Int. J. Engng Ed. Vol. 22, No. 2, pp. 257–263, 2006
Printed in Great Britain.
0949-149X/91 $3.00+0.00

Assessing Engineering Internship Efficacy: Industry's Perception of Student Performance*

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Ira A Fulton School of Engineering administrators and faculty have integrated curricular materials and strategies to ensure that students possess the competencies that are embedded in the Accreditation Board for Engineering and Technology (ABET) criteria. One measure to assess student performance is to gather feedback from industry managers who employ students as interns while they are still enrolled in school. The current study examined internship program efficacy in the Ira A Fulton School of Engineering. Program success was determined by the following three criteria: 1) student performance outcomes based on ABET criteria, 2) number of student participants and industry partners, and 3) industry-university collaboration. A primary objective of this study was to develop an assessment instrument and process that would capture alignment between ABET criteria and student performance in internships. This paper will outline critical inherent variables that contribute to internship program impact and will describe methods to enable assessment alignment between program outcomes and accreditation criteria. Industry feedback reveals that both undergraduate and graduate students possess the majority of skills defined in the EC2000 a–k competencies. Significant differences between undergraduate and graduate students were not evident. This is an important finding particularly in terms of accreditation criteria. Faculty who teach undergraduate higher-level courses may also teach graduate courses. Thus, it is likely that instructors who have been implementing methods to accomplish school objectives and outcomes in their undergraduate courses are also integrating those same strategies into their graduate courses. The formative assessment has determined program strengths and opportunities for improvement and thus will define further practices and processes to ensure future success.

INTRODUCTION

RESEARCHERS have studied the effect of internships and cooperative education experiences in engineering, and found that they positively affected students in three dimensions [1]: GPA, duration of time in school, and starting salary. Several other studies [2, 3] revealed more positive outcomes for interns in terms of academic standing and higher cumulative grade point averages than for non-experienced engineering majors. In addition, internship experiences decrease job search time and increase the probability of promotion and advancement after hire [4]. Industry partnerships and practical work experience for both faculty and students can also benefit the university [5] in a changing technological economy [6, 7]. Industry–university collaboration enables School administrators to anticipate shifts in industry trends and also to gather critical industry feedback on student performance and program impact in order to adjust the curriculum and programs accordingly.

* Accepted 29 September 2005.

THE RESEARCH PROBLEM

The Ira A. Fulton School administrators and faculty have made every attempt to ensure that graduates possess the qualities that are embedded in the Accreditation Board for Engineering and Technology (ABET) criteria. As faculty are developing methodology for assessing performance on the ABET outcomes [8], a School team began creating an instrument to assess internship performance based upon the same criteria. ABET has increased the thrust for faculty to quantitatively assess these competencies, which has promoted interest in developing and identifying relevant assessment instruments [9]. However, only a handful of tools and methods are available [10]. The study started with the assumption that EC2000 requires all engineering programs to demonstrate that their senior graduates meet the requirements listed in Criteria 3 (a–k). After a thorough search of the literature, it was evident that few universities are evaluating their engineering internship programs with ABET criteria. One of our objectives was to align the internship assessment with the ABET student performance outcomes. Thus, many of the survey questions reflected these competencies. The evaluation and EIP team attempted to answer the following research questions:

- What is industry's perception of Fulton's undergraduate and graduate interns in terms of ABET criteria?
- Do internships foster university–industry collaboration?
- Why is industry employing university interns?

THE FULTON ENGINEERING INTERNSHIP PROGRAMS

The study investigated outcomes from two diverse internship programs within the School of Engineering, the Engineering Internship Program (EIP) and the Harrington Department of Bioengineering Internship Program. The EIP serves all engineering students and the Harrington Department targets bioengineering students and biomedical and biotechnology industries. Although the two programs typically serve different types of students and industry members, their objectives are similar. The common features they share include the following:

- to characterize and reflect the objectives and goals of the School (accreditation criteria);
- to serve both undergraduate and graduate students;
- to promote self-sufficiency and industry-university collaboration.

The research goal was to align program assessment with School objectives and outcomes. Thus we evaluated the effectiveness of both programs using the same criteria.

The Engineering Internship Program (EIP)

The Engineering Internship Program (EIP) at Arizona State University's Ira A. Fulton School of Engineering was initially created by the Associate Dean of Student Affairs in 1986 to promote students' real-world industry placement and to acquire much needed scholarship money to attract and retain top transfer students and incoming freshman. The EIP is unique among internship programs because it not only places students with industry, but also has an imperative to establish and maintain industry partnerships, and cultivate industry support for the Dean's Industry Scholarship Fund. Over the years, the EIP has grown to become a revenue stream for the college of $1.1 million in 2004, with all income stemming from industry sponsors.

The nourishment of industry relations lies at the crux of the EIP's existence, since industry supports the program entirely. The EIP director is responsible for developing, implementing and promoting programs for EIP Internships by establishing and maintaining relevant industry partnerships with the Fulton School of Engineering. In order to engage industry in the EIP, the Director must identify the salient value of the program to diverse industry organizations, and encourage industry collaboration and financial participation in various scholarship funds. She is also responsible for the planning, development and management of the EIP services and activities for students and corporate sponsors by monitoring internships, and handling negotiations resolving disputes, either legal or internal. The director advises students regarding the issues that impact student success and retention in industry internships, and speaks to student, industry, and faculty groups to promote awareness of the EIP.

The EIPs unique model of collecting scholarship money in conjunction with internships has the flexibility to incorporate other departments and centers in need of scholarship funding for their students. Recently, the EIP has established scholarship funding for other programs in the Fulton school. For example, with an Intel fellowship created under the auspices of the Associate Dean of Research, scholarship money was allocated to the Center for Engineering Diversity and Retention, which works to promote the interests of traditionally unrepresented populations in engineering. Other programs have also received scholarship money when their students were placed at industry through the EIP, such as Connection One and the Computational Biosciences department.

Harrington Department of Bioengineering Internship Program

The Harrington Department of Bioengineering Internship Program includes programs in industry, clinical and shadow experiences, research, and prosthetic and orthotics, among others. The department's Industrial Internship Program is without question the most successful and flourishing component of the program as a whole. Funded by the Whitaker Foundation from 1996 to 2002, the Industrial Internship Program was established to aid in the preparation of students for biomedical engineering careers in the medical device and biotechnology industries and to familiarize companies with the talents and abilities of students earning a bioengineering degree. Since its start, the Industrial Internship Program has developed into a unique and successful program. Some of the unique qualities of the program are discussed in detail below.

The department employs a full-time internship program coordinator who serves as a point of contact for students, faculty and industry. She works actively to make contacts through faculty, department alumni, and career fairs. She also aids students with the fundamental skills of résumé writing and job searching, co-instructs the program's corresponding internship seminar, and occasionally facilitates research collaborations by connecting faculty with interested companies. In addition to the internship coordinator, a department faculty member, the department chair, and a business manager provide faculty and business support to the program.

Especially unique is the Industrial Internship Program's financial structure since the end of Whitaker funding in 2002. To join the Harrington Department of Bioengineering Industrial Internship Program, companies (both local and national) pay semesterly or yearly membership fees, depending on their specific needs. By joining the program, companies receive résumés each summer, fall, and spring of both qualified undergraduate (junior and seniors only) and graduate student candidates. In addition, any student selected for an internship is hired as a university student employee and paid by the university. Companies are invoiced at the end of each semester or internship session for the amount paid (along with some small processing fees). Such fees and payments are all tax deductible and save each company a great deal of time and money, as they fully avoid the cost of advertising and marketing for interns.

Each student selected for an internship opportunity in any facet of the program is required to enroll in the BME 484/584 Internship Seminar in an effort to maintain contact with the interns, and to ensure that internships are both an educational and professional experience. During the course of the seminar, each industrial intern completes numerous presentations on the company for which they are interning, an internship portfolio, and a poster of their internship experience to be presented at the department's annual Biomedical Engineering Day (BME Day). Each year the department hosts the BME Day to recruit high school students, which includes guest speakers, lab tours, breakfast and lunch. During the poster session, both capstone (senior design) students and the interns present their work through professional posters and demonstrations. Many industry program members attend the afternoon poster session, as well as faculty and department graduate students.

METHODS AND DATA ANALYSIS

The process

This section highlights measurements and analysis by the Director of Assessment and Evaluation. Program efficacy was determined by the following criteria:

- student performance outcomes based on ABET criteria;
- number of student participants and industry partners; and
- industry-university collaboration.

To accomplish the assessment objectives the following data sources were employed: student and industry data computed over the past year and survey responses to determine industry satisfaction and industry-university collaboration. Data were systematically recorded to ensure reliability.

A comprehensive survey was developed by the Ira A. Fulton School that industry used to evaluate the performance of interns and industry–university collaboration. Furthermore, industry partners were asked if an opportunity occurred, would they hire the intern. The evaluation team pilot tested the survey to ascertain wording clarity, appropriateness, and validity of the instrument. The team worked with the Associate Dean of Academic Affairs, department chairs, and the Director of Strategic Planning to refine the text, determine statistical appropriateness, and ensure alignment with ABET criteria and School objectives, an overall goal of the project.

To facilitate the School's effort to improve engineering students' competencies, in 1999 a committee was charged to develop a survey that would be administered to engineering students every year, starting in the year 2000. It was our goal to align the internship survey with the School survey to assess industry's perception of student performance. In this way, the project collected industry feedback: 1) to determine internship efficacy and 2) to examine the correlation between school objectives and student performance outcomes. Thus, if survey results indicated an opportunity for improvement in the curriculum, the School would be able to make changes, thus, facilitating the continuous improvement loop. It is valuable to gain industry's perception of enginering students with regards to the new (ABET) criteria during their enrollment. By investigating these issues we are better able to identify and focus on areas of improvement for all students.

ABET criteria that were embedded in the survey include:

- math, engineering, and technical competence;
- design and product realization; communication skills;
- awareness of professionalism and ethics;
- life-long learning;
- teaming competence;
- knowledge of societal, political, and community issues.

Survey sections were dedicated to these student outcomes as the School has made a significant effort to infuse these criteria into curricular materials, classroom activities, and program objectives.

Surveys were delivered by electronic mail and were also available in an online format whereby industry members could submit their results to the Assessment and Evaluation Office directly to ensure confidentiality and anonimity. Of the 52 industry managers contacted, 40 responded to the survey, yielding a 77% response rate. Departments who continually provide internships for the EIP are as follows: computer systems engineering, electrical engineering, industrial engineering, aerospace, bioengineering, and civil engineering.

The survey used a 5-point Likert scale employing the following range: 1= Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly Agree. Data were examined for general trends and by department and intern type (e.g., graduate or undergraduate). Non-parametric statistics were used since the distribution was presented in ordinal form. Non-parametric statistics are generally more conservative than statistics that assume normality.

A conservative approach for analyzing the data was taken. Mann-Whitney non-parametric tests were conducted on confidence measures and statements to determine student differences. Non-parametric tests are used when the distributions are such that both or all are presented in ordinal form and when populations from which the samples were selected are known to lack normality.

EMPIRICAL RESULTS OF THE STUDY

The University–Industry collaborative survey project was successful in capturing internship program efficacy concerning all of the stated criteria and more specifically assessing the majority of the ABET a–k competencies. In general, the survey results highlighted the fact that industry members are extremely satisfied with the internship program, the interns, and the industry–university collaboration that it fosters. Corporations have indicated that they are satisfied with the academic preparation and the overall performance of the engineering interns. The majority of industry members stated that the 'Scholarship portion of the fee schedule enhances Industry–University collaboration' a thrust of the Ira A. Fulton School and the university.

Assessment revealed that students are perceived as having the majority of the skills and abilities listed in ABET Criteria 3 (a–k). Significant differences between undergraduate and graduate students were not evident. This is an important finding particularly in terms of ABET criteria. Faculty who teach undergraduate higher-level courses may also teach graduate courses. Thus, it is likely that those instructors who have been implementing methods to accomplish school objectives and ABET a–k criteria in their undergraduate courses are also integrating those same strategies into their graduate courses. Internship programs appear to be important in today's educational experience, as indicated in the following excerpt: 'Internships are a very critical part of today's educational process. As an employer I would be reluctant to hire a student fresh out of school without any work experience.' Another commented: 'Overall, these are valuable programs which serve many university–industry needs.'

Regarding student and industry participants, the EIP increased its student participant number from 92 in 2003 to 101 in 2004. One of the strengths of the program is that it employs students for 12 months of the year with summer being a very productive month. In 2004, the EIP employed 26 students in the spring, 40 students in the summer, and 35 in the fall. About 22 industry partners employ EIP interns including companies such as Dell, Intel, Honeywell, Humana, Motorola, Pearson Digital Learning, Phillips and TGEN.

The Harrington Department of Bioengineering typically places 26 students per year, which also includes the summer months. Since 1996, 228 internships have been established through the department's Industrial Internship Program. This number does not include clinical, prosthetic and orthotics internships. Approximately 39 companies have participated in the industrial portion of the program. Currently, the three largest program supporters and most active members are CR Bard (Bard Peripheral Vascular), OrthoLogic, and Alliance Medical Corporation.

Industry overall satisfaction

Results reveal that industry partners participating in engineering internship programs are extremely satisfied with the industry–university collaboration as indicated by their agreement with that survey item (97% agreed or strongly agreed). In addition, industry members indicated that they are satisfied with the academic preparation (92%) and performance (89.7%) of the intern. An industry excerpt further supports this assertion, 'I am very satisfied with interns and their performance. A win/win environment is established and maintained from both parties. This leads to a very successful program.' The majority of respondents stated that they would hire the intern if they had an opening in their department (97.5%). One industry respondent stated the following, 'I have been very satisfied with the interns I have worked with and two of them are now on-board with the company following graduation.' No statistically significant differences were evident between the two groups, which indicated that student performance is consistent for engineering undergraduate and graduates. See Table 1.

ABET Criteria 3 a–k Alignment

As mentioned above, our objective was to align internship assessment with ABET criteria and many of the survey questions reflected those competencies. Data analysis suggested that six of the ABET criteria a–k are strengths of the School reflected in internship performance. More specifically, industry partners perceived that interns were equipped with a strong foundation in mathematics and basic engineering; designed systems, devices, and components as needed; were committed to professional and ethical responsibility; worked effectively in teams; communicated effectively; and were life-long learners. Engineering knowledge, conceptualization, and potential are revealed in the following excerpt, 'The intern was far ahead of the field and we are still using his innovations. When he left, my V.P. and I used his

Table 1. Internship overall satisfaction: industry–university collaboration

Survey item	Intern type	Mean	Standard deviation
I am satisfied with the industry-university collaboration	Undergraduate	4.71	0.470
	Graduate	4.59	0.590
I am satisfied with the academic preparation of the intern	Undergraduate	4.41	0.618
	Graduate	4.41	0.666
I am satisfied with the performance of the intern	Undergraduate	4.65	0.606
	Graduate	4.38	0.740
If there was an opening, would you hire this intern?	Undergraduate	4.76	0.437
	Graduate	4.77	0.528

ideas and concepts and we are still working on them today.'

Data reveal that competencies a, c, d, f, g, and i received strong responses. An industry participant offered the following comment: 'The interns I have worked with have very good basic software engineering skills.' Another corporate manager discussed several competencies: 'Interns have been highly motivated and professional and would be a great addition to any group. Academic preparation was excellent. Overall they have been highly qualified.' One respondent supported the Bioengineering interns and their program: 'The ASU Bioengineering program is definitely preparing students to be productive in industry. They are being taught real-life problems, not just theory. I was particularly impressed with the poster session at BME Day because the posters were on such a profession level.'

Industry members indicated that students were aware of societal, political, and community issues; however this response was not as strong as the other ABET competencies. Similarly, ABET h criteria (understanding the impact of engineering solutions in a global and societal context) received lower responses. Since criteria such as ABET f, g, h, i, and j are difficult to ascertain, particularly if you ask students to assess themselves, industry feedback is critical. Thus, the Ira A. Fulton School will be able to document student performance outcomes based upon the input of industry managers while students are out working in their field. See Table 2.

Communications skills

Critical attention was paid to engineering communication skills as they have been identified as a weakness in the engineering student population [11]. Prior research revealed that although industry members viewed communication skills as 'Most important,' they felt that engineering students were 'less prepared' in that area [12]. As part of the current research process, the survey team developed four additional questions dedicated to the diverse areas in communication. It was evident that interns were successful in the areas of preparing appropriate computer-based and graphical materials and in communicating effectively across the technical boundaries of engineering with transfer to work settings. This finding is noteworthy as it reveals that engineering students are able to apply and communicate technical information in a work context. Although two of the communication survey items received lower response ratings, they were still above average. The lower items included the ability to plan, prepare, write, and assess written and oral reports. See Table 3.

Reasons for selecting university interns

Industry participants were asked to indicate how they heard about the Ira A. Fulton School internship programs. The majority (54%) stated that they were aware of the programs because their company has hired Fulton interns. Additionally over one third indicated that they heard about the program through another company manager and through communication with School faculty. Industry members indicated reasons why they were interested in employing interns. Although they identified cost effectiveness, the primary reason was the 'quality of the Ira A Fulton School interns' (96%). Other reasons mentioned were the mentoring aspect and that interns could fill part-time opportunities. See Table 4.

Table 2. Internship ABET Alignment: ABET Criteria, survey results

ABET competency used	Mean	Standard deviation
ABET a: Interns were equipped with a strong foundation in mathematics and basic engineering	4.23	0.677
ABET c: Interns were able to design systems, devices, and components as needed	4.12	0.857
ABET f: Interns maintained a sense of commitment to professionalism and ethical responsibility	4.33	0.797
ABET d: Interns work effectively in teams and in multidisciplinary environments	4.28	0.716
ABET g: Interns were able to communicate effectively in oral, written, computer-based, and graphical forms	4.02	0.698
ABET h: Interns are aware of and sensitive to social and political issues pertinent to their discipline	3.81	0.811
ABET i: Interns had an understanding of and interest in continued life long learning of technologies	4.13	0.875
ABET j: Interns were aware of societal, political, and community issues	3.79	0.687

Table 3. Intern competency in communication skills

Survey item	Mean	Standard deviation
Interns appropriately plan, prepare, write and assess written reports	3.95	0.783
Interns appropriately plan, prepare, deliver and assess formal and informal oral presentations	3.83	0.737
Interns communicate effectively across the technical boundaries of engineering with transfer into work settings	4.15	0.670
Interns prepare appropriate computer-based and graphical materials	4.36	0.537

Table 4. Reasons for selecting interns

Survey item	Industry response (%)	Standard deviation
Quality of interns	96	0.196
Mentoring aspect	88	0.332
Cost effectiveness	95	0.218
Part time opportunities available	82	0.405
Lower visible headcount	75	0.463
Intern had prior work experience	82	0.405

CONCLUSIONS

The study has revealed overall satisfaction with engineering internship programs and their student participants. The investigation showed the School's success in concert with internship efficacy as revealed by strong responses to ABET a–k criteria. More specifically, both graduate and undergraduates were equipped with a foundation in mathematics and basic engineering, worked effectively in teams, were professional, designed systems, devices, and components as needed, and continued in life-long learning technologies. However, opportunities for improvement emerged. Students were less aware of societal and community issues and were perceived as less skilled in planning, preparing, writing reports and in presenting the material. These areas will be further examined this year during accreditation and curricular committee meetings.

To increase the value of the survey research effort, the team held engineering internship programs to the same standards as other engineering programs and aligned their student outcomes and industry satisfaction with ABET criteria. The evaluation team organized and disseminated the materials and findings to other constituencies in the School. Department chairs whose students regularly participate in internship programs will integrate these data into their overall assessment plan and will embed it in their next ABET and University Reports. One administrator stated that the industry data will be very useful in the ABET accreditation requirements to assess outcomes and objectives. Deans, department chairs, and faculty will be able to examine the current data to drive future processes and practices in the Ira A. Fulton School to ensure continuing success.

Acknowledgement—The authors and the Ira A. Fulton School of Engineering recognize and appreciate the efforts of industry participants, associate deans, faculty, and department chairs for their participation in this study. We would like to also acknowledge Dr. Norma Hubele, the Ira A. Fulton School of Engineering Director of Strategic Initiatives, for her valuable contributions.

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