A Preliminary Analysis of Employer Ratings of Engineering Co-op Students

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Abstract

Internships and co-ops provide students the opportunity to develop both the technical and non-technical skills that comprise the EC 2000 a-k outcomes. At the Mercer University School of Engineering (MUSE), we are using employer feedback to investigate all eleven EC2000 a-k outcomes in an attempt to gain an outsider's perspective on our curriculum. MUSE faculty adapted the eleven EC 2000 outcomes into eight learning outcomes, known as the MUSE 8, to reflect the mission of our engineering school. In 2001, Shelia Barnett, director of the Industrial Experience Program and Joan Burtner, member of the Assessment Committee, obtained Institutional Review Board approval to survey employers to monitor the effect of co-op experiences on EC2000 learning outcomes. To facilitate this research, the existing Employer's Evaluation form was revised to include direct references to the MUSE 8. This revised form was first distributed to employers at the beginning of the Summer 2001 term. Forty-eight students participated in the program during the Summer 2001 term; thirty-nine Employer's Evaluation forms were returned to the Industrial Experience Program Office. We are using the information included in the thirty-nine returned surveys as our baseline data. Data has since been collected for Fall 2001, Spring 2002 and Summer 2002. Seventeen students participated during Fall 2001, twelve during Spring 2002 and thirty-three during Summer 2002. For these students, employers returned sixteen, eleven and thirty-one forms, respectively. This paper describes select data from the employer survey as it relates to MUSE 8 outcomes.

Introduction

Cooperative (co-op) education has long been recognized as a win-win situation for both employers and students. From the students' point of view, co-op offers participants the ability to get hands-on experience and earn a decent wage [12]. Furthermore, the co-operative experience gives students a chance to develop the professional-practice skills that are not often evidenced in new hires [9, 13]. Employers benefit by getting high-quality temporary employees who are often given special short-term projects [12]. In addition, employees of cooperative education students use the co-op experience as an opportunity to recruit well-qualified graduates (Katz). In a survey of 68 supervisors, managers, and human resource staff from a total of 55 engineering firms, Duggan [8] showed that recruiting quality employees is the major reason for using coop students. Hurd and Hendy [11] report that improved retention is another benefit. Their research review indicated that employees who had previous coop experience with the company were retained at a higher rate than those who had no previous experience. A 1995 survey of corporate cooperative education directors [10] indicated that new hires who had previous co-op experience exhibited greater maturity and problem solving ability than those who had no co-op experience.

Although it is generally accepted that participating in an engineering co-op program provides students with valuable practical experience, there is a lack of specific literature documenting the benefits of co-op/intern programs, especially with respect to fundamental engineering principles [4]. Researchers at other engineering schools have offered anecdotal evidence that university-sponsored

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work experiences provide a rich environment in which students can develop non-technical skills related to learning outcomes such as teamwork and communication, but only a few have provided quantitative data. Wankat, Oreovicz and Delgass [17] report that a 1994 alumni survey indicated that practical work experience, along with lab and design courses taken at the school, were very important sources for learning certain "soft skills". The survey instrument listed written and oral communication, ethics, teamwork, leadership, and meeting skills; however, other EC2000 a-k outcomes such as global and contemporary issues were not included in the survey. Canale, Cates, and Duwart [7] collected quantitative data at two different engineering co-op programs. Their research examined student perceptions as to the impact of the co-op experiences on achievement of EC 2000 outcomes. The Wankat, Oreovicz and Delgass [17] results as well as those of Canale, Cates, and Duwart [7] indicate that students' non-course activities such as co-ops and internships offer a very good opportunity for students to develop their non-technical or soft skills. However, neither study reported data from the employer's viewpoint. The survey data we report here reflects the employers' evaluation of the engineering co-op students' skills.

The Mercer University School of Engineering (MUSE) supports industrial experience as an approach to learning. We know that practical experience adds relevance to the students' education and will fortify the learning process. To help facilitate this process, the following learning objectives were developed for the Industrial Experience Program:

- to improve student learning inside and outside the classroom,
- to prepare students for the journey of lifelong learning, to increase the number of students with practical engineering experience prior to graduation,
- to strengthen relationships between Mercer University and employers who hire Mercer University students and graduates, and
- to provide enthusiastic and high-quality graduates for our employers [2].

MUSE demonstrates this support of the industrial experience option to learning with the collaboration between Career Services and MUSE. Through this collaboration, students who qualify (GPA of 2.5 or better) and participate are provided individual career development support through various workshops specifically targeted to freshman students and one-on-one sessions for upper level students by the Career Services staff. This unique pairing of Career Services with the academic mission of the MUSE Industrial Experience Program leverages the expertise in each department [2].

The MUSE Industrial Experience Program is an active participant in school-wide quality assurance efforts. According to the new ABET guidelines [1] (see http://www.abet.org/policies.html), universities must show they are assessing their curriculum using a variety of methods in an effort to achieve specific learning outcomes. This curriculum improvement process may be seen as part of an overall quality improvement effort [5, 14, 15] that will benefit all of the stakeholders, including students, parents, employers, faculty, and administrators. Here at Mercer, we have decided to use formal employer evaluations as one method to investigate the eleven EC2000 a-k outcomes to gain an outsider's perspective on our curriculum. Although employee feedback has always been an important component of our co-op assessment process, we did not link employer ratings to specified learning outcomes before the advent of EC2000. In 2001, Shelia Barnett, director of Industrial Experience, revised the Mercer University School of Engineering Industrial Experience Program student evaluation forms to obtain employer feedback related to the EC2000 criteria. Data for Summer 2001 [3], Fall 2001, Spring 2002 and Summer 2002 semesters have been collected. This paper presents a preliminary analysis of that data with an emphasis on the baseline term (Summer 2001).

The Survey Instrument and Results

The Employer's Evaluation form was reviewed and approved by Mercer's Institutional Review Board in Spring 2001. The survey includes twenty-five questions related to students' work performance. Nineteen of the twenty-five questions use a Likert-type scale with the following values: Excellent 5;

Very Good 4; Average 3; Below Average 2; and Poor 1. The remaining survey questions allow non-Likert responses; these questions deal with students' strengths and weaknesses and future employment status. Copies of the employer survey may be obtained by contacting one of the authors.

The School of Engineering has adapted the eleven EC2000 a-k outcomes to meet the needs of our school. The resulting outcomes are known as the MUSE 8 and are listed in Table 1, along with baseline data from the Summer 2001 survey. Table 1 includes rank-ordered evaluation data by outcome, beginning with the most highly rated outcome (teamwork, M = 4.42) and ending with the lowest rated outcome (leadership and community service, M = 4.05).

Table 1: Employer Survey Baseline Data Rank-ordered by Outcome - Summer 2001 (U01),

Outcome	Description	Mean Score*
5	Ability to function effectively on interdisciplinary teams	4.42
6	Ability to communicate effectively in a variety of modes, i.e. written, oral and visual	4.39
1	Ability to apply mathematics and science principles to the solution of engineering problems	4.31
2	Ability to apply appropriate breadth and depth of skills in identification and analysis of engineering problems.	4.22
4	Ability to design and conduct experiments and analyze data	4.19
3	Ability to apply appropriate breadth and depth of skills in engineering design and analysis of engineering problems	4.17
7	Ability to relate the practice of engineering to global contemporary issues, to professional ethics, and the need for lifelong learning.	4.09
8	Ability to provide leadership and contribute to sustaining and improving the community.	4.05
Overall		*4.23*

*Scale: Poor-1 Fair-2 Good-3 Very Good-4 Excellent-5

Table 2 summarizes the employer ratings by outcome for the four times in which the survey has been administered. The outcomes in Table 2 are listed in numerical order. Outcomes 1-4 of the MUSE 8 may be classified as technical engineering skills that have been traditionally associated with the engineering profession. Outcomes 5-8 reflect the non-technical or engineering-related professional practice skills that are also an important component of a modern engineering education. While outcomes 5 and 6 represent non-technical areas that are traditionally associated with an engineering education, outcomes 7 and 8 deal with areas that are relatively new to the engineering curriculum.

Table 2: Employer Evaluation by Outcome - Summer 2001 (U01), Fall 2001 (F01), Spring 2002 (S02), and Summer 2002 (U02)

Outcome	***Brief Description***	***Mean Score* U01***	***Mean Score* F01***	***Mean Score* S02***	***Mean Score* U02***
1	Application of math and science principles	4.31	4.19	4.09	4.43
2	Identification of engineering problems	4.22	4.19	4.27	4.30
3	Design and analysis of solutions to engineering problems	4.17	4.06	4.09	4.36
4	Experimentation and data analysis	4.19	4.19	4.00	4.36
5	Teamwork	4.42	4.25	4.09	4.50
6	Communication	4.39	4.25	4.18	4.47
7	Global awareness/ professional and ethical practices	4.09	4.31	4.36	4.66
8	Leadership and community service	4.05	4.13	3.91	4.32
Overall		**4.23**	**4.20**	**4.13**	**4.42**

*Scale: Poor-1 Fair-2 Good-3 Very Good-4 Excellent-5

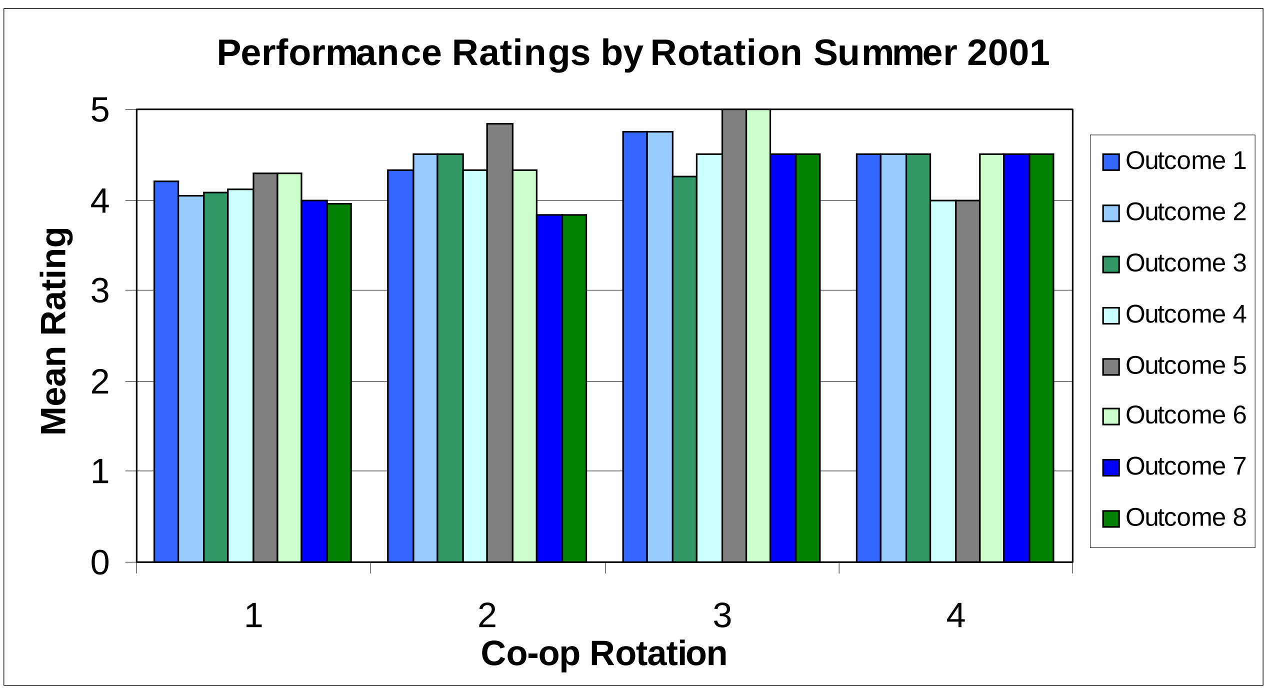

Figure 1. Differences in Employer Ratings as a Function of Co-op Rotation for the Baseline Term

We were interested in determining the relationship between amount of co-op experience and employer ratings. Figure 1 offers a graphical representation of ratings as a function of co-op experience for the baseline term. Table 3 shows the mean ratings by work experience level (co-op rotation) for the baseline term. Our hypothesis was that more experienced students would receive higher ratings.

Table 3: Comparison of Average Ratings by Work Experience Level - Summer 2001.

Outcome	**Co-Op Rotation**			
	1st	2nd	3rd	4th
1	4.21	4.33	4.75	4.50
2	4.04	4.50	4.75	4.50
3	4.08	4.50	4.25	4.50
4	4.12	4.33	4.50	4.00
5	4.30	4.83	5.00	4.00
6	4.30	4.33	5.00	4.50
7	4.00	3.83	4.50	4.50
8	3.96	3.83	4.50	4.50
Overall Mean	*4.12*	*4.31*	*4.66*	*4.38*

*Poor-1 Fair-2 Good-3 Very Good-4 Excellent-5

Discussion

The data in Table 1 form the benchmark data for our study. As seen in Table 1, Outcomes 1, 5, and 6 received the highest average ratings in the Summer 2001 term. It is perhaps not surprising that communication and teamwork are so highly rated by employers. Anecdotal evidence from past conversations with employers has indicated that our students perform well in these areas. Considering previous survey results, it is somewhat surprising that the employers give such a high rating to our students' ability to apply math and science. As reported by Burtner [6] our freshmen have exhibited low self-confidence in their math and science ability. Freshman students enrolled in the Mercer University School of Engineering during the AY 99-00 who took the Pittsburgh Freshman Engineering Attitudes Survey© rated themselves 3.1 (on a 1-5 scale) for the math and science outcome. On the other hand, employers of students who had just completed their freshman year gave the work experience students a rating of 4.4 (also on a 1-5 scale). Although outcomes 2,3, and 4 received slightly lower scores, the data show employers are generally satisfied with students' ability to solve problems and analyze data. Outcomes 7 and 8 received the lowest average scores. These results are not unexpected, as anecdotal evidence indicates employers typically do not evaluate engineering students on attributes such as global awareness and community service. Regardless of relative rank, it is important to note that each outcome was rated greater than 4.0, on average, by employers. This is encouraging news and is consistent with research conducted by Todd, Barron and Pangborn [16].

Figure 1 and Table 3 show comparisons of ratings by work experience level (co-op year) for Summer 2001, Fall 2001, Spring 2002, and Summer 2002, respectively. By looking at the employer evaluation based on the number of work rotations the work experience students have completed, we may infer the potential benefit of additional co-op rotations. For Summer 2001, 27 of the surveys returned were for students enrolled in the program for the first time; the numbers for the second, third and fourth rotations were six, four, and two, respectively. There does not seem to be a clear pattern in the employer's ratings for the overall mean of the eight outcomes; the mean ratings for the four experience levels are 4.12, 4.31, 4.66, and 4.38, respectively.

As part of our preliminary analysis, we decided to investigate the relative performance of experienced and novice co-op students. The statistical package Minitab was used for each analysis, and partial results for the marginally significant outcomes are reported in Figures 2 and 3. For outcome 2, there were 25 first term co-op students (BEG) and 6 second term students (INT). Due to the small number of advanced level co-op students, we combined the 3rd and 4th rotation students into one group (ADV).

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Analysis of Variance for U01OUTC2

Source     DF        SS        MS        F        P
ExperBIA    2     2.477     1.238     3.05    0.060
Error      34    13.793     0.406
Total      36    16.270
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
Level       N      Mean     StDev  ------+---------+---------+---------+
1 BEG      25    4.0400    0.6758   (-----*-----)
2 INT       6    4.5000    0.5477       (------------*-------------)
3 ADV       6    4.6667    0.5164           (-------------*------------)
                                   ------+---------+---------+---------+
Pooled StDev =   0.6369                 4.00      4.40      4.80      5.20
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Figure 2. Minitab Output for Technical Outcome 2 ANOVA

As can be seen in Figure 2, the experienced students (levels INT and ADV) received higher mean ratings than the inexperienced (BEG) students with respect to their ability to identify and analyze engineering problems. However, the differences were only marginally significant ($F = 3.05$, $p = 0.06$). The plot of the confidence intervals shows that there was a steady increase in ratings as a function of experience.

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Analysis of Variance for U01OUTC5

Source     DF        SS        MS        F        P
ExperBIA    2     1.793     0.897     2.74    0.078
Error      36    11.796     0.328
Total      38    13.590
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
Level       N      Mean     StDev  ----+---------+---------+---------+--
1 BEG      27    4.2963    0.6086  (------*-----)
2 INT       6    4.8333    0.4082           (------------*-------------)
3 ADV       6    4.6667    0.5164      (------------*-------------)
                                   ----+---------+---------+---------+--
Pooled StDev =   0.5724               4.20      4.55      4.90      5.25
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Figure 3. Minitab Output for Non-technical Outcome 5 ANOVA

The one-way ANOVA for outcome 5, teamwork, was also marginally significant ($F = 2.74$, $p = 0.078$). The plot of the confidence intervals does not show a steady increase in ratings as a function of experience. Nevertheless, there is a clear difference between beginning co-op students and experienced co-op students. We will need to investigate this phenomenon further before drawing any conclusions as to the relationship between cumulative co-op experience and workplace expertise as judged by the students' supervisors.

Conclusion

Employers expressed a high degree of satisfaction, on average, for the students' performance on all eight MUSE outcomes. During the baseline year, teamwork and communication were the most highly rated non-technical skills. The ability to apply math and science principles was the most highly rated technical skill. Preliminary analyses indicated mild support for the hypothesis that more experienced students would receive higher ratings, on average, than new co-ops.

Data from our surveys have been presented to the entire faculty [3] as part of our new assessment program, instigated, in part, by recent changes in engineering accreditation guidelines. The data are especially important as they provide input from an external source that can be used to help complete the feedback loop as we continually assess the engineering curriculum.

References

1. ABET, *Accreditation Policies and Procedures*, Accreditation Board for Engineering and Technology, Inc., http://www.abet.org/criteria.html, Retrieved from the World Wide Web December 16, 2002.

2. Barnett, S., (2002). Industrial Experience and Engineering Freshman: A Pilot Program, *American Society for Engineering Education Annual Conference Proceedings*, Session 2793.

3. Barnett, S. and J. Burtner., (2001, October 19). "Industrial Experience Program Employer Survey MUSE 8/EC 2000 Results." Unpublished report presented to the MUSE Faculty.

4. Bayless, D.J., (Oct 1999) "Using Industrial Summer Intern Programs as a Tool for Engineering Education", *Journal of Engineering Education*, pp. 465-469.

5. Benefield, L.D., L.L. Tentham, K.K. Hodedadi, & W.F. Walker, (1997, Jan) "Quality Improvement in a College of Engineering Instructional Program", *Journal of Engineering Education*, pp. 57-64.

6. Burtner, J., (2001, March 26). "Pittsburgh Freshman Engineering Attitudes Survey© EC 2000 Results". Unpublished report presented to the MUSE Faculty.

7. Canale, R., C. Cates, & E. Duwart, (2000). Co-op and ABET 2000: The Added Learning Dimension. *American Society for Engineering Education Annual Conference Proceedings*, Session 1661.

8. Duggan, M.B., (1989) "Engineering Employers and Cooperative Education: What is Important to Them?" *Journal of Cooperative Education*. 26(1), 76-79

9. Evans, D.L., G.C. Beakley, P.E. Crouch & G.T. Yamaguchi, (Oct 1993), “Attributes of Engineering Graduates and Their Impact on Curriculum Design”, *Journal of Engineering Education*, Volume 82, No. 4, pp 203-211.

10. Friel, T., (1995, Jan) "Engineering Cooperative Education: A Statistical Analysis of Employer Benefits”, *Journal of Engineering Education*, pp 1-6.

11. Hurd, J. and M. Hendy, (1997) "What We Know About Co-op Employer': A Synthesis of Research in the USA and in Canada." *Journal of Cooperative Education* 32(2), 55-69.

12. Lang, J.D., S. Crues, F.D. McVey, & J. McMasters, (1999, Jan) “Industry Expectations of New Engineers: A Survey to Assist Curriculum Designers”, *Journal of Engineering Education*, pp. 43-51.

13. Radharamanan, R., (2003). "Use of Quality Tools and Standards for Continuous Improvement in Engineering Education" *American Society for Engineering Education Southeastern Conference Proceedings*. Industrial Division.

14. Sarin, S., (2000), “Quality Assurance in Engineering Education: A Comparison of EC-2000 and ISO-9000,” *Journal of Engineering Education*, Vol. 89, No. 4, pp. 495 – 501.

15. Todd, A.M., K..A. Barron, & R.N. Pangborn, (2002) “Changes in Perceived Learning Accessed in Stages from Mid-Stream Academic through Professional Careers”. *American Society for Engineering Education Conference Proceedings*, Session 3630.

16. Wankat, P.C., F.S. Oreovicz, & W.N. Delgass, (1998). Integrating soft criteria into the ChE curriculum. *American Society for Engineering Education Annual Conference Proceedings*, Session 2613.

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