or coop. This longitudinal study analyzed aggregated data collected for 10 engineering programs across ten-years, which included 29 assessment terms dating from the fall 2001 through the fall 2011 terms. Analysis was performed across 15 workplace competencies, defined through the collaboration of more than 200 constituents to measure learning outcomes defined in the ABET Criterion 3 (a-k) outcomes. The central focus of the study investigated the relationship between the supervisor and student self-assessment ratings to understand if internship students' self-assessment ratings are relational to their supervisor assessment ratings, and if it is a reliable method for assessing the students' demonstration of competencies in the workplace, as a measure for achievement of learning outcomes. Workplace competency assessment is important for assessment of undergraduate students' preparedness for entry into the engineering workplace, and is important for the process of continuous program improvement. Self-assessment provides students with opportunities for reflection to address deficiencies in individual competencies. This study used two-tailed Wilcoxon signed rank tests for non-parametric paired samples to measure the relationship between assessment ratings for supervisor and student assessments across programs and competencies, while investigating the relationship across the span of 10 years. Results supported students' self-assessment of workplace competencies as a valuable method for determining performance levels in the workplace and played an important part in assessment of undergraduate preparedness for entry into the engineering workplace. This research can benefit the student continuous improvement processes for enhancing their knowledge, skills, and abilities in 15 measurable workplace competencies, and provide valuable information for program evaluation and curriculum development.

Keywords: Assessment, Bonferroni adjustment criterion, Experiential learning, Self-assessment, Workplace Competencies, Wilcoxon test

Introduction

Every fall and spring semester and summer, undergraduate students participate in internships with companies as part of an experiential learning experience through the College of Engineering (COE) at Iowa State University. Internships provide engineering programs with opportunities to measure students' preparedness for entry into the workplace through quantifiable learning outcomes measured as workplace competencies. These competencies consist of knowledge, skills, attitudes, values, and behaviors that internship students demonstrate in the workplace [2]. Internships enable students to combine classroom learning with supervised work experiences, where they have the opportunity to demonstrate the knowledge, skills, and abilities (KSA) they have acquired during their undergraduate educational experience. Students can apply their KSAs in a dynamic work setting where they can transfer that knowledge to new challenges while gaining practical work experience within their program of study. Demonstration of these KSAs is an important measure of achievement within the educational process. Brumm et al. explain: “success is now focused on how well students achieve desired learning outcomes, not simply whether they’ve completed required coursework” [3, p. 1].

The COE, in collaboration with a constituency of over 200 industry leaders, academic leaders, engineering alumni, students, and parents, identified 15 competencies to address the ABET Criterion 3 (a-k) outcomes, which define knowledge, skills, and abilities (KSA) students should be able to demonstrate by the completion of their undergraduate engineering education [2]. The workplace competencies are each comprised of 2-8 observable and measurable key actions, a total of 64, that quantify the students’ KSAs related to each competency. These program outcomes provide statements that describe the expectations that students will know or be able to demonstrate upon graduation from the program [3]. Workplace competencies satisfy this requirement by monitoring the students’ ability to transfer what they have learned to new challenges, moving beyond measurement of the acquisition of the skill or knowledge [3]. Supervisor assessment of internship students’ demonstration of workplace competencies satisfies ABET guidelines for direct assessment of the outcomes, while self-assessment of outcomes provides indirect assessment measures [4].

Data have been collected since the fall 2001 internship term. This study includes 29 assessment terms from fall 2001 through fall 2011, with overall aggregated respondent numbers for student self-assessments (Se) reaching 5,440 entries and 4,239 supervisor assessments (Su).

Table 1. Relationship between program outcomes matrix and workplace competency

	Engineering 2000 Criterion 3 Program Outcomes	Workplace competency													
		Analysis & Judgment	Communications	Continuous Learning	Cultural Adaptability	Customer Focus	Engineering Knowledge	General Knowledge	Initiative	Innovation	Integrity	Planning	Professional Impact	Quality Orientation	Teamwork
(a)	an ability to apply knowledge of mathematics, science, and engineering	X		X			X		X						
(b)	an ability to design and conduct experiments, as well as to analyze and interpret data	X		X		X	X		X	X		X		X	X
(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	X	X	X	X	X	X		X	X		X		X	X
(d)	an ability to function on multi-disciplinary teams	X	X		X	X			X		X	X	X		X
(e)	an ability to identify, formulate, and solve engineering problems	X	X	X		X	X		X	X				X	X
(f)	an understanding of professional and ethical responsibility	X		X	X			X			X			X	
(g)	an ability to communicate effectively		X			X		X	X				X		
(h)	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	X		X	X		X	X							
(i)	a recognition of the need for, and an ability to engage in life-long learning			X						X					
(j)	a knowledge of contemporary issues	X		X	X			X							
(k)	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	X		X	X		X		X					X	

Adapted from: Brumm, Hanneman, & Mickelson (2006).

Self-assessment is an indirect assessment method that engages the student in the learning process through personal reflection, which helps to enhance their learning experience [5] and provides formative learning opportunities to focus on the knowledge, skills and abilities that require improvement.

Experiential Learning

Internships, a single work related term (semester, or semester plus summer, or summer) and coops, a multiple work related term where responsibilities increase with experience on the job, offer students the opportunity to gain valuable on-the-job work experience while testing possible career paths. Experiential learning is the process of learning through experience, where “knowledge is created through the transformation of experience” and is enriched in the learning process [6, p. 41]. This process for the construction of knowledge involves a creative tension among four learning modes – experiencing, reflecting, thinking, and acting, where the learner engages in a recursive process that is responsive to the contextual situation and what is being learned [5]. Sixty-seven percent of employers polled in an AAC&U survey positively identified experiential learning (internships and community-based projects) as useful in evaluating the engineering graduate’s potential for success, and 50% identify experiential learning as the area to devote the most resources for assessment [7]. Only 13% believed college transcripts to be useful in determining a students’ achievement level in important program learning outcomes [7]. It is an assessment environment more closely structured to simulate later types of learning situations, and one of the truest forms of active learning [8]. Individuals can demonstrate intellectual autonomy, becoming architects of their own education, which enhances their learning experience [9] [5]

[10]. Experiential learning involves four important phases: (1) tangible experiences, which lead to (2) observations and experiences, (3) forming abstract concepts, which concludes with (4) testing these experiences in new situations. All of these phases enhance learning [6]. The transfer of prior knowledge and skills into new challenges is an essential skill toward the graduate's success in the workplace. Achieving expertise requires practice and drill to advance strong initial knowledge within a contexts [11], and experiential learning provides training across different context, providing better knowledge transfer than learning within a single context [11] [12].

Self-assessment

Self-assessment of workplace competencies is an indirect assessment method vital to the experiential learning process, and provides opportunities for reflection on their strengths and weaknesses, to improve targeted learning outcomes [13]. Task familiarity influences the accuracy of self-assessments, and is "reasonably stable when compared with the stability of actual performance" [14, p. 648]. It is a formative learning opportunity that helps students focus on areas of deficiency, which allows them to pursue guidance to enhance their KSA. Formative feedback from the supervisor's workplace competency assessments (WCA) helps to identify desired goals, assess their current competency of these goals, and provides an understanding of methods to close the gap between the two; all three components are necessary to improve the student's learning experience [15]. In-class research has shown that student self-assessment raised their achievement significantly [15] [16] [17] [18].

Dunning, Heath and Suls note that inflation is possible when older students believe the self-assessments will impact their grades [19, p.88]; self-assessment ratings can exceed their supervisor's ratings by more than one-half of one standard deviation [20][21]. Studies conducted by Arnold & Garland [22] challenge this claim, showing business students on internships tended to rate their performance assessments lower than their supervisor assessment ratings. As students gain more experience this differential gap tends to close [22]. Higher competency within the assessed area equates to greater expected accuracy levels when self-assessing that competency [23] [24].

Self-assessment requires a level of metacognition, or "thinking about thinking" [25, p. 32] to be effective, which is central to the self-assessment process. It enables us "to be aware of, monitor, and control mental processes" [25, p. 211]. Students that understand their cognitive processes, can employ the necessary skills to complete a task or achieve a goal, and are better prepared to "compensate for both low ability and insufficient information" [26, p. 34]. Practicing the reflective processes will lead to improved metacognition. Fitzgerald et al, [14] reported on the reliability of self-assessment, stating that student's self-assessment accuracy "is reasonably stable when compared with the stability of actual performance" [14, p. 648]. Assessment of workplace competencies results from demonstration of actual performance in the workplace, which should measure performance competency with relative accuracy. Self-assessment feedback of workplace competencies preparation received from experienced alumni provides valuable feedback that aids in continuous improvement of engineering program curriculum. As alumni gain experience and expertise in their field, self-assessment studies demonstrate that assessment accuracy improves [27].

Purpose of the Study

This study centers its focus around the relationship between supervisor assessment ratings (Su) and student self-assessment ratings (Se) across the 15 workplace competencies collected between the 2001-11 assessment terms. The study strives to answer the central question: "What relationships exist between self-assessment and supervisor assessment of engineering internship students' demonstration of workplace competencies?" This study strives to analyze the questions:

1. What is the relationship between 2001-11 supervisor and student self-assessment ratings across the 15 workplace competencies by workplace competency and COE program?
2. What is the relationship between 2001-11 supervisor and student self-assessment ratings across the 64 key actions linked to the 15 workplace competencies by program?
3. What is the relationship between 2001-11 supervisor and student self-assessment ratings across 15 workplace competencies for all engineering internship students combined?
4. What is the relationship between 2001-11 supervisor and student self-assessment ratings across 64 key actions related to the 15 workplace competencies for all engineering internship students combined?

Methodology

Sample

Samples are comprised of undergraduate students actively enrolled in an engineering program during a paid internship at an employer's location, and the supervisors that were involved in managing the internships. Results do not directly reflect the Iowa State University engineering student population, although more than 80% of graduates from engineering programs participate in some form of experiential education [28].

Instrument

The workplace competency assessment survey was administered by the College of Engineering through the Online Performance and Learning (OPAL®) software developed by Development Dimensions International Inc. (DDI) [29], a global leader in talent management and assessment. It involves performance-related questions that survey the respondent's perception of how well the student performed in key actions linked to fifteen workplace competencies. The key actions are actions performed in the work environment that are clear, independent, and assessable measures for demonstration of the 15 workplace competencies. The instrument focuses on the question: "When given the opportunity, how often does this person perform the action?" Responses are quantified through a 5-point summated (Likert-type) scale [30] designed to assess internship students' demonstration of the competency key actions (1 = never or almost never; 2 = seldom; 3 = sometimes; 4 = often; 5 = always or almost always).

Data Collection

In order to receive academic credit for the internship, students are required to complete a workplace competency assessment (WCA) survey near the end of an internship, and the internship supervisor are asked to complete an identical assessment [24]. As part of the contractual agreement with the Online Performance and Learning (OPAL®) assessment software supplier DDI Corporation [17], individual identification is recorded, but only to be used to track direct feedback from supervisors that students can access to gain insight into their strengths and deficiencies. Individual respondent information is not available for use by the college, and thus the data does not provide information on the variance. The WCA survey asks respondents to rate the student's demonstration of 64 key action items linked to the 15 College of Engineering workplace competencies. Workplace competency ratings derive from the average of related key action ratings. Numbers (*n*) reflected in the tests identify the instances used in the tests according to the number of competencies or key actions measured. Actual respondent numbers for each competency represents the aggregate number of program respondents (Table 2) factored into each score. The overall 2001-11 COE responses for student self-assessments (Se) were 5440, and supervisor assessments (Su) were 4239. Aggregate respondent totals by program for 2006-11 and 2001-05 were provided as reference, corresponding to the accreditation cycle.

Table 2. Respondent numbers by program

	2001-11 Respondents	
COE Program	Se	Su
Aerospace (AER)	351	298
Agricultural (AGR)	219	190
Chemical (CHE)	411	334
Civil (CIV)	580	445
Computer (CPR)	410	323
Construction (CON)	797	553
Electrical (ELE)	402	313
Industrial (IND)	484	370
Materials (MAT)	216	174
Mechanical (MEC)	1,570	1,239
Combined COE	5,440	4,239

Managing Non-responses or Missing Values

Respondents have the ability to select the “no response” (NR) option, which is treated as a missing value. Missing values occur for multiple reasons that are undocumented in the responses. In this research, categories that indicate no response by the respondents are omitted from the analysis.

Assumptions

The following assumptions were:

1. Students have an understanding of the 15 workplace competencies and the related key actions.
2. Supervisors have monitored the internship activities with reasonable opportunity to observe student performance.

3. Both respondents have provided a fair and accurate assessment on the demonstration of the workplace competencies.

Statistical Design

Assessment data are collected from the online workplace competency assessment survey by year, internship session (Spring, Spring/Summer, Summer, Summer/Fall, and Fall), by the program: Aerospace (AER), Agricultural (AGR), Chemical (CHE), Civil (CIV), Computer (CPR), Construction (CON), Electrical (ELE), Industrial (IND), Materials (MAT), Mechanical (MEC), or all internship students in the College of Engineering (COE). The data are also separated by respondent type (Supervisor or Student self-assessment), and workplace competency (Analysis & Judgment, Teamwork, etc.). The data consist of mean scores for 64 specific key actions demonstrated during the internship, which are averaged into the related 15 workplace competencies. The total respondent number (*n*) for each competency represents the aggregate number of respondents factored into each score. The total respondent number (*n*) for each competency represents the aggregate number of respondents factored into each score. This study consists of aggregated assessment terms from fall 2001 through fall 2011.

Data analyses were performed using Minitab®-16 where a two-tailed Wilcoxon signed rank tests for paired samples (Wilcoxon test) were used as the non-parametric equivalent of the paired samples parametric *t*-test. A level of Type I Error (α) ≤ 0.05 was employed to establish statistical significance, which establishes a maximum probability of 5% that the null hypothesis will be rejected incorrectly. An attained significance value of $p \leq \alpha$ demonstrates a statistically significant difference between the supervisor and self-assessment scores, which supports the conclusion of rejecting the null hypothesis of no difference. Test outcomes where $p > \alpha$ indicate that insufficient evidence exists to reject the null hypothesis of no difference.

The Wilcoxon test for paired samples, (Wilcoxon test), was used for this study as the non-parametric equivalent of the paired samples parametric *t*-test. The aggregated (Level 2) data does not provide information on distribution. Contractual agreements with the software distributor, Development Distribution Incorporated (DDI), does not allow access to the raw data where variance may be calculated or to individual respondent information for the programs. The process results in a standardized data set that can be used for analysis purposes. The lack of access to variance information eliminates the ability to use parametric testing methods for this study. By ranking the absolute values of the differences between the paired data values using the Wilcoxon signed rank test, the results of a statistical test based on the number of negative and positive differences could be determined. Mean scores provided will also lessen the variances when compared to individual scores. By ranking the absolute values of the differences between the paired data values, the results of a statistical test based on the number of negative and positive differences could be determined. The non-parametric statistics were calculated using a two-sided hypothesis test, which compares the mean values, provided in the raw data by hypothesizing that the difference between Supervisor WCA rankings (Su) and Student Self-assessment WCA rankings (Se) are not different. A drawback in using the Wilcoxon signed rank test is the power of the test compared to similar parametric tests. With the signed rank test, it is less likely that the null hypothesis be rejected when it is false. The smaller the Type I error level or alpha (α), the less likely it is to reject the null hypothesis (H_0). The lower power of the test using the signed rank test will also decrease a chance of detecting an effect when it exists. For this study, an alpha level of 0.05 was used, which means the chance of finding an effect that does not really exist is 5%.

The Bonferroni adjustment method for multiple significance tests was used to conduct and interpret results for the test for multiple comparisons, which corrects the *p*-values for multiple repetitions of the same test. Using a significance value for alpha (α) of 0.05, this value was divided by the number of comparisons being tested. In this case, there are 10 tests; therefore, the alpha value is 0.05/10, or 0.005. Under these circumstances, a test is declared to be statistically significant if $p \leq 0.005$. All other differences are determined not to be statistically significant.

Results

2001-11 supervisor (Su) and self-assessment (Se) by competency and program

This test analyzes the relationship between Su and Se ratings for internship workplace competencies, aggregated across the 29 internship terms collected between 2001 and 2011 (see Table 3). Paired scores from the aggregated mean competency ratings for supervisor assessment (Su) and student self-assessment (Se) ratings were calculated using the Wilcoxon test to determine the relational difference in ratings for each of the 15 competencies. Results for programs demonstrating statistical significance when Bonferroni adjustment criterion is applied ($p \leq 0.005$) are identified (see Table 4).

Estimated median values were provided to indicate if higher supervisor or student rating values are experienced. A positive estimated median value from the equation: Su – Se, identifies a higher median supervisor rating.

Table 3. 2001-11 Program competency assessment ratings by workplace competency

	COE Program																			
Workplace competency	*AER*		*AGR*		*CIV*		*CHE*		*CON*		*CPR*		*ELE*		*IND*		*MAT*		*MEC*	
	Su	*Se*	*Su*	*Se*	*Su*	*Se*	*Su*	*Se*	*Su*	*Se*	*Su*	*Se*	*Su*	*Se*	*Su*	*Se*	*Su*	*Se*	*Su*	*Se*
Analysis and Judgment	4.40	4.32	4.40	4.31	4.38	4.33	4.27	4.24	4.33	4.33	4.46	4.40	4.47	4.38	4.31	4.39	4.40	4.31	4.34	4.31
Communications	4.19	4.14	4.28	4.17	4.31	4.21	4.15	4.12	4.18	4.20	4.29	4.23	4.32	4.21	4.24	4.26	4.27	4.20	4.17	4.16
Continuous Learning	4.43	4.26	4.47	4.36	4.43	4.36	4.28	4.19	4.42	4.40	4.47	4.44	4.56	4.39	4.37	4.38	4.42	4.31	4.41	4.33
Cultural Adaptability	4.38	4.47	4.41	4.49	4.51	4.45	4.42	4.47	4.52	4.49	4.56	4.58	4.61	4.53	4.53	4.58	4.49	4.54	4.50	4.47
Customer Focus	4.30	4.13	4.30	4.15	4.40	4.29	4.15	3.96	4.26	4.21	4.26	4.21	4.38	4.23	4.32	4.26	4.29	4.07	4.26	4.14
Engineering Knowledge	4.41	4.28	4.43	4.30	4.57	4.33	4.38	4.20	4.39	4.34	4.54	4.45	4.56	4.37	4.31	4.35	4.49	4.35	4.45	4.35
General Knowledge	4.27	4.36	4.31	4.40	4.41	4.30	4.22	4.16	4.34	4.40	4.41	4.37	4.39	4.32	4.29	4.40	4.40	4.30	4.32	4.29
Initiative	4.47	4.15	4.53	4.26	4.42	4.23	4.25	4.07	4.31	4.27	4.42	4.28	4.49	4.22	4.32	4.24	4.42	4.18	4.38	4.20
Innovation	4.15	4.03	4.21	4.11	4.20	4.07	3.96	3.96	4.06	4.09	4.22	4.21	4.24	4.14	4.14	4.16	4.18	4.03	4.17	4.11
Integrity	4.86	4.77	4.86	4.81	4.82	4.74	4.80	4.70	4.79	4.74	4.79	4.78	4.90	4.79	4.79	4.78	4.88	4.76	4.79	4.75
Planning	4.38	4.33	4.47	4.39	4.50	4.42	4.33	4.26	4.37	4.45	4.42	4.36	4.50	4.37	4.41	4.47	4.47	4.33	4.40	4.37
Professional Impact	4.59	4.44	4.52	4.46	4.60	4.42	4.43	4.37	4.52	4.45	4.52	4.44	4.57	4.39	4.57	4.53	4.57	4.38	4.51	4.42
Quality Orientation	4.55	4.45	4.60	4.53	4.58	4.52	4.52	4.40	4.51	4.48	4.53	4.56	4.58	4.50	4.52	4.48	4.67	4.50	4.51	4.45
Teamwork	4.44	4.46	4.59	4.44	4.39	4.47	4.42	4.34	4.49	4.49	4.52	4.52	4.54	4.46	4.44	4.54	4.56	4.45	4.47	4.45
Safety Awareness	4.21	4.03	4.44	4.04	4.28	4.40	4.40	4.26	4.40	4.30	4.42	4.27	4.47	4.30	4.39	4.30	4.40	4.19	4.40	4.18

Using the Bonferroni adjustment criterion ($\alpha \leq 0.005$), all programs for the following workplace competencies; Analysis and Judgment, Communications, Cultural Adaptability, General Knowledge, Innovation, Planning, and Teamwork did not meet the criterion to reject the null hypothesis indicating no significant statistical difference between supervisor assessment ratings and the paired student self-assessment ratings. Results for the following workplace competencies showed no significant difference between supervisor assessment and student self-assessment in all programs had all programs except those listed.

Programs where results showed a significant difference by workplace competency included: Continuous Learning, AER (p=.005) and ELE (p=.001), Customer Focus MEC ($p < 0.001$) , Engineering Knowledge AGR (p= 0.005), CIV ($p < 0.001$), CHE ($p = 0.001$), ELE ($p < 0.001$), and MEC ($p < 0.001$), Initiative AER ($p < 0.001$), AGR ($p < 0.001$), CIV (p= 0.003), CHE (p= 0.002), ELE ($p < 0.001$), MAT (p=.003), and MEC ($p < 0.001$), Integrity, CHE (p= 0.004) and ELE (p< 0.001), Professional Impact, ($\alpha \leq 0.005$), AER (p=.002), CIV (p=.005), ELE (p<.001), and MEC (p<.001), Quality Orientation, CHE (p=.003), and Safety Awareness, MEC (p<.001). Results for each of these met the criterion to reject the null hypothesis (see Table 4).

All programs in the following workplace competencies; Continuous Learning, Engineering Knowledge, Initiative, Integrity, Professional Impact, Quality Orientation, and Safety Awareness resulted in a positive outcome descriptively for the Wilcoxon estimated median, indicating that supervisor assessment ratings were slightly higher than the paired student self-assessment ratings. The following workplace competencies reflected a Wilcoxon

Table 4. Statistical significance of 2001-11 Su-Se results using Bonferroni adjustment criterion

2001-11 Su-Se	*COE Programs*										*Rejecting H_0*
	AER	*AGR*	*CIV*	*CHE*	*CPR*	*CON*	*ELE*	*IND*	*MAT*	*MEC*	*$\alpha = 0.005$*
Analysis & Judgment											*0*
Communication											*0*
Continuous Learning	*X*						*X*				*2*
Cultural Adaptability											*0*
Customer Focus										*X*	*1*
Engineering Knowledge		*X*	*X*	*X*			*X*			*X*	*5*
General Knowledge											*0*
Initiative	*X*	*X*	*X*	*X*			*X*		*X*	*X*	*7*
Innovation											*0*
Integrity				*X*			*X*				*2*
Planning											*0*
Professional impact	*X*		*X*				*X*			*X*	*4*
Quality Orientation				*X*							*1*
Safety										*X*	*1*
Teamwork											*0*
Significant Competencies ($\alpha = 0.005$)	*3*	*2*	*3*	*4*	*0*	*0*	*5*	*0*	*1*	*5*	

estimated medians for Analysis and Judgment, IND (-0.022) , Communications, CON (-.006) and ELE (-0.028), Cultural Adaptability, ER (-0.080), CHE (-0.030), IND (-0.030) and MAT (-0.030), Customer Focus, CON (-0.006) and ELE (-0.028), General Knowledge, AER (-0.075), AGR (-0.045), CON (-0.057), IND (-0.061), Innovation, CON (-0.015) and ELE (-0.060), Planning, CON (-0.082) and IND (-0.075), and Teamwork, IND (-0.081) reflect a positive outcome descriptively, for all programs.

Relationships between supervisor assessments (Su) and student self-assessments (Se) across 2001-2011 assessments terms for overall COE ratings

When comparing combined COE 2001-11 aggregated supervisor and student self-assessment ratings across the 15 workplace competencies (*n*= 15), it is concluded with 95% confidence (α = 0.05) that the median difference between supervisor (Su) and student self-assessment (Se) ratings for assessment terms from fall 2001 to fall 2011demonstrate a significant difference between Su and Se ratings (*p*= 0.001), therefore rejecting the null hypothesis that paired supervisor and student self-assessment ratings are equal.

When comparing combined COE 2001-11 aggregated supervisor and student self-assessment ratings across the 64 workplace competency key actions (*n*= 64), it is concluded with 95% confidence (α = 0.05), that the median difference between supervisor (Su) and student self-assessment (Se) ratings for assessment terms from fall 2001 to fall 2011demonstrate a significant difference between Su and Se ratings (*p*<.001), therefore the null hypothesis is rejected. The Wilcoxon estimated median for the overall 2001-11 aggregated COE data demonstrates a positive outcome of 0.074, indicating that the Supervisor (Su) median response rated is slightly higher than the paired Student (Se) Actual number of supervisor (Su) respondents for the survey were 4,239, and student self-assessments (Se) were 5,440.

Relationship between 2001-11 supervisor and self-assessment ratings across 64 competency key actions

This test analyzes the statistical relationship between aggregated supervisor (Su) and student self-assessment (Se) workplace competency assessment ratings by engineering program across 64 workplace competency key actions (n= 64) collected between fall 2001 and fall 2011 using the Wilcoxon signed rank test for non-parametric data. The data reflect mean values for each program over 29 separate assessment terms; actual respondent numbers are noted in Table 1. When calculating 2001-11aggregated data by workplace competency, the relationship between supervisor (Su) and self-assessments (Se), the tests failed to reject the null hypothesis for IND (p= .523), and rejected the null hypothesis for all other programs: AER (p<.001), AGR (p<.001), CIV (p< 0.001), CHE (p< 0.001), CON (p= 0.005), CPR (p< 0.001), ELE (p< 0.001), MAT (p< 0.001), and MEC (p< 0.001). The estimated median for all programs reflect a positive outcome and ranged from 0.008 to 0.163, indicating that the Supervisor (Su) median response rated slightly higher than the paired Student (Se) response. Data are analyzed using a 95% confidence interval.

Discussion and Conclusions

Based on results of this study on the relationship between paired supervisor assessment (Su) and student self-assessment (Se) ratings between fall 2001 and fall 2011 measuring students' demonstration of workplace competencies during internships and coops, using the Bonferroni adjustment criterion ($\alpha = 0.005$) , the following conclusions can be made with 99.5% confidence.

- The analysis revealed that Analysis & Judgment, Communication, Continuous Learning, Cultural Adaptability, Customer Focus, General Knowledge, Innovation, Integrity, Planning, Quality Orientation, Safety, and Teamwork have 80% or more programs showing results that indicate no significant difference between supervisor and student self-assessment ratings. This relationship supports aggregated student self-assessment ratings as a valid assessment tool when compared to the paired supervisor assessment ratings.
    - Almost half of those competencies (47%) resulted in all 10 programs having no significant difference between supervisor and self-assessment ratings.
    - The analysis of only two competencies resulted in a highly significant difference between paired ratings of supervisors' assessments and students' self-assessments; with Initiative at a 30%, and Engineering Knowledge at a 50% rate. This indicates the ratings between paired supervisor assessments and student self-assessments were significantly different in these competencies, meaning Su and Se were most often not equal. It is speculated that freshman and sophomores having participated in an internship would not have been prepared in core engineering classes, which could influence the results for competencies like Engineering Knowledge and Initiative, which includes key actions assessing acting quickly to problems, taking independent action to implement new ideas or solutions without prompting, and taking action beyond job requirements.

- The relationship for Professional Impact showed that 60% of the programs demonstrated that supervisor and student self-assessment ratings were not significantly different.

- When focusing on the 10 COE programs , the analysis revealed, all of the programs demonstrated that supervisor and student self-assessment ratings were not significantly different in two-thirds or more of the workplace competencies. Seventy percent of the programs showed no significant difference between supervisor and student self-assessment in 80% or more workplace competencies. This indicates that self-assessment ratings are a strongly reliable method for assessment of workplace competencies in internships and coops.
- When comparing 2001-11 supervisor assessment ratings and student self-assessment ratings across 64 key actions related to the workplace competencies, the analysis revealed that 90% of the programs showed a significant difference between the ratings. This indicates that supervisor and student self-assessment are not equal, and therefore this test proves less reliable for comparison of the two ratings.
- The three tests reflect a positive Wilcoxon estimated median, indicating a slightly higher supervisor rating than student self-assessment rating, which helps to establish there is no inflation of self-assessment ratings in this study.

Based on the results of this study, when comparing the relationship between paired supervisor (Su) assessments ratings and student self-assessment (Se) ratings for combined COE ratings using the Wilcoxon singed rank test ($\alpha = 0.05$), the following conclusions can be made with 95% confidence:

- When comparing the relationship between paired supervisor (Su) assessments ratings and student self-assessment (Se) ratings across the 15 workplace competencies there is a significant difference between supervisor assessment and student self-assessment ratings, indicating the two are not equal. From this analysis, it can be concluded that it is a less reliable method for comparing supervisor and student self-assessments.
- The statistical analysis showed when comparing the relationship between paired supervisor (Su) assessments ratings and student self-assessment (Se) ratings across the 64 key actions related to the 15 workplace competencies there is a significant difference between supervisor assessment and student self-assessment ratings, indicating the two are not equal. From this analysis, it can be concluded that it is a less reliable method for comparing supervisor and student self-assessments.
- The two tests reflect a positive Wilcoxon estimated median, indicating a slightly higher supervisor rating than student self-assessment rating, which helps to establish there is no inflation of self-assessment ratings in this study.

Based on the findings of this study, the following recommendations for future research studies include:

- Additional research is required to identify the causal difference between Initiative, Engineering Knowledge, and Professional Impact.
- Additional research is needed to determine the influence freshman and sophomore internship students have on competency assessment ratings for Engineering Knowledge and other competencies. This requires access to individual level data.

- Gaining access to individual student assessment ratings to correlate ratings based on individual characteristics such as: class ranking, gender, student organization affiliations, etc.
- On-going research should continue to investigate the relationship of supervisor and student self-assessment rating during the current accreditation cycle.

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CHAPTER 3. INTERNSHIP WORKPLACE COMPETENCIES ASSESSMENT: COMPARING SUPERVISOR ASSESSMENT AND STUDENT SELF-ASSESSMENT RATINGS ACROSS ACCREDITATION CYCLES.

A manuscript prepared for submission to the *International Journal of Engineering Education*

Mark A. Laingen, Thomas J. Brumm, Steven A. Freeman, Mack C. Shelley II,
& Steven K. Mickelson

Abstract

This longitudinal study examined the relationship between supervisors' assessment ratings and internship students' self-assessment ratings for the demonstration of 15 workplace competencies, spanning ten years and 29 assessment terms, from fall 2001 through fall 2011. The study analyzed the aggregated statistical data from workplace competency assessment ratings data organized by the 2001-05 assessment terms and 2006-11 assessment terms based on the relative accreditation cycle. Data were analyzed using the Wilcoxon signed rank tests as a non-parametric equivalent to the paired *t*-test, which determined the median difference between supervisor assessment and student self-assessment ratings for the 15 workplace competencies. Bonferroni adjustment criterion were used to correct for multiple comparisons. The overarching focus of the study sought to validate internship students' self-assessment of workplace competencies through the relationship with the paired supervisor assessments.

Keywords: Bonferroni adjustment criterion, experiential learning, Wilcoxon testing, self-assessment, workplace competency assessment

Introduction

This study investigated the relationship between supervisor assessment ratings and student self-assessment ratings for the demonstration of 15 workplace competencies assessed at the conclusion of engineering internships, consisting of a single work related term (semester, or semester plus summer, or summer), or cooperative work experience, consisting of a multiple work related term where responsibilities increase with job experience. The College of Engineering (COE) at Iowa State University (ISU), in collaboration with a constituency of 212 industry leaders, academic leaders, engineering alumni, active engineering students, and parents, identified 15 workplace competencies that are each comprised of 2-8 observable and measurable key actions to quantify the students' knowledge, skills, and abilities (KSA) related to each of the ABET Criterion 3 (a-k) outcomes [1]. The ABET Criterion 3 outcomes define the KSA students should be able to demonstrate by the completion of their undergraduate engineering education [2]. Workplace competency assessment data have been collected since the fall 2001 internship term. This study focused on assessment terms from fall 2001 through fall 2011 spanning ten years and two accreditation cycles. The study included 29 separate assessment terms, with overall respondent numbers for student self-assessments totaling 5,440 students, and supervisor assessment responses totaling 4,239 entries.

Although this study does not represent the entire COE student population, more than 85% of COE undergraduate students have participated in internships or coops [1], which provide exceptional representation for the undergraduate engineering population. Supervisor response rates have consistently ranged from 65-80% participation [1]. Data analysis and statistics calculated in this study focus on the relationship between internship students' and supervisors' workplace competency ratings within 10 COE programs for each of the 15 workplace competencies across the 2 assessment term groups related to the 2001-05 and 2006-11 accreditation cycles . The study sought to verify the hypothesis that internship students' self-assessment of workplace competencies are a reliable method for determining students' preparation for transition into the engineering workplace.

Purpose of the Study

This study focused on the central question: "What relationships exist between supervisor assessment and internship students' self-assessment ratings for workplace competencies when comparing the 2001-05 accreditation cycle to the 2006-11 accreditation cycle?" Specific questions targeted in this study include:

1. What is the relationship between engineering internship students' self-assessment and supervisors' assessment ratings for demonstration of internship workplace competencies between the 2001-2005 assessment terms within each engineering program?
2. What is the relationship between engineering internship students' self-assessment and supervisor assessment ratings for demonstration of workplace competencies in the workplace between the 2006-2011 assessment terms within each engineering program?
3. What is the relationship between the 2001-05 and 2006-11 supervisor assessment sessions within the 15 workplace competencies?
4. What is the relationship between the 2001-05 and 2006-11 student self-assessment sessions within the 15 workplace competencies?

This study focused on the strength of the relationship between supervisor assessments and student self-assessments, and the reliability of self-assessments as a measure of workplace competency.

Literature Review

Experiential Learning

Experiential learning, a term labeled by Kolb [3] for the process of learning through experiences is an environment where "…knowledge is created through the transformation of experience" [3, p. 41]. Experiential learning through internships, a single work related term (semester, or semester plus summer, or summer) and coops, a multiple work related term where responsibilities increase with experience on the job, offer students the opportunity to gain valuable on-the-job work experience while testing possible career paths. Experiential learning gained through internships and cooperative work experience, identified as internships for this study, is one of the truest forms of active learning, where learning is enriched in the process, which provides an authentic assessment environment where knowledge is gained through experiences more closely structured to simulate later types of learning situations [3] [4] [5]. Currently over two-thirds of employers positively identify experiential learning environments as a useful environment for evaluating the graduates' potential for success, and fifty percent target experiential learning, through internships and community-based projects, as the place where institutions should devote the most resources for assessment [6] [7]. In contrast, college transcripts are viewed as useful for determining a student's level of achievement for important program learning outcomes by one eighth of those surveyed [6].

Experiential learning encompasses four learning modes – experiencing, reflecting, thinking, and acting –where the learner engages all four modes based on the learning situation and what is being learned [4]. Internship students have the autonomy to become builders of their education and continually advance their skills in the process [8] [9]. Four important phases that enhance the experiential learning process involves, (1) tangible experiences, which lead to (2) observations and experiences, (3) forming abstract concepts, which concludes with (4) testing these experiences in new situations [4]. Experiential learning provides a formative feedback process that improves learning through the transfer of prior knowledge and skills to new challenges. This skill set is a critical factor in a graduate’s opportunity for success in the workplace. Practice and drill are required to advance understanding within a context, and strong initial knowledge is a necessity for the transfer of knowledge toward achieving expertise [10]. Students have a better opportunity to learn a concept if they are provided opportunities to practice their knowledge and skills in a variety of applications [10].

Workplace environments provide an opportunity for internship students to practice their acquired knowledge, skills, and abilities (KSA) in an authentic work environment, leading toward higher levels of competency and expertise by completion of their undergraduate studies. This achievement of knowledge, skills, and organized characteristics is the result of development and understanding acquired en-route to higher levels of expertise [10]. Expertise gained through this experience enhances the student’s capability to draw from a more specific depth of knowledge and skills, with more intuition and less effort to recall [11]. The experience enables the assessment of situations through reasoning, and demonstrating organization in their knowledge and understanding of their situation, using problem-solving skills to transfer prior knowledge to new challenges.

Workplace Competencies

The COE programs, through the support of Engineering Career Services [12] have used workplace competency assessments data since fall 2001 as a method of assessment for undergraduate students' demonstration of workplace competencies in internships and cooperative work experiences. Workplace competencies are mapped to the ABET Criterion 3 (a-k) student learning outcomes [2], with 2-8 key actions linked to each outcome. A total of 64 key actions are used to quantify the 15 workplace competencies through clear, definable, readily observable, and instantly measureable metrics that are "consistent with the visions and missions of our college and university, and align with existing employer assessment, development and performance management practices" [1, p. 124]. These competencies directly link to the ABET Criterion 3 (a-k) outcomes, in which students must demonstrate competency prior to completion of their undergraduate studies. It was determined by the COE that the ABET (a-k) outcomes were too difficult to measure directly [1]. Each outcome represented "some collection of workplace competencies necessary for the practice of engineering at the professional level" [1, p. 2]. Providing measurable actions to address the ABET (a-k) outcomes allowed the COE to quantify how well internship students were able to demonstrate their knowledge, skills, and abilities that they have acquired during their undergraduate education experiences.

Engineering students' academic learning experiences are concentrated primarily within the walls of classrooms; constituents surveyed have ranked this environment with less than a 50% probability, as the least likely setting for students to have the opportunity to demonstrate the competencies The engineering workplace was ranked with a 90% probability as the most likely place for opportunities to demonstrate the communication competency. Engineering cooperatives and internships were ranked second, with an 80% probability [1]. Brumm et al. [1] define competency-based learning as "involving the redefining of program, classroom, and experiential education objectives as competencies or skills, and focusing coursework on competency development" [1, p. 2].

A student's strengths and deficiencies in acquired knowledge, skills, and abilities (KSA) are measured through assessment of internship students' workplace competencies. Engineering experiential education is the only opportunity during the undergraduate engineering program that provides a direct observation of the students' demonstration of the ABET (a-k) Criterion 3 outcomes while in a professional engineering environment [13]. All other opportunities are "at best a simulation of engineering practices" [13, p. 2], and align with existing employer assessment, development and performance management practices" [21, p. 124]. Workplace competencies are consistently used in industry for ongoing assessment of personal and professional development. In workplaces that are continually expanding and advancing technologically, competencies help employers determine if graduates can apply the knowledge learned beyond the acquisition of that knowledge [14]. Completion of coursework requirements is no longer entirely the primary concentration for student success. Demonstration of competency is now measured by achievement of program learning outcomes [1]. Outcome-based learning environments challenge students to apply their knowledge to perform meaningful tasks in the most effective environment where learning occurs [15] [16]. Proficiency of workplace competencies is essential to future success for graduating students [17] and helps answer constituent questions about student preparedness for entry into the workplace.

Methodology

Sample

Samples consisted of two respondent groups for each assessment term; the first group includes self-assessment ratings (Se) from undergraduate students actively enrolled in an engineering program during an internship at an employer's location, and the second set included assessment ratings from supervisors (Su) that have observed the students during the internship. Program respondent numbers varied each semester based on enrollment in a summer or professional internship. Results do not directly reflect the Iowa State University engineering student population, although more than 80% of graduates from engineering programs participated in some form of experiential education [13].

Instrument

The workplace competency assessment surveys were administered by the College of Engineering through the Online Performance and Learning (OPAL™) software developed by Development Dimensions International Inc. (DDI) [18], a global leader in talent management and assessment. It involved performance-related questions that survey the respondents' perception of how well the student performed in key actions linked to fifteen workplace competencies. The instrument focused on the question, "When given the opportunity, how often does this person perform the action?" Responses were quantified through a 5-point summated (Likert-type) scale [19] designed to assess internship students' demonstration of the competency key actions (1 = never or almost never; 2 = seldom; 3 = sometimes; 4 = often; 5 = always or almost always).

Data Collection

Data from workplace competency assessment surveys have been collected since completion of the fall 2001 term. In order to receive academic credit for the internship, students were required to complete a workplace competency assessment (WCA) survey near the end of an internship, and the internship supervisors were asked to complete an identical assessment survey [13]. As part of the contractual agreement with OPAL® assessment software supplier Development Distribution Incorporated (DDI) [18], individual respondent identification were recorded, but only accessible by the student to track supervisor feedback in an effort to gain insight into their strengths and deficiencies. Contractual agreements with the software distributor, DDI did not allow access to the raw data where variance could be calculated or to individual respondent information for the programs. The process resulted in a standardized data set that could be used for analysis purposes. The lack of access to variance information eliminated the ability to use parametric testing methods for this study. The WCA survey asked respondents to rate the internship/cooperative students on the demonstration of 64 key action items linked to 15 workplace competencies. Key actions are descriptions of activities designed to provide clear, concise, specific, observable and assessable descriptions that identify each of the 15 workplace competencies to quantify the ABET Criterion 3 (a-k) Outcomes [13]. Each workplace competency is comprised of between 2 and 8 key action items.

Data Analysis

Workplace competency assessment data were collected from the online workplace competency assessment surveys and organized by year(2001-11), internship session (Spring, Spring/Summer, Summer, Summer/Fall, and Fall), by the program: Aerospace (AER), Agricultural (AGR), Chemical (CHE), Civil (CIV), Computer (CPR), Construction (CON), Electrical (ELE), Industrial (IND), Materials (MAT), Mechanical (MEC), or by combined internship students in the College of Engineering (COE). The data are also separated by respondent (Supervisor or Student self-assessment), and workplace competency (Analysis & Judgment, Teamwork, etc.). The data consisted of mean scores for 64 specific key actions demonstrated during the internship, which were averaged into the 15 workplace competencies. The total respondent number (*n*) for each competency represent the aggregate number of respondents factored into each score (Table 1). This study consists of assessment terms for collection years 2001-05 (past accreditation cycle), and the 2006-11 collection years (recent accreditation cycle).

Data analyses were performed using Minitab®-16 where a two-tailed Wilcoxon signed rank tests for paired samples (Wilcoxon test) was used as the non-parametric equivalent of the paired samples parametric *t*-test. A level of Type I Error (α) ≤ 0.05 was employed to establish statistical significance, which established a maximum probability of

Table 1. Respondent numbers by program, respondent, and accreditation cycle

	Accreditation Cycle			
	2006-11		2001-05	
COE Program	**Se**	**Su**	**Se**	**Su**
Aerospace	210	174	141	124
Agricultural	132	109	87	81
Chemical	213	159	198	175
Civil	325	227	255	218
Computer	140	90	270	233
Construction	520	343	277	210
Electrical	195	133	207	180
Industrial	272	191	212	179
Materials	119	91	97	83
Mechanical	798	558	772	681
Combined COE	2,924	2,075	2,516	2,164

5% that the null hypothesis will be rejected incorrectly. An attained significance value of $p \leq \alpha$ demonstrates a statistically significant difference between the supervisor and self-assessment scores, which supports the conclusion of rejecting the null hypothesis of no difference. Test outcomes where $p > \alpha$ indicate that insufficient evidence exists to reject the null hypothesis of no difference.

Aggregated data did not provide information on distribution. Contractual agreements with the software distributor, Development Distribution Incorporated (DDI) did not allow access to the raw data where variance was calculated or to individual respondent information for the programs. The process resulted in a standardized data set that was provided for analysis purposes. The lack of access to variance information eliminated the ability to use parametric testing methods for this study. By ranking the absolute values of the differences between the paired data values using the Wilcoxon signed rank test, the results of a statistical test based on the number of negative and positive differences could be determined. Mean scores provided will also lessen the variances when compared to individual scores.

A shortcoming in using the Wilcoxon signed rank test was the power of the test compared to similar parametric tests. With the signed rank test, it is less likely that the null hypothesis be rejected when it is false. With a smaller Type I error level or alpha (α), the less likely it was to reject the null hypothesis (H_0). The lower power of the test using the signed rank test also decreased the chance of detecting an effect when it exists. For this study an alpha level of 0.05 was used, therefore the chance of finding an effect that does not really exist is 5%.

The Bonferroni adjustment method for multiple significance tests was used to conduct and interpret results for the test for multiple comparisons, which corrected the *p*-values for multiple repetitions of the same test. Using a significance value for alpha (α) of 0.05, this value was divided by the number of comparisons being tested. In this case there were a total of 10 test; therefore an alpha value of 0.05/10, or 0.005 was used. Under these circumstances, a test was declared to be statistically significant if $p \leq 0.005$. All other differences were determined not to be statistically significant. For this test the data were analyzed using five tests to identify the relationships between supervisor and self-assessment ratings based on the research questions.

Managing Non-responses or Missing Values

Respondents were provided the option to select “no response” (NR), which were treated as a missing value. Missing values occurred for multiple reasons that were undocumented in the responses. In this research, categories that indicated no response by the respondents were omitted from the analysis.

Assumptions

The following assumptions were made:

1. Students had an understanding of the 15 workplace competencies and the related key actions.
2. Supervisors have monitored the internship activities with reasonable opportunity to observe student performance.
3. Both respondents have provided a fair and accurate assessment on the demonstration of the workplace competencies.

Limitations

Data from the workplace competency assessment surveys were the result of student and supervisor assessment of performance in the workplace based on the opportunity to demonstrate competency in each of the 15 workplace competencies at the completion of an internship conducted in the employers workplace. Demonstration of competency required observation by the supervisor at a level that provides accurate assessment.

Delimitations

The study was delimited by the following:

1. Data provided by the workplace competency assessment survey results did not provide information on individual respondents or supervisors.

2. Data available from each assessment term were provided as mean values based on the number of respondents for the term.

Results

The data were examined to determine the relationship between internship students' self-assessment ratings (Se) and the paired supervisors' assessment ratings (Su) for each of the 15 workplace competencies and calculated for each engineering program. Data were grouped by the 2001-05 assessment terms ($n = 16$) and the 2006-11 assessment terms ($n = 13$) which corresponded to the past two accreditation cycles. Results were calculated under the Bonferroni adjustment criterion ($\alpha \leq 0.005$), where statistical significance indicated the program met the criterion to reject the null hypothesis, resulting in supervisor and student self-assessment ratings that were not equal.

For the combined 2006-11 assessment terms, there was no difference in the supervisor assessment ratings and the paired student self-assessment ratings for the following competencies: Analysis and Judgment, Cultural Adaptability, General Knowledge, Innovation, Integrity, Planning, Professional Impact, Quality Orientation, and Teamwork.

For combined 2006-11assessment terms there was however, a significant difference between supervisor assessment ratings and the paired student self-assessment workplace competency ratings for the following competencies and relevant College of Engineering programs: Communication, AGR ($p = 0.002$); Continuous Learning, AER ($p = 0.005$) and AGR ($p = 0.005$); Customer Focus, MEC ($p = 0.003$); Engineering Knowledge, CIV ($p = 0.002$) and CON ($p = 0.005$); Initiative, AER ($p = 0.004$) and ELE ($p = 0.003$); and Safety Awareness, AGR ($p = 0.004$) and MEC ($p = 0.003$).

The calculated Wilcoxon estimated median results for combined 2006-11assessment terms (*n* =13) indicated a positive outcome descriptively, for all programs with exception of those listed below. A positive estimated median indicates that the supervisor assessment median rating were higher than the paired student self-assessment workplace competency rating. Competencies and the related programs where the supervisor assessment rating was lower than the paired student self-assessment include: Analysis & Judgment, CON (-0.003) and IND (-0.044); Cultural Adaptability, AER (-0037), IND (-0.040) and MAT (-0.030); General Knowledge, AER (-0.055), AGR (-0.042), and CON (-0.040); Innovation, CON (-0.003) and IND (-0.044); Planning, CON (-0.060) and ELE (-0.054); Quality Orientation, CPR (-0.012), Teamwork, CPR (-0.046) and IND (-0.105). The results indicated in all cases that 70% or more of the programs reflected a higher supervisor assessment rating than the paired student self-assessment rating.

For 2001-05 there was no difference between the supervisor assessment ratings and the paired student self-assessment ratings for: Analysis and Judgment, Communication, Continuous Learning, Cultural Adaptability, Customer Focus, Engineering Knowledge, General Knowledge, Innovation, Integrity, Planning, Professional Impact, Quality Orientation, Safety Awareness, and Teamwork.

For 2001-05, there was however, a significant difference between supervisor assessment and student self-assessment ratings for workplace competencies: Communication, AGR (p = 0.002), Initiative, AGR ($p = 0.003$), ELE ($p = 0.003$), and MEC ($p < 0.001$), and Professional Impact, ELE ($p = 0.002$).

The calculated Wilcoxon estimated median results for combined 2001-05 assessment terms (*n* =16), indicated a positive outcome descriptively, for all programs with exception of those listed below. A positive estimated median indicates that the supervisor assessment median rating were higher than the paired student self-assessment workplace competency rating. Competencies and the related programs where the supervisor assessment rating was lower than the paired student self-assessment rating include: Analysis & Judgment, IND (-0.008), Communication, CHE (-0.008), CON (-0.020), IND (-0.048), and MEC (-0.018), Continuous Learning, CON (-0.015), Cultural Adaptability, AER (-0.128), AGR (-0.008), CHE (-0.065), IND (-0.030), and MAT (-0.010), Customer Focus, CON (-0.015), General Knowledge, AER (-0.093), AGR (-0.043), CON (-0.075), IND (-0.130), and MEC (-0.020), Innovation, CON (-0.005), Integrity, IND (-0.048), Planning CON (-0.105), and IND (-0.110), and Teamwork, AER (-0.065), CIV (-0.015), CON (-0.030), and IND (-0.068).

Respondent Relationships between 2006-11 and 2001-05 Accreditation Cycles

This section investigated the relationship between respondent ratings for combined competency assessment across terms within the 2006-11 and 2001-05 accreditation cycles (Table 3.). Data were calculated by engineering programs. Self-assessments and supervisor assessments have been isolated to learn the relationship between the two assessment groups. Data were analyzed using a 99.5% confidence interval.

Supervisor Assessment Data

When 2006-11assessment terms were compared to the 2001-05 assessment terms the supervisor assessments there were significant differences for the AGR (p= 0.001), CIV (p = 0.001), CHE (p = 0.001), and MEC (p = 0.002) programs. The supervisor assessments were not significantly different for 6 programs: AER, CON, CPR, ELE, IND and MAT using the

Table 2. Significant difference between supervisor and self-assessment ratings in 2001-05 and 2006-11 assessment terms

	COE Programs									
	AER	AGR	CIV	CHE	CPR	CON	ELE	IND	MAT	MEC
Analysis & Judgment										
Communication		**B**								
Cont. Learning	**B**	**B**								
Cultural Adaptability										
Customer Focus										**B**
Eng. Knowledge			**B**			**B**				
Gen. Knowledge										
Initiative	**B**	**A**					**A B**			**A**
Innovation								**B**		
Integrity										
Planning										
Professional impact										
Quality Orientation										
Safety Awareness		**B**								**B**
Teamwork										

A represents 2001-05 assessment terms; **B** represents 2006-11 assessment terms.

Table 3. Respondent relationships across accreditation cycles and engineering programs

Program	Supervisor (Su)		Student (Se)	
	p	Estimated Median	*p*	Estimated Median
Aerospace	0.478	0.011	0.842	-0.006
Agricultural	**0.001**	0.091	0.148	0.033
Civil	**0.001**	0.099	**0.001**	0.075
Chemical	**0.001**	0.077	0.033	0.047
Construction	0.589	0.010	0.887	0.001
Computer	0.011	-0.067	0.293	-0.017
Electrical	0.842	-0.003	0.977	-0.001
Industrial	0.443	0.018	0.222	-0.031
Materials	0.029	-0.066	**0.003**	-0.104
Mechanical	**0.002**	-0.056	0.044	-0.032

(*n* = 15); **BOLD** represents a significant difference between 2006-11 and 2001-05 Supervisor assessment ratings, and 2006-11 and 2001-05 Self-assessment ratings (α= 0.005)

Bonferroni adjustment criterion (α = 0.005). The Wilcoxon estimated median values reflected a positive outcome, indicating that 2006-11 (Su) median responses were slightly higher than the paired 2001-05(Su) responses, for all programs except CPR (-0.070), ELE (-0.003), MAT (-0.066), and MEC (-0.056).

Student Self-assessment Data

When 2006-11assessment terms were compared to the 2001-05 assessment terms for student self-assessments there were significant differences for the Civil (*p*=0.001) and Materials (*p*=0.003) programs, using the Bonferroni adjustment criterion (α = 0.005). The Wilcoxon estimated median values reflected a positive outcome, indicating that 2006-11 (Se) median responses were slightly higher than the paired 2001-05(Se) responses, for all programs except Aerospace (-0.006), Computer (-0.017), Electrical (-0.013), Industrial (-0.031), Materials (-0.104), and Mechanical (-0.032).

COE Assessment Relationships

When 2006-11 supervisor assessment ratings were compared to the 2001-05 supervisor assessment ratings for the COE (Table 4) using the Wilcoxon signed rank test (α = 0.05) across the 10 engineering programs, there was a significant difference (p = 0.029) between the supervisor assessment ratings. The Wilcoxon estimated median value (0.030) reflected a positive value, indicating that the 2006-11 supervisor ratings ranked slightly higher than the 2001-05 supervisor ratings. Results were based on 2,075 supervisor respondents.

When 2006-11 student self-assessment ratings were compared to the 2001-05 student self-assessment ratings for the COE (Table 4) using the Wilcoxon signed rank test (α = 0.05) across the 10 engineering programs, there was no significant difference between student self-assessment ratings (p = 0.379). The Wilcoxon estimated median value (0.011) reflected a positive outcome, indicating that the 2006-11 student ratings ranked higher than the 2001-05 student ratings. The results were based on 2,924 student self-assessments.

Conclusions

Based on the results of the test that examined the relationship between supervisor assessment ratings and the paired student self-assessment ratings between the 2001-05 and

Table 4. COE supervisor and self-assessment relationships across accreditation cycles

Comparison test	*n*	*p*	Estimated Median
2006-11 Su – 2001-05 Su COE	15	0.029	0.030
2006-11 Se – 2001-05 Se COE	15	0.379	0.011

the 2006-11 assessment terms, across the 15 workplace competencies, when using the Bonferroni adjustment criterion (α = 0.005), the following conclusions were made with 99.5% confidence.

- Analysis revealed that all of the 15 workplace competencies for the 2006-11 and 2001-05 terms resulted in 80% or more programs showing no significant difference between supervisor and student self-assessment of workplace competency ratings.
  - All programs in the 2001-05 terms resulted in no statistical difference between Su and Se ratings for 80% of the workplace competencies.
  - All programs in the 2006-11 terms resulted in no statistical difference between Su and Se ratings for 60% of the workplace competencies.
- The competencies; Continuous Learning, Engineering Knowledge, Initiative, and Safety Awareness showed a statistical difference between Su and Se in 2 programs.
- Engineering programs that appeared to have a statistical difference between Su and Se most frequently were Agricultural (20% of competencies), and Aerospace and Mechanical (13% of competencies).
- The number of competencies with all programs resulting in higher supervisor assessment ratings versus the paired student self-assessment ratings changed from 33.3% in 2001-05 to 53.3% in 2006-11.
  - Competencies with 90% or more programs having a higher supervisor assessment rating increased from 33.3% in 2001-05 to 60% 2006-11, while competencies with 80 % or more programs having a higher supervisor rating increased from 73% in 2001-05 to 87% in 2006-11.

- The number of programs with five or more competencies indicating a significant difference between supervisor assessment ratings and the paired self-assessment ratings, from the 2001-05 assessment terms to the 2006-11 assessment terms, dropped from 2 to 0, the number of programs with 3 or more dropped from 3 to 1, and the number of programs with 1 or more competencies showing a difference dropped from 10 to 6 programs.

Based on supervisor assessment ratings relationships between the 2001-05 and the 2006-11 assessment terms, across the 15 workplace competencies ($\alpha = 0.005$), the following conclusions were made with 99.5% confidence.

- Supervisor assessment ratings between the 2006-11 and 2001-05 assessment terms indicated 60% of the engineering programs and overall COE data resulted in no significant difference between supervisor assessment ratings in the two accreditation cycles.
- Supervisor assessment ratings were higher for 60% of the engineering programs in the 2006-11 assessment terms when compared to the 2001-05 assessment ratings. This verifies higher workplace competency assessment ratings in the 2006-11 assessment terms.

Based on student self-assessment ratings relationships between the 2001-05 and the 2006-11 assessment terms, across the 15 workplace competencies ($\alpha = 0.005$), the following conclusions were made with 99.5% confidence.

- Ratings showed no significant difference between the 2006-11 assessment terms when compared to the 2001-05 assessment terms for 80% of the engineering programs.

- Student self-assessment ratings were higher in the 2006-11assessment terms when compared to the 2001-05 terms for 40% of the engineering programs, indicating a higher rating for student demonstration of workplace competencies in the past assessment terms. This could be due in part to the reduction in negative Wilcoxon estimated median values comparing supervisor and student self-assessments from the 2006-11 and 2001-05 assessment terms.

Using the Wilcoxon signed rank test ($\alpha = 0.05$) to compare combined COE ratings (n=15), the following conclusions can be made with 95% confidence.

- No significant difference in combined COE assessment ratings between the 2006-11 and 2001-05 self-assessment ratings
- A higher Wilcoxon estimated median value in the 2006-11 assessment terms versus the 2001-05 assessment terms

Future Research

Research on engineering internship students’ demonstration of workplace competency during experiential learning opportunities provides a variety of possibilities for future studies. Topics of interest include:

- Isolate assessment ratings by individual workplace competency key actions to investigate relational comparisons of key actions across accreditation cycles.
- Study how internship supervisors’ workplace competency assessment ratings impacted student personal development activities in the final years of study prior to graduation.

- Monitor individual assessment ratings from internship students' self-assessments to establish a baseline that could be reviewed in the post-graduate years following entry into the workplace to study the change in self-assessments as young engineers' transition from novice to expert within their field of study.

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CHAPTER 4. EXAMINING THE USE OF INTERNSHIP WORKPLACE COMPETENCY ASSESSMENTS FOR CONTINUOUS IMPROVEMENT.

A manuscript prepared for submission to the *Journal of Technology Studies*

Mark A. Laingen, Thomas J. Brumm, Steven A. Freeman, & Kevin P. Saunders

Abstract

This study explored how workplace competency assessment data from internship students and their supervisors, collected by Iowa State University College of Engineering programs 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 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. In addition, this study examines competency achievement percentages related to the ABET Criterion 3 (a-k) outcomes across the same timeline. The third part of the study investigated how workplace competency assessment data are used to support continuous improvement for program curricula in the COE. The intent 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 (ABET, 2010). 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" (AAC&U, 2008, p. 18), and half of the employers target them as the place where institutions should devote the most resources for assessment (AAC&U, 2008).

Experiential learning environments provide places where "knowledge is created through the transformation of experience" (Kolb, 1984, p. 41), while enhancing their learning experience (Kolb & Kolb, 2005). 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" (McKeachie, 2006, p. 80) where students can demonstrate "intellectual autonomy" (Wiggins, 1998, p. 39), and receive valuable feedback from the experience (Butler & Winne, 1995; Gentry, 1990; Kanfer & Kanfer, 1991; Ley & Young, 2001). 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 (Kolb and Kolb, 2005). Kolb (1984) 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 ABET Criterion 3 (a-k) outcomes; student self-assessment has become more commonplace in assessments and evaluations (Blanche, 1988). This indirect assessment method provides a formative learning environment where students can reflect on their experiences, which supports performance evaluation, identifies their strengths and weaknesses, and provides a direction to improve on learning outcomes (Klenowski, 1995). As a formative assessment, it confirms desired goals, evidence on achievement of the goals, and provides a measure of the gap between the two. Understanding all three are important before they can act to improve their learning (Black & William, 1998). As students gain work experience and transition toward higher expertise, this gap tends to close (Arnold & Garland, 1990; Arnold, Willoughby, & Calkins, 1985). Research has shown that self-assessment raised students' achievement levels significantly (Black & William, 1998; Chappuis & Stiggins, 2002; Rolheiser & Ross, 2001; White & Frederiksen, 1998), and accuracy is "reasonably stable when compared with the stability of actual performance" (Fitzgerald, White, & Gruppen, 2003, p. 648).

Self-assessment has notable inconsistencies. Results of a Sitzmann et al. (2010) study found that 32% of studies on self-assessment identify it as an indicator of learning. Rate inflation has also been documented in cases where older students believe self-assessments will affect their grades (Dunning, Heath & Suls, 2004). A Harris and Schaubroeck study (1988) resulted in self-assessment ratings exceeding supervisor ratings by more than one-half of one standard deviation, although an Arnold & Garland study (1990) challenge those results citing business students on internships tended to rate their performance assessments lower than their supervisor assessment ratings.

Workplaces today are continually expanding and advancing technologically. Competency assessment helps employers determine if graduates can apply prior knowledge beyond the acquisition of that knowledge or skillset (Robinson and Robinson, 1999). As graduates gain expertise through the KSA acquired in the workplace, these alumni provide feedback that is beneficial to the CI process. Reflection of their progression through self-assessment provides valuable analysis of strengths and deficiencies, which also enhances personal CI and career development.

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” (Brumm, Mickelson, Steward, & Kaleita-Forbes, 2006, p. 2). Learning environments that challenge students to apply their knowledge to perform meaningful tasks are considered the most effective environments (Marzano et al., 1993). 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 (Brumm, Hanneman, & Mickelson, 2006). 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 (Hanneman, Mickelson, Pringnitz & Lehman, 2002). All other opportunities provide “at best, a simulation of engineering practices” (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 (Brumm, Mickelson, Steward, & Kaleita-Forbes, 2006). 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 (Brumm, Hanneman, & Mickelson, 2006). The ABET Criterion 3 (a-k) Student Learning Outcomes (ABET, 2010) 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 (Brumm et al., 2006), 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” (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" (Brumm, Hanneman, & Mickelson, 2006, 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 (Brumm, et al., 2006). 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,

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).

Constituents did not provde 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

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” (Emery, Kramer & Tian, 2001, 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 (2006) explain that engineering experiential education “can and should be integral to the curricular continuous improvement process” (p. 127).

Critical voices to the CI process, Bessant, Caffyn, and Gallagher (2001) 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 (2001). By developing a model for learning, practicing, and mastering the behaviors for CI, higher levels of success can be achieved (2001). Often, CI practices are used for assessment, yet not carried into evaluation. Identification of the opportunity for improvement must be linked to the evaluation needs (Astin, 1991).

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 (Huba, 2000).

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 (Brumm et al., 2006).

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 (Brumm, Hanneman, & Mickelson, 2006). 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 (6) 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 (ABET, 2010) 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

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	**4.50**	**5**	**4.53**	**2**	**4.52**	**4**	**4.47**	**3**
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	**4.85**	**1**	**4.79**	**1**	**4.77**	**1**	**4.73**	**1**
Planning	4.45	6	4.40	6	4.41	9	4.36	6
Professional Impact	**4.53**	**3**	**4.43**	**5**	**4.53**	**3**	**4.43**	**5**
Quality Orientation	**4.56**	**2**	**4.48**	**3**	**4.54**	**2**	**4.50**	**2**
Safety Awareness *	4.40	9	<u>4.21</u>	<u>11</u>	**4.49**	**5**	**4.47**	**4**
Teamwork	**4.50**	**4**	**4.45**	**4**	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.

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.

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

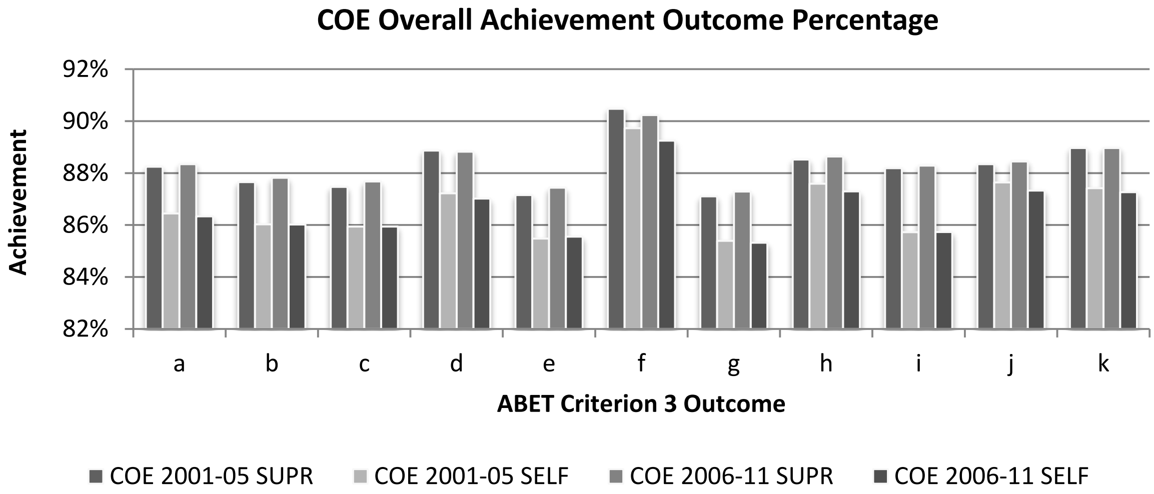

Figure 1. Percentages for College of Engineering overall achievement outcomes

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 (Eisner, 2002; Kolb & Kolb, 2005; McKeachie et al., 2006; Wiggins, 1998). 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 2006-11assessment 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 (Brumm et al., 2006) 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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CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

General Summary

The central focus of this study investigated the relationships between supervisor assessment ratings and student self-assessment ratings for the demonstration of workplace competencies during internships. The study observed the relationship across 10 College of Engineering (COE) programs, across the 15 workplace competencies, and across the 2001-05 and 2006-11 internship assessment terms related to COE program accreditation cycles. Additionally, the study investigated how the data benefits COE programs, and determines how they have used this information in the continuous improvement process for program accreditation and curriculum development. The overarching research questions driving this study were:

1. What relationships exist between supervisor assessment (Su) and self-assessment (Se) of engineering internship students' demonstration of workplace competencies, between the 2001-11 assessment terms, across competencies, across programs, and across the College of Engineering?
2. What relationships exist between supervisor assessment (Su) and self-assessment (Se) ratings for workplace competencies when comparing the 2001-05 accreditation cycle to the 2006-11 accreditation cycle across programs and competencies?
3. How have internship students' workplace competency assessment data been used in the continuous improvement process for engineering program evaluation and curriculum development?

4. How have workplace competency assessment rankings that identify the strengths and weaknesses of workplace competency assessments changed from the 2001-05 accreditation cycle to the most recent 2006-11 cycle.

Summary of Results

Question 1, Chapter 2, investigated the relationships between supervisor assessment ratings and student self-assessment ratings for the demonstration of workplace competencies in engineering internships. Data were compared across the 2001-2011 assessment terms, testing the median difference between paired data using the Wilcoxon signed rank test and Bonferroni adjustment criterion ($\alpha = 0.005$) in Minitab 16® to test the median difference across the 15 workplace competencies. The following conclusion can be made with 99.5% confidence:

- Mean ratings for all competencies scored at or above 4.0 on the 5-pt Likert scale, indicating when internship students are provided with the opportunity to perform a key action in the workplace they are "often" performing the task.
- Results show with 99.5% confidence when comparing supervisor assessment ratings and the paired student self-assessment ratings across the 15 workplace competencies from the 2001 assessment term through the 2011 terms, the ratings between the 2 groups are deemed to be equal, validating student self-assessment as a reliable assessment method for demonstration of workplace competencies.
- Test results from median difference values indicate that in a high percentage of the cases supervisor scores rate higher than the student self-assessment scores. These tests support the work by Fitzgerald et al. (2003), which claimed student self-

assessment accuracy is relatively stable when compared with the stability of actual performance.

- Results from tests across the 64 key actions proved less reliable when comparing the supervisor ratings to the student self-assessment ratings.

Based on these findings, the following observations were made:

- In this assessment model, students are not directly graded on their performance of the workplace competencies therefore; they are less likely to inflate their self-assessment ratings to protect their GPA.
- By the completion of an internship students have achieved a higher level of expertise in the areas of context for the workplace competency topics, resulting in a more knowledgeable, skilled assessment level that is more capable of accurately assessing their performance rating
- With the understanding that their immediate supervisors will also rate their competency levels, there is a higher level of accountability on their self-assessment ratings, in part because of the knowledge that their supervisors will be rating them on each key action for the competencies.

Question 2, Chapter 3, investigated workplace competency assessments, by comparing changes in supervisor assessment and student self-assessment ratings across the 2001-05 and 2006-11 accreditation cycles. The Wilcoxon signed rank test and the Bonferroni adjustment criterion ($\alpha = 0.005$) were used to determine the relationship between supervisor assessment ratings and student self-assessment ratings across the 2001-05 and 2006-11 assessment terms corresponding to the accreditation cycles. The following conclusion can be made with 99.5% confidence:

- With all 15 of the workplace competencies resulting in an 80% or greater number of COE programs showing no significant difference between the supervisor and student self-assessment ratings across the 2001-05 and 2006-11 accreditation terms, it is concluded the evidence shows a strong relationship between supervisor and self-assessments, validating the reliability of self-assessment using this method.
- Based on results from the Wilcoxon estimated median tests, there was a strong improvement from the 2001-05 assessment terms (33%) to the 2006-11 terms (53%), when identifying programs that demonstrated 100% achievement of higher supervisor ratings than student self-assessment ratings. This indicates students are improving in their reliability to assess workplace competency performance.

Test results compared the relationship for supervisor assessment ratings across the 2006-11 and 2001-05 assessment terms, and student self-assessment ratings across the same terms. The Wilcoxon signed rank test and the Bonferroni adjustment criterion ($\alpha = 0.005$) were used to determine these relationships. From the test results, the following conclusions can be made with 99.5% confidence:

- Sixty percent of the engineering programs plus the COE data results were conclusive that there was no significant difference between supervisor workplace competency assessment ratings across the assessment terms related to the two accreditation cycles, and had a higher 2006-11 supervisor rating compared to the 2001-05 ratings. From this analysis is can be concluded that supervisor assessment ratings have remained stable across the accreditation cycles and supervisor ratings are most commonly higher in the 2006-11 assessment terms.

- Eighty percent of the engineering programs showed student self-assessment ratings were consistent with no significant difference across the 2001-05 and 2006-11 assessment terms related to the two accreditation cycles. Self-assessment ratings in the 2001-05 assessment terms tended to be rated higher than the paired 2006-11 term ratings, with only 40% of self-assessment ratings improving in the 2006-11 terms. This aligns with an increase in the number of positive Wilcoxon estimated median values for the self-assessment data. One assumption is improvements in preparing students on workplace competencies have provided them with more accurate assessment ratings. Further research is required to validate this assumption.

Question 3. In Chapter 4, the quantitative tests examined the use of internship workplace competency strengths and weaknesses based on assessment ratings, and ABET (a-k) Outcomes achievement percentages from workplace competency assessment ratings for accreditation and continuous improvement practices. The following conclusions can be made with 95% confidence:

- A comparison of workplace competency strengths and weaknesses between the 2001-05 and 2006-11 assessment terms have been stable, with minimal change for both Top-5 and Bottom-5 competencies when comparing them based on the two accreditation cycles.
- In all 15 competencies, the lowest ranked workplace competencies for all programs ranked above the 4.0 mark on the 5-point Likert scale, indicating when students are

provided the opportunity they "often" demonstrate competency. This results in a satisfactory rating for all competencies.

- The range between highest and lowest ranking competencies is consistently less than one-half of one assessment rating point, indicating that given the opportunity to demonstrate the action in the workplace students often demonstrate the competency to satisfactory standards. The results also indicate that self-assessment ratings compare slightly under the paired supervisor ratings, which eliminates concern of rate inflation. Based on the high representation of students engaging in internships and cooperative work experiences the results provide a strong representation of the undergraduate engineering population.
- Achievement percentages resulted in a 70% overall improvement from the 2001-05 assessment terms to the 2006-11 terms, and more than 50% of those improvements demonstrating significant change. Three programs; Computer, Materials, and Mechanical reflected a slight drop in overall achievement percentages.
    - Fifty percent of the programs demonstrated improvement in all 11 ABET Outcomes (a-k), with only two programs improving in under 50% of the outcomes. The COE overall results showed improvement in 82% of the outcomes. The results demonstrate positive movement for continuous improvement of ABET outcomes from the 2001-05 to the 2006-11 assessment terms.
    - Ninety-three percent of the competencies are included in this improvement, only Integrity is not which was included in both outcomes (d) assessing the ability to function on multi-disciplinary teams, and (f) which assesses an understanding of professional and ethical responsibilities, that did not result in improvement.

Students would be less likely to have the opportunity to demonstrate these competencies during an internship or cooperative work experiences.

- With outcomes (a) and (g) showing 90% and 80% of programs respectively showing improvement, outcomes (h, i, j, and k) showing 70% of programs improving , and outcomes (b, c, e, and f) showing 60% of the programs improving, it can be concluded that 91% of all ABET outcomes were reflected in a higher than 50% program improvement with outcome (d) the ability to function on multi-disciplinary teams, having the lowest ranking with 50% of programs improving in achievement. This could be in part because of limited exposure to perform the task.

Survey result from open-ended question and comments provided by respondents offered feedback to improve how internship workplace competency assessment data could be enhanced to provide more useful information to the programs:

- Improve the continuous improvement process using workplace competency assessment data
- provide a comparison of current assessment cycles to prior assessment cycles for use on continuous improvement analysis
- Provide more analysis at the key actions level
- Encourage supervisor comments and feedback on internship experiences
- Investigate methods or software that allow the ability to track individual data: student years during internships, gender, extra-curricular activities, ethnicity, GPA, etc.
- provide temporal data to track changes over time.

Workplace competency assessment provides useful information to programs for use in evaluation of the program curricula, but it is only one part of the entire program assessment factor. The NCEES (2013) Fundamentals of Engineering (FE) Exam data results are more heavily weighted values for providing feedback on the achievement levels of the students. Successful completion of the NCEES Fe Exams and the resulting scores provide strong insight into the competency levels achieved by undergraduate students.

General Conclusion

Engineering education strives to develop young engineers with a higher capacity to achieve practical solutions, analyze objectives, and design for practical solutions while improving the professional competence of the student as they migrate into their engineering careers. This transformation from novice engineering student into a higher level of expertise plays out in the classroom and beyond. Internships and Coops provide a platform for students to demonstrate the knowledge, skills and abilities they have acquired throughout their educational experience in a practical workplace setting. The ability to practice their acquired knowledge and skills in an experiential learning environment is strongly regarded as the location where the student can best develop what they have learned. Each program has unique educational objectives for their students to achieve from the point of graduation through the first 5 years of their professional engineering career. These Program Educational Objectives (PEOs) are defined to meet the requirements of accreditation bodies, constituents, the College of Engineering. As students graduate from their engineering program and enter the workplace, they will become a valuable source of feedback to help assess undergraduates preparation for entry into their engineering career. Alumni' self-assessment of workplace competencies becomes more important for programs as direct assessment opportunities with employers dissipates. Accurate alumni self-assessment for measurement of workplace key action competency can be confidently used as valid and reliable feedback through the confirmation found in the data from internship self-assessment and supervisor assessment relational significance discovered in this study.

Although given less weight in the continuous improvement process for program evaluation and curriculum development, workplace competency assessment data is valuable to determine how well students demonstrate competency in a workplace environment, which as McKeachie et al. (1985) and numerous others suggest is the truest environment for the measure of achievement of competency in the workplace.

Recommendations for Future Research

This study examined mean scores from aggregate data collected at the conclusion of internships. The potential for more in-depth research exists with the ability to associate the data back to individual respondents. Successful demonstration of workplace competency could be correlated with numerous identifying characteristics without linking the data back to the individual. Important relationships that will provide insight into the student maturity in knowledge and skill sets prior to entering into internships, such as:

- Research based on traditional students and community college transfer students to learn how this correlates with successful achievement of workplace competencies.
- Research on class status could provide insight into workplace competency achievement for freshman, sophomore, and junior level students in internships and

cooperative work environments, improvements through maturity of their educational experiences.

- Research to learn the correlation between internship students GPA or High School class ranking and level of ratings for workplace competencies in an engineering outcomes.
- Research could identify how coursework is requisite to successful demonstration of competency in the workplace, and deficiencies in competency at the point of internship participation.
- A study on student participation in student organizations, professional organizations, or extra-curricular activities could correlate how these activities benefit student learning and achievement.
- Much could be learned from research how demonstration of workplace competencies correlates with the ethnicity of the internship students. Data linked to ethnicity could provide valuable information how different ethnic groups compare and ultimately provide a better understanding of the strengths and challenges that impact the different groups. From this information programs could prepare interventions to improve areas of lower performance in competencies focusing on specific ethnic groups.
- Gender related studies could provide researchers with insight into the relationships between competency strengths and challenges along gender lines. This information would support educational programs like the Women in Science and Engineering (WISE), and other gender related programs.

This research did not investigate the role that program option preference and related instruction has in the relationship between self-assessment and supervisor assessment. Observation of the data provided questions related to why some engineering programs consistently demonstrate a higher level of confidence in competency versus other programs. Knowledge in this area could be valuable for understanding the mechanisms in place to build confidence and better self-reflection in students. It may also lead to an understanding of the types of individuals that choose certain types of career paths.

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APPENDIX A. COMPETENCY AND KEY ACTION BREAKDOWN

10. Analysis and judgment

Definition: 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.

Key Actions

- (11) Identifies issues, problems and opportunities. Recognizes issues, problems, or opportunities and determines whether action is needed.
- (12) Gathers information. Identifies the need for and collects information to better understand issues, problems, and opportunities.
- (13) Interprets information. Integrates information from a variety of sources; detects trends, associations, and cause-effect relationships.
- (14) Generates alternatives. Creates relevant options for addressing problems/opportunities and achieving desired outcomes
- (15) Commits to action. Implements decisions or initiates action within a reasonable time.
- (16) Chooses appropriate actions. Formulates clear decision criteria; evaluates options by considering implications and consequences; chooses an effective option.
- (17) 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.
- (18) Values diversity. Embraces and values diverse collection of inputs, values, perspectives, and thought paradigms in approaching the application of engineering and technology to products and processes.

20. Communication

Definition: 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.

Key Actions

- (21) Organizes the communication. Clarifies purpose and importance; stresses major points; follows a logical sequence.
- (22) Maintains audience attention. Keeps the audience engaged through use of techniques such as analogies, illustrations, body language, and voice inflection.
- (23) 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.
- (24) Ensures understanding. Seeks input from audience; checks understanding; presents message in different ways to enhance understanding.
- (25) Adheres to accepted conventions. Uses syntax, pace, volume, diction, and mechanics appropriate to the media being used.
- (26) Comprehends communication from others. Attends to messages from others; correctly interprets messages and responds appropriately.

30. Continuous learning

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 their application.

Key Actions

- (31) Targets learning needs. Seeks and uses feedback and other sources of information to identify appropriate areas for learning.
- (32) Seeks learning activities. Identifies and participates in appropriate learning activities (e.g., courses, reading, self-study, coaching, and experiential learning) that help fulfill learning needs.

- (33) 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).
- (34) Applies knowledge or skill. Puts new knowledge, understanding, or skill to practical use on the job; furthers learning through trial and error.
- (35) 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.

40. Cultural Adaptability

Definition: 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.

Key Actions

- (41) Demonstrates inclusive behavior. Establishes effective relationships with people of other cultures and backgrounds; shows genuine acceptance of people from backgrounds different from one's own.
- (42) 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.
- (43) Adapts behavior to other cultures. Adjusts own approach to interactions, communications, and decision making to be appropriate and effective within another culture without sacrificing own values.
- (44) Adapts products and processes to cultural concerns. Identifies, understands and incorporates cultural factors into the design of products and processes

50. Customer Focus

Definition: Making customers and their needs a primary focus of one's actions; developing and sustaining productive customer relationships.

Key Actions

- (51) Seeks to understand customers. Actively seeks information to understand customers' circumstances, problems, expectations, and needs.
- (52) Educates customers. Shares information with customers to build their understanding of issues and capabilities.
- (53) Builds collaborative relationships. Builds rapport and cooperative relationships with customers.
- (54) 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 over-commitments.
- (55) Sets up customer feedback systems. Implements effective ways to monitor and evaluate customer concerns, issues, and satisfaction and to anticipate customer needs.

60. Engineering/Technical Knowledge

Definition: Having achieved a satisfactory level of knowledge in the relevant specialty areas of mathematics, science and engineering/technology.

Key Actions

- (61) Knowledge of Mathematics. Demonstrates a knowledge of the mathematical principles required to practice engineering or apply and manage technology in one's specialty area.
- (62) Knowledge of Science. Demonstrates a knowledge of the scientific principles required to practice engineering or apply and manage technology in one's specialty area.
- (63) Knowledge of experimental analysis. Demonstrates a knowledge of the principles of experimental data analysis in one's specialty area.

- (64) Knowledge of current engineering/technology tools. Demonstrates a knowledge of the use of contemporary tools needed to practice engineering or *apply and manage technology* in an effective manner.
- (65) Knowledge of technology. Demonstrates a knowledge of engineering/technology principles required to practice in one's specialty area.

70. General Knowledge

Definition: Having achieved a satisfactory level of knowledge outside the areas of mathematics, science, engineering and technology.

Key Actions

- (71) General Knowledge. Demonstrates a knowledge of important current issues and events outside the areas of mathematics, science, engineering and technology
- (72) Relates general knowledge to engineering/technology. Demonstrates a knowledge of the interrelationships between important issues and events outside of engineering/technology and one's engineering/technology specialty area.

80. Initiative

Definition: Taking prompt action to accomplish objectives; taking action to achieve goals beyond what is required; being proactive.

Key Actions

- (81) Responds quickly. Takes immediate action when confronted with a problem or when made aware of a situation.
- (82) Takes independent action. Implements new ideas or potential solutions without prompting; does not wait for others to take action or to request action.
- (83) Goes above and beyond. Takes action that goes beyond job requirements in order to achieve objectives.

90. Innovation

Definition: Generating innovative solutions in work situations; trying different and novel ways to deal with work problems and opportunities.

Key Actions

- (91) 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.
- (92) Leverages diverse resources. Draws upon multiple and diverse sources (individuals, disciplines, bodies of knowledge) for ideas and inspiration
- (93) 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.
- (94) Evaluates multiple solutions. Examines numerous potential solutions and evaluates each before accepting any.
- (95) Ensures relevance. Targets important areas for innovation and develops solutions that address meaningful work issues.

100. Integrity

Definition: Maintaining social, ethical, and organizational norms; firmly adhering to codes of conduct and professional ethical principles.

Key Actions

- (101) Demonstrates honesty. Deals with people in an honest and forthright manner; represents information and data accurately and completely.
- (102) Keeps commitments. Performs actions as promised; does not share confidential information.

- (103) Behaves consistently. Ensures that words and actions are consistent; behaves consistently across situations.

110. Planning

Definition: Effectively managing one's time and resources to ensure that work is completed efficiently.

Key Actions

- (111) Prioritizes. Identifies more critical and less critical activities and tasks; adjusts priorities when appropriate
- (112) Makes preparations. Ensures that required equipment and/or materials are in appropriate locations so that own and others' work can be done effectively.
- (113) Schedules. Effectively allocates own time to complete work; coordinates own and others' schedules to avoid conflicts.
- (114) Leverages resources. Takes advantage of available resources (individuals, processes, departments, and tools) to complete work efficiently.
- (115) Stays focused. Uses time effectively and prevents irrelevant issues or distractions from interfering with work completion.

120. Professional Impact

Definition: Creating a good first impression; commanding attention and respect; showing an air of confidence.

Key Actions

- (121) Dresses appropriately. Maintains professional, businesslike image.
- (122) Displays professional demeanor. Exhibits a calm appearance; does not appear nervous or overly anxious; responds openly and warmly when appropriate.
- (123) Speaks confidently. Speaks with a self-assured tone of voice.

130. Quality Orientation

Definition: 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.

Key Actions

- (131) Follows procedures. Accurately and carefully follows established procedures for completing work tasks.
- (132) Ensures high-quality output. Vigilantly watches over job processes, tasks, and work products to ensure freedom from errors, omissions, or defects
- (133) Takes action. Initiates action to correct quality problems or notifies others of quality issues as appropriate.

140. Safety Awareness

Definition: Identifying and correcting conditions that affect employee safety; upholding safety standards.

Key Actions

- (141) Identifies safety issues and problems. Detects hazardous working conditions and safety problems; checks equipment and/or work area regularly.
- (142) Takes corrective action. Reports or corrects unsafe working conditions; makes recommendations and/or improves safety and security procedures; enforces safety regulations and procedures.
- (143) Monitors the corrective action. Monitors safety or security issues after taking corrective action and ensures continued compliance.

150. Teamwork

Definition: Actively participating as a member of a team to move the team toward the completion of goals.

Key Actions

- (151) 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.
- (152) Involves others. Listens to and fully involves others in team decisions and actions; values and uses individual differences and talents.
- (153) Informs others on the team. Shares important or relevant information with the team.
- (154) Models commitment. Adheres to the team's expectations and guidelines; fulfills team responsibilities; demonstrates personal commitment to the team.

Source: Dept. of Agricultural & Bio-systems Engineering, Iowa State University

APPENDIX B. WORKPLACE COMPETENCY TO ABET OUTCOMES MATRIX

Engineering 2003-04 Criterion 3 Program Outcomes and Assessment		ISU Competency													
		Engineering Knowledge	General Knowledge	Continuous Learning	Quality Orientation	Initiative	Innovation	Cultural Adaptability	Analysis and Judgement	Planning	Communication	Teamwork	Integrity	Professional Impact	Customer Focus
(a)	an ability to apply knowledge of mathematics, science and engineering	●		●		●			●						
(b)	an ability to design and conduct experiments, as well as to analyze and interpret data	●		●	●	●	●		●	●		●			●
(c)	an ability to desing a system, component, or process to meet desired needs	●		●	●	●	●	●	●	●	●	●			●
(d)	an ability to function on interdisciplinary teams					●		●	●	●	●	●	●	●	●
(e)	an ability to identify, formulate and solve engineering problems	●		●	●	●	●		●		●	●			●
(f)	an iunderstnding of professional and ethical responsibility		●	●	●			●	●				●		
(g)	an ability to communicate effectively		●			●					●			●	●
(h)	the broad education necessary to understand the inmpact of engineering solutions is a global and societal context	●	●	●				●	●						
(i)	a recognition of the need for, and the abilityh to engage in life-long learning			●			●								
(j)	a knowledge of contemporary issues		●	●				●	●						
(k)	an ability to use the techniques, skills and modern engineering tools necessary for engineering practice	●		●	●	●		●	●						

Source : Dept. of Agricultural and Bio-systems Engineering, Iowa State University

APPENDIX C. WORKPLACE COMPETENCY ASSESSMENT SURVEY

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?

Never or almost never. This person hardly ever performs the action.

Seldom. This person often does not perform the action.

Sometimes. This person performs the action about half of the time.

Often. This person performs the action on most occasions.

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.

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

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

● 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

Generates alternatives
Creates relevant options for addressing problems/opportunities and achieving desired outcomes.

● 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

Gathers information
Identifies the need for and collects information to better understand issues, problems, and opportunities.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

Identifies issues, problems, and opportunities
Recognizes issues, problems, or opportunities and determines whether action is needed.

● 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.

● 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

Adheres to accepted conventions
Uses syntax, pace, volume, diction, and mechanics appropriate to the media being used.

● 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

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

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

Organizes the communication
Clarifies purpose and importance; stresses major points; follows a logical sequence.

● 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.

● 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

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

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

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

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

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.

● 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

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

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

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

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

● 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

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

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

Knowledge of experimental design and analysis
Demonstrates a knowledge of the principles of experimental design and data analysis in one's specialty area.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

Knowledge of current engineering tools
Demonstrates a knowledge of the use of contemporary tools needed to practice engineering in an effective manner.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

General Knowledge (ISU Accreditation Aligned)
Having achieved a satisfactory level of knowledge outside the areas of mathematics, science and engineering.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

General Knowledge
Demonstrates a knowledge of important current issues and events outside the areas of mathematics, science and engineering.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

Relates general knowledge to engineering
Demonstrates a knowledge of the interrelationships between important issues and events outside of engineering and one's engineering specialty area.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

Initiative (ISU Accreditation Aligned)
Taking prompt action to accomplish objectives; taking action to achieve goals beyond what is required; being proactive.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

Responds quickly
Takes immediate action when confronted with a problem or when made aware of a situation.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

Takes independent action
Implements new ideas or potential solutions without prompting; does not wait for others to take action or to request action.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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.

● 1 ● 2 ● 3 ● 4 ● 5 ● No Response

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.

APPENDIX D. USING OPAL DATA FOR CONTINUOUS IMPROVEMENT OF THE PROGRAM CURRICULUM

Thank you for your interest in developing better practices used for using internship workplace competency assessment data in the continuous improvement process for engineering curricula development.

The objective of this survey is to gain a better understanding how engineering programs utilize workplace competency (WC) assessment data collected at the completion of each internship work session through the Online Performance and Learning (OPAL™) Assessment Survey toward continuous improvement process in curriculum development.

Information collected is solely to learn better practices used for applying workplace competency data to improve the program curriculum.

Confidential information provided in this survey will be protected with the highest level of integrity. Every effort is made to protect all participants from identification. It should be understood that because of the limited number of respondents and the nature of this information, it may not possible to maintain complete anonymity. Any question that is determined to compromise respondent confidentiality can be skipped.

Your participation in this survey is valuable to the study, but participation is voluntary. There is no penalty for declining to participate. No incentives, financial or other are provided for participation.

Information learned in this study will provide answers to the following research questions:

1. How have engineering programs applied WC self-assessment ratings toward continuous improvement of the program curricula?

2. How have engineering programs applied WC supervisor assessment ratings toward continuous improvement of the program curricula?

3. How have achievement outcomes percentages calculated from self- and supervisor workplace competency assessment ratings supported the curriculum development process?

4. How have overall College of Engineering workplace competency assessment ratings data for self- and supervisor assessment influenced the program curriculum development process?

5. How have alumni surveys been used to collect workplace competency assessment data for engineering program curriculum development?

6. How have workplace competency assessment data enhanced program curriculum development since the 2006 ABET accreditation reports?

7. How have top 5 and bottom 5 ranked WC rankings been used to improve the program curriculum?

A total of 47 questions are included in the survey, which should take approximately 30 minutes to complete.

Thank you for your participation in this research. Results will be made available through dissemination of peer reviewed articles leading to the completion of my doctoral dissertation.

1. Survey participation.

An informed consent form is included in the initial email that was sent to you inviting your participation in the study. Please review this form if you have any questions about the study, confidentiality concerns, compensation, or other questions.

By clicking on the box below you are agreeing to participate in the study. This box must be check to proceed with the remainder of the questions. If you do not wish to participate in the study please find the exit button at the top of the page and click on the button to exit.

◯ I agree to participate in this study

Program Information

2. What undergraduate engineering program are you affiliated with?

3. What is your role in the continuous improvement process for your program (choose all that apply)?

- [ ] Current COE ABET Committee member
- [ ] Past COE ABET Committee (or Student Learning Task Force) member
- [ ] Program curriculum committee member
- [ ] Program ABET or outcomes assessment committee member
- [ ] ABET Self-Study author or co-author
- [ ] Departmental associate chair for undergraduate education (or equivalent)
- [ ] Academic advisor
- [ ] Other (please specify)

4. How would you describe your experience working with workplace competency assessment data?

General Questions

5. How helpful have 2001-05 workplace competency assessment data been for the continuous improvement process during the latest accreditation cycle?

Not helpful	Somewhat helpful	Helpful	Very Helpful	N/A
○	○	○	○	○

6. How helpful have 2001-05 workplace competency assessment data been for evaluation of continuous improvement actions taken since the previous accreditation cycle?

Not helpful	Somewhat helpful	Helpful	Very Helpful	N/A
○	○	○	○	○

Comments:

7. What threshold value should be defined as acceptable workplace competency, based on the current summative scale (1-5) from the Online Performance and Learning Assessment Survey? (Example: 2.5, 2.75, 3.0, 3.25, ...)

8. What threshold value should be defined as the acceptable achievement percentage for student outcomes linked to each ABET Criterion 3 (a-k) outcome? (Example: 50%, 75%, 85%, ...)

NOTE: For each ABET competency:
% Achievement = [(∑ (competency ranking)(weighting factor)) / (∑ (5)(weighting factor))] X 100%

9. How useful are Program vs. COE data comparisons on individual competency key actions when evaluating the program curriculum?

No Importance	Little Importance	Somewhat Important	Important	Very Important	N/A
○	○	○	○	○	○

10. What information on workplace competency assessments, not currently provided in ECS reports to the College of Engineering ABET Committee, could be added to enhance the continuous improvement process in program curriculum development?

Section 1: Self-Assessment

Questions presented in the following sections relate to your specific engineering program, and not referencing the College of Engineering as a whole.

11. Prior to starting their internship, students are provided with adequate information to ensure a strong understanding of the ISU Workplace Competencies.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

12. Internship students are fully instructed on the importance of workplace competency assessment data for program accreditation preparations.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

13. Internship students are fully instructed on the importance how workplace competency assessment data are used for program curriculum development.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

14. Student self-assessment of workplace competencies provide information useful for continuous improvement of the program curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

15. Student self-assessment of their demonstration of workplace competencies has proven to be a trusted assessment method for evaluating achievement of ISU learning outcomes.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

16. Student self-assessment of workplace competencies is valued as a reliable method for evaluation of achievement percentages for program learning outcomes.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

Section 2: Supervisor Assessment

Questions presented in the following sections relate to your specific engineering program, and not referencing the College of Engineering as a whole.

17. Internship employment supervisors are informed of the importance of workplace competency assessment data for program accreditation preparations.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

18. Internship employment supervisors are informed of the importance how workplace competency assessment data are used for program curriculum development.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

19. Our program works closely with employers to encourage feedback on student workplace competency assessment through the Online Performance and Learning (OPAL) assessment survey .

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

20. Our program has defined an acceptable supervisor assessment response rate for assessing intern students demonstration of workplace competencies.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

Please note the response percentage if applicable.

21. Supervisors of interns in our program have been provided adequate instruction on assessing intern students' workplace competencies.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

Comments:

22. Feedback from supervisor assessment provides valuable feedback on students strengths and deficiencies that can be used for continuous improvement of the program curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

23. Supervisors have the best opportunity to provide accurate feedback on student demonstration of workplace competencies.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

24. Supervisors have demonstrated strong support for assessment of internship students' workplace competencies as part of the continuous improvement process for program curriculum development.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

Comments:

25. When comparing self- and supervisor assessment ratings, more weight is placed on supervisor assessment of the students demonstration of workplace competencies.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

26. Supervisor assessment is a trusted method for rating student demonstration of workplace competency key actions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
○	○	○	○	○	○

Comments:

Section 3: Alumni Assessment

Questions presented in the following sections relate to your specific engineering program, and not referencing the College of Engineering as a whole.

Responses to the following questions are based on the following response codes:

Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree, NB – No basis for determination

27. Alumni are currently asked to complete an online workplace competency assessment survey as part of the continuous improvement process for curriculum development.

- ◯ True
- ◯ False

28. Alumni are made aware of the importance that their participation in workplace competency assessment has toward future curriculum development.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
◯	◯	◯	◯	◯	◯

29. Alumni workplace competency assessment survey data are an important component in our program continuous improvement process for program curriculum development.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
◯	◯	◯	◯	◯	◯

30. Alumni feedback on their preparedness in the workplace competencies is implemented into the continuous improvement process for curriculum development.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
◯	◯	◯	◯	◯	◯

31. Alumni response rates on their preparedness in the workplace competencies are considered to be satisfactory for use in the continuous improvement process for curriculum development.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	NB
◯	◯	◯	◯	◯	◯

Section 5: Additional Comments

47. Please provide any additional comments you may have in this area. If referencing an individual questions please note the question number for your response.

This completes the Workplace Competency Assessment Survey.

Thank you for your participation in this research.

Understanding how Online Performance and Learning (OPAL™) Workplace Competency Assessment Survey data are helping programs evaluate internship student's demonstration of ISU Competencies is important. Lessons learned will help to provide a better understanding of the benefits of using workplace competency assessments for continuous improvement of the engineering program curricula.

A meeting scheduler web link has been sent to you to determine a time when this focus group can meet to complete research for this study. A time will be determined and a request to reserve that time will be sent to you. Snacks and beverage will be provided during the focus group meeting.

I look forward to meeting with you to further discuss the use of workplace competency assessments' benefits in the continuous improvement process for curriculum development.

Mark A. Laingen
Ph.D. Candidate, Dept. of Agriculture and Biosystems Engineering
Iowa State University
mlaingen@iastate.edu
309-235-3967

APPENDIX E. RESPONDENT BREAKDOWN BY ASSESSMENT TERMS FOR THE COE

RESPONSE BREAKDOWN

	COE Totals 2001-05				COE Totals 2006-11		
INTERN/COOP TERM	SELF	SUPR	TOTAL	INTERN/COOP TERM	SELF	SUPR	TOTAL
05 - 105-F05	186	154	340	11 - 111-F11	162	137	299
05 - 105	187	163	350	11 - S11-111	362	262	624
05 - S05-105	117	113	230	10 - 110-F10	127	99	226
05 - S05	30	30	60	10 - S10-110	256	220	476
04 - 104-F04	149	129	278	09 - 109-F09	109	98	207
04 - 104	155	133	288	09 - S09-109	318	214	534
04 - S04-104	134	111	245	08 - F08	172	131	303
04 - S04	15	12	27	08 - S08-108	464	290	754
03 - 103-F03	131	116	247	07 - F07	210	134	344
03 - 103	164	142	306	07 - S07-107	531	373	904
03 - S03-103	82	71	153	06 - F06	213	117	330
03 - S03	68	53	121	06 - S06-106	212	173	385
02 - 102-F02	143	130	273	06 - 106	201	153	354
02 - 102	170	154	324				
02 - S02-102	153	140	293				
01 - F01	219	187	406				
TOTALS	2516	2164	4680	TOTALS	2924	2075	5386
PERCENTAGE		86.0%		PERCENTAGE		71.0%	

APPENDIX F. ASSESSMENT SURVEY COMPLETION RATE

Workplace Competency Assessment Survey Completion Response Rate

	Aerospace			Agricultural			Chemical			Civil			Computer			Construction			Electrical			Industrial			Materials			Mechanical		
INTERN/COOP TERM	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total
11 - 111-F11	11	6	17	6	7	13	11	8	19	14	8	22	9	10	19	16	12	28	11	8	19	19	19	38	6	8	14	59	51	110
11 - S11-111	20	15	35	18	14	32	18	14	32	37	28	65	14	5	19	93	73	166	17	11	28	32	26	58	14	8	22	99	68	167
10 - 110-F10	13	11	24	6	4	10	5	5	10	34	24	58	7	6	13	9	7	16	9	8	17	7	5	12	1	1	2	36	28	64
10 - S10-110	22	17	39	14	10	24	23	23	46	25	21	46	7	6	13	61	50	111	9	9	18	30	24	54	11	10	21	54	50	104
09 - 109-F09	7	7	14	3	2	5	8	4	12	24	21	45	10	10	20	7	7	14	5	4	9	11	9	20	7	7	14	27	27	54
09 - S09-109	21	20	41	18	16	34	30	24	54	30	25	55	15	4	19	62	45	107	19	4	23	35	16	51	19	15	34	69	45	114
08 - F08	15	12	27	13	10	23	13	12	25	14	10	24	8	7	15	16	6	22	7	5	12	14	13	27	12	9	21	60	47	107
08 - S08-108	48	39	87	24	19	43	30	26	56	40	28	68	17	7	24	98	53	151	31	20	51	33	19	52	15	10	25	128	69	197
07 - F07	14	13	27	9	11	20	14	12	26	26	14	40	12	8	20	21	12	33	19	19	38	20	10	30	7	4	11	68	31	99
07 - S07-107	28	26	54	14	11	25	46	23	69	62	36	98	19	16	35	116	76	192	42	28	70	51	36	87	15	14	29	138	107	245
06 - F06	11	8	19	7	5	12	15	8	23	19	12	31	22	11	33	21	2	23	26	17	43	20	14	34	12	5	17	60	35	95
06 - S06-106	7	7	14	12	9	21	8	6	14	22	17	39	36	30	66	10	7	17	16	11	27	25	21	46	10	8	18	66	57	123
06 - 106	4	3	7	13	9	22	16	11	27	29	22	51	42	25	67	8	5	13	10	7	17	20	16	36	7	6	13	52	49	101
TOTALS	210	174	384	132	109	241	213	159	372	325	227	552	140	90	230	520	343	863	195	133	328	272	191	463	119	91	210	798	558	1356
PERCENTAGE		82.9%			82.6%			74.6%			69.8%			64.3%			66.0%			68.2%			70.2%			76.5%			69.9%	

	Aerospace			Agricultural			Chemical			Civil			Computer			Construction			Electrical			Industrial			Materials			Mechanical		
INTERN/COOP TERM	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total	Self	Supr	Total
05 - 105-F05	7	8	15	2	2	4	22	20	42	14	11	25	16	9	25	11	9	20	10	8	18	16	13	29	12	11	23	76	63	139
05 - 105	12	8	20	6	6	12	10	10	20	15	14	29	18	16	34	34	26	60	16	15	31	12	11	23	12	9	21	52	48	100
05 - S05-105	6	7	13	5	3	8	9	9	18	3	2	5	14	12	26	14	15	29	5	4	9	11	11	22	4	4	8	46	46	92
05 - S05	3	2	5	3	3	6	2	2	4	0	0	0	4	5	9	1	1	2	4	5	9	1	1	2	5	5	10	7	6	13
04 - 104-F04	6	4	10	3	3	6	13	13	26	15	12	27	14	12	26	17	12	29	14	13	27	14	13	27	7	7	14	46	40	86
04 - 104	15	14	29	7	6	13	10	8	18	17	13	30	19	16	35	18	14	32	15	15	30	8	5	13	5	5	10	41	37	78
04 - S04-104	3	2	5	4	3	7	5	5	10	15	13	28	14	13	27	12	8	20	10	8	18	13	12	25	8	5	13	50	42	92
04 - S04	1	1	2	0	0	0	5	4	9	2	0	2	0	0	0	0	0	0	3	3	6	0	0	0	3	3	6	1	1	2
03 - 103-F03	6	4	10	4	3	7	12	10	22	21	18	39	14	14	28	12	10	22	11	10	21	10	9	19	3	3	6	38	35	73
03 - 103	13	13	26	7	7	14	9	8	17	15	12	27	27	20	47	15	12	27	17	16	33	12	10	22	2	2	4	47	42	89
03 - S03-103	6	7	13	4	4	8	6	5	11	4	4	8	3	2	5	6	4	10	7	5	12	9	8	17	2	1	3	35	31	66
03 - S03	4	3	7	3	2	5	2	2	4	10	10	20	12	8	20	2	2	4	5	4	9	7	5	12	3	1	4	20	16	36
02 - 102-F02	5	5	10	9	8	17	18	16	34	21	21	42	24	22	46	15	15	30	10	9	19	7	5	12	2	2	4	32	27	59
02 - 102	11	10	21	7	8	15	9	9	18	16	17	33	16	16	32	14	10	24	19	17	36	15	14	29	6	5	11	57	48	105
02 - S02-102	12	12	24	3	2	5	22	21	43	15	12	27	18	16	34	11	8	19	11	9	20	10	8	18	2	2	4	49	50	99
01 - F01	6	6	12	9	11	20	20	16	36	21	20	41	39	40	79	17	9	26	24	21	45	22	17	39	4	4	8	57	43	100
TOTALS	141	124	265	87	81	168	198	175	373	255	218	473	270	233	503	277	210	487	207	180	387	212	179	391	97	83	180	772	681	1453
PERCENTAGE		87.9%			93.1%			88.4%			85.5%			86.3%			75.8%			87.0%			84.4%			85.6%			88.2%	