Assessing Cooperative Education Through the Lens of ABET Outcomes

By
Gwen Lee-Thomas, Ph.D., Director of Assessment
Arleen Anderson, Assistant Director of Career Services
Rose-Hulman Institute of Technology
Terre Haute, Indiana

Introduction:

The purpose of the Rose-Hulman Cooperative Education (co-op) program is to provide the student with an opportunity to gain hands-on, discipline-specific experience that complements and supplements classroom theoretical instruction. Students are encouraged to establish objectives specifying significant and appropriate learning that is expected to result from the work experience. A successful experience is determined by the *outcomes* of the experience, not just for the experience alone.

Categories of learning objectives include:

- Knowledge Acquisition
- Intellectual and Functional Skill Development
- Problem-Solving
- Clarified Values

In addition to assessing the co-op experience through the lens of EC 2000, Rose-Hulman has been actively involved in the re-engineering of the freshmen and sophomore curricula to integrate courses designed around competences that are highly correlated with EC2000. These curricula were borne out of a National Science Foundation grant that currently funds the collaborating efforts of six institutions' colleges of engineering to form the Foundation Coalition. Each institution has worked diligently to reform their freshmen and sophomore engineering curriculum, and in some cases, upper division curriculum. Rose-Hulman's Foundation Coalition (FC) related curricula include the Integrated First-Year Curriculum in Science, Engineering, and Mathematics (IFYCSEM) for freshmen students and the Sophomore Engineering Curriculum (SEC).

As a cooperative effort, the competencies measured in the integrated curriculum for freshmen and the sophomore engineering curriculum look at the same competencies as the co-op program which all fall within EC 2000. These include integration of subjects, teaming, communication, technology, problem-solving, and life-long learning. Therefore, this report looks at whether or not those students in the Foundation Coalition rate their co-op experience differently than those students who were not in either of the FC programs, and simultaneously, do employers rate the FC students differently than they rate the non-FC students.

To measure the effectiveness of the co-op experience for all Rose-Hulman students, the office of Career Services collects data on co-op students using four different instruments (1) Inventory of Abilities: Self Analysis Profile, (2) Co-op Student Evaluation, (3) Employer Cooperative Education Evaluation Form and (4) Student Essays.

In this report, these data are presented in aggregate and served as resource data for institute-wide assessment and departmental ABET accreditation assessment planning.

Limitations:

First, the data analyses in this report, should not be used as generalizations for all students who co-op. There were approximately 81 students who co-oped, however, data for only 36 students were available. Second, the student respondents in the Foundation Coalition program could differ in their experiences. The IFYCSEM program is different from the SEC program and students' participation in one program did not guarantee participation in the other program. Although FC co-op students were compared to non-FC co-op students, the analyses did not control for the differences in the two FC programs. Finally, these data did not account for the number of times a student has been on a co-op experience.

Methodology:

The Office of Institutional Research & Assessment compiled all available data from Career Services for data analysis on students who co-oped during the 1997-98 and 1998-99 fall, winter, spring, and summer quarters. Then the Office of Institutional Research and Assessment identified those students who were in the FC programs from the co-op list. Data from each instrument were aggregated and analyzed in total as well as by major. Student files that contained data on any of the above-mentioned instruments were selected for the analysis. (All students did not have all instruments nor did all instruments have all questions answered, therefore the n varies for each instrument.) As a result, there were approximately 36 out of 81 student files from which data were gathered representing 44% of the co-op students. The data were analyzed and reported for each of the instruments and aggregated with all majors and classes. Students from four departments (mechanical engineering—25, chemical engineering—9, electrical engineering—1, and civil engineering—1) were part of the analysis. Of the 36 co-op students, 11 students were in one of the Foundation Coalition programs resulting in a representation of 31%.

- Co-Op Student Evaluation:
  The purpose of the *Co-op Student Evaluation* was to obtain general information on the student and the company. Additionally, there was a rated questionnaire designed to obtain student responses on several items regarding the co-op experience as well as the students' perception of the assistance received from the Career Services Office. The questionnaire contained a Likert scale of poor to excellent represented by numbers 1–5. There were also several open-ended questions, however, only the scaled questions were analyzed from this evaluation form.

- Inventory of Abilities: Self-Analysis Profile:
  This instrument was sub-divided into three parts—A, B, and C. Part A identified ten abilities that the student was expected to have as a result of the co-op experience.

The student then rated their "competence" on each of these abilities from 1 to 10 with 1 representing very limited and 10 representing highly competent. Part B contained two open-ended questions that requested information on the students' opportunity to work with other engineering students from other schools. Part C of this instrument listed ten ability items that were similar to those in Part A of the instrument. The student was asked to identify what percentage of their classroom experience vs. extra-curricular activities contributed to their perceived "competence" in the ten areas. This report contains quantitative data from parts A & C, only.

- Employer Cooperative Education Evaluation Form:
  This form was completed by the students' employer and submitted to Career Services. The form included ten ability items that were categorized as typifying work performance. This instrument consisted of a six-point Likert scale from 5 to 1 with 5 being outstanding and 1 being unacceptable. The sixth point was N/A (not applicable).

- Student Essays:
  Each co-op student was requested to submit a final report for each co-op term. The purpose of the report was to have the student evaluate the educational content and quality of the co-op assignment. The report was to include a thoughtful analysis of what the student learned that would be presented as a job report/evaluation. The report was also expected to contain the students' objectives and their evaluation of how well the experience met them.

Findings:

The data from the co-op experience was compiled from each student's file that included at least one of the instruments identified above. The student essays were analyzed separately with selected quotes that are listed in Appendix I. Also, the aggregate analyses of these data do not control for the number of times a student co-oped (level of co-op experience), the class rank of the student, or the type of company or work the students was assigned.

Co-op Student Evaluation Form:
The data from the Student Evaluation revealed that over 60% of the respondents rated their supervisors either excellent or good while 78% rated their co-workers excellent or good. Findings from the data revealed that over half (57%) of the students felt that the level of responsibility, their learning benefit, and the salary was either good or excellent. Forty-six percent of the students did not respond to questions regarding whether or not their coursework had prepared them for the co-op experience nor to any of the questions on Career Services (C.S.) except for the question on preparation meetings offered by C.S. (See Table 1) The "no response" column in Table 1 shows that students either did not fill out the evaluation form or chose not to answer the question(s).

Co-Op Student Evaluation
Table 1

N = 28

Question	Excellent	Good	Average	Below Average	Poor	No Response
Supervisor	36%	25%	14%	4%	0%	21%
Co-Workers	32%	46%	0%	0%	0%	21%
Work Environment	29%	29%	18%	0%	4%	21%
Quality of Assignment (n=26)	12%	23%	8%	8%	4%	46%
Level of Responsibility	25%	32%	11%	4%	4%	25%
Learning Benefit	36%	18%	25%	0%	0%	21%
Salary	14%	43%	18%	4%	0%	21%
Course work preparation for Co-op	11%	18%	25%	0%	0%	46%
Help from C.S. staff*	29%	18%	4%	4%	0%	46%
Preparation meetings offered by C.S. prior to assignment.*	11%	29%	4%	4%	0%	54%
C.S. assistance *before* placement.*	32%	14%	7%	0%	0%	46%
C.S. assistance *during* placement.*	21%	14%	11%	4%	4%	46%

(*C.S. = Career Services)

Although there were differences between the FC student and non-FC student responses, the differences appears to have occurred in the strength of the responses rather than the direction of the responses. For instance, more FC students presented a higher rating for "good" in each category whereas more non-FC students presented higher ratings for "excellent" in each of the categories. The only category where this was not the case was in "Learning Benefit." Forty-five percent of the FC students responded that the learning benefit from the co-op experience was excellent, compared to 36% for non-FC students.

Inventory of Abilities: *Self-Analysis Profile*:

The data from this instrument were analyzed for Parts A and C only. Part A identified ten abilities that the student was expected to have as a result of the co-op experience. The student then rated their perception of their "competence" on each of these abilities from 1 to 10 with 1 representing very limited and 10 representing highly competent. There were 36 students who completed "Part A" this instrument and of those all but four students rated themselves 5 and above on all abilities. The four students who did not rate themselves 5 on all abilities, rated themselves 4 or 3 on all the abilities. (See Table 1 in the Attachment)

On a scale of 1-10, with 10 being highly competent, #1 (The ability to design and conduct experiments, as well as to analyze and interpret data) received the most "8" ratings (28%). There were three abilities rated as "8" by 25% of the students. First, ability #2 (Ability to design a system, component, or process to meet desired needs) received a rating of 6 from 25% of the students. The ability #5 (An understanding of professional and ethical responsibility) received a rating of 9 by 25% of the students; and ability #6c (An ability to communicate effectively in technical writing) was rated 8. For question #8 (A recognition of the need for, and the ability to engage in life-long learning), 25% of the students rated themselves 10. Only one student rated 10 on questions #1, #2, #4, #6b, #6c, #9, and #10.

When students were separated by FC and non-FC, there appeared to be little to no difference in how the students responded regarding their abilities. The highest percentage of FC students rated themselves between 6 and 9 with fewer students rating themselves 10 or 5 and none of the students rated themselves below three.

Part C of the *Self-Analysis Profile* is designed to have students identify how much of their abilities were attributed to the classroom experience versus any other extra-curricular or co-curricular activities (i.e., organizations, clubs, engineering-related work experience, etc.). For example, a student may rate the ability to communicate effectively in formal presentations 60% classroom and 40% extra-curricular/work. There were approximately 21 student responses to this section of the instrument. (See Table 2 in the Attachment)

The findings for "Part C" revealed that more than half the students (52% to 62%) attributed 30 to 50% of their classroom experience to being able to meet abilities #5, #7, #8, and #9. Also, 48% of the students attributed only 10 to 25% of their classroom experience to #6a (Ability to communicate effectively, interpersonally), while 48% of the students attributed 80 to 100% to experiences other than class. It was also interesting to note that 71% of the students attributed 30 to 50% of their ability to identify, formulate and solve engineering problems to experiences in activities outside the classroom, and 57% of the students attributed 30 to 50% of their experiences outside the class to their ability to design and conduct experiments, as well as analyze and interpret data. When analyzing the students' perception regarding ability to work in multi-disciplinary teams, 72% of the students believed that up to 50% of that ability was attributed to the classroom, while 53% of the students believe that 55 to 100% of that ability was attributed to experiences outside the class. Finally, 62% of the students attributed 30 to 50% of their understanding of a broad education and its impact on engineering solutions in a global and societal context (#7) to the classroom experience.

It appears that of those students who rated themselves high on the ability to design and conduct experiments, as well as analyze and interpret data (Ability #1), 57% perceived that 30 to 50% of that ability was attributed to experiences outside the classroom. Also, of the second largest group of students (25%) who rated themselves 6 on the ability to design a system, component or process to meet desired needs, 48% of those students believed that 30 to 50% of that ability is attributed to the classroom experience. Of the two remaining abilities in Part A (#5 and #6) that were identified by 25% of the students

and received ratings of 9 and 8, respectively, 52% of those students attributed 30 to 50% of #5 (An understanding of professional and ethical responsibility) to classroom experiences while 48% attributed #6c (Ability to communicate effectively in technical writing) to experiences outside the classroom).

When the FC students were separated the results indicated that more students responded that up to 50% of their experiences were balanced between the classroom and co-op. Fewer FC students believed that 55 – 100% of their experiences were balanced between the classroom and co-op. More specifically, students responded that 55 to 100% of the opportunities to develop their ability to design and conduct an experiment and their ability to function on a multidisciplinary team resulted from the classroom experiences, 55% and 44%, respectively.

Employer Evaluation Form:

This instrument contains ten work performance categories that each employer used to rate the student. The ten categories include:

1) Personal commitment
2) Job knowledge: *Ability to identify, formulate, and solve engineering problems*.
3) Judgment: *An understanding of professional and ethical responsibility (dependability).*
4) Interpersonal skills
5) Teamwork: *Ability to work on multi-disciplinary teams.*
6) Communication: *Formal presentation & technical writing*.
7) Time management
8) Technical ability: *Ability to use modern engineering/computing techniques, skills and tools.*
9) Appearance: *Appropriate to the environment*.
10) Academic preparedness: *Academic preparation for this position/assignment*.

Each student was rated by their employer on a scale of 5 (outstanding) to 1 (unacceptable) if the ability/category was applicable. There were 15 employer evaluations for students that accounted for 54% of the co-op files used in this study.

The findings revealed that 74 to 97% of the students received ratings of 4 (good) or 5 (outstanding) on all ten of the work performance abilities and no students received poor or unacceptable on any of the abilities. More specifically, 55% of the students received 5 (outstanding) for personal commitment while 61% of the students received 4 (good) on knowledge, judgment, interpersonal skills, and time management. Twenty-three percent of the students were rated 3 (acceptable) on judgment. (See Table 3 in the Attachment).

When the FC students were separated the findings revealed that employers rated all students either outstanding or good on personal commitment, interpersonal skills, teamwork, and time management. Eighty-six percent of the students were rated excellent or good on appearance, and 71 to 76% of the students were rated outstanding or good on job knowledge, judgment, communication, technical ability, and academic preparedness.

In comparison more FC students were rated higher than non-FC students in the areas of personal commitment, judgment, time management and academic preparedness.

Student Essays:

Students were expected to submit an essay to help the student evaluate the educational content and quality of the co-op assignment. The report was expected to include a thoughtful analysis of what the student learned that would be presented as a job report/evaluation. There were 17 essays submitted and analyzed.

Although, the essays were required to indicate what objectives the students had established for themselves and whether or not those objectives were met in the co-op experience, many students did not identify their objectives, clearly. The majority of the respondents indicated that they had learned a great deal from their co-op experience. What they learned ranged from developing an understanding of office politics to redesigning a current process to maximize efficiency. Approximately 29% of the students conveyed that much of their classroom preparation contributed to their success in their ability to do well on their co-op assignments, and 18% indicated that their knowledge of how engineering, science, and math is applied in the real world improved.

More specifically, when the essays were compared to ABET Criterion 3, a through k, several indices appeared. First, 29% of the students indicated that their co-op experience contributed to their ability to work in multi-disciplinary teams, while 41% indicated that their ability to communicate was enhanced by their co-op experience. As for life-long learning, 70% of the students identified some form of continuous learning or ability to learn something on their own, and 24% of the students identified experiences that contributed to their ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Conclusion:

In conclusion, overall, it appears that the cooperative education experience, for most students responding to the survey, is meeting the original intent of the program (". . . to provide the student with an opportunity to gain hands-on, discipline-specific experience that complements and supplements classroom theoretical instruction). Students identified the coupling of classroom experience and co-op work experience as necessary components to their overall education as an engineer at Rose-Hulman. More specifically, several students found a reciprocal effect regarding their classroom and co-op experiences. Students indicated that their classroom experience was essential to their ability to do well with the co-op and the co-op experience enhanced their ability to do well in the classroom.

When the FC students were compared with the non-FC students there appeared to be quite a bit of similarity in how the students rated themselves, except in a few areas. A

larger percentage of FC students tended to rate their ability within the 6 to 9 range whereas more non-FC student ratings were spread out across 5 to 10.

However, when the employers' responses were taken into account, the FC students received higher ratings in four of the ten areas (notably academic preparedness), while non-FC students were rated higher in interpersonal skills, teamwork, communication and technical ability. Employers rated both groups the same in job knowledge and appearance.

Overall, employers rated the students either good or excellent in every category regarding work performance and only a few students were rated as only acceptable. Also, several indices were apparent with regard to ABET Criterion 3, a through k. Many of the students not only perceived themselves as being competent in several of the EC2000 Criteria, the employers rated them competent, as well.

Recommendations:

As a result of the data analyses, several recommendations were based on the findings. First, since the majority of all students in both groups conveyed that their co-op and classroom experiences presented a positive reciprocal affect, it is recommended that the co-op program continue to be a part of the students' overall educational experience. Second, as a result of students' high perception of their abilities resulting from the co-op experience, as well as the ratings received from their employers, it is recommended that more students participate in the co-op program. Third, the data need to be analyzed on an annual basis so that longitudinal effectiveness of the co-op program and its impact on student learning can be provided for departments, faculty, and administrators for assessment and continuous improvement. Finally, although the FC programs are designed to focus on teaming, communication, life-long learning, problem-solving, technology, and integration of subject matter, the only evidence that could imply that FC students' classroom experience impacted their co-op experience differently than non-FC students was based on the higher ratings the FC students received from employers in the area of academic preparedness.

APPENDIX I

Co-Op Experience Essay Quotes:

"Overall, my co-op session at AVX was extremely valuable to me because I was exposed to more science in the engineering field and was able to see an application of engineering on many levels." **(Chemical Engineering)**

"I was able to observe how people and personalities work together and how politics in a company can affect everything from the morale of the workers to the product itself" **(Mechanical Engineering/Economics)**

"I need to work on time management and putting more detail into my work. I also need to work on getting to know the politics of the work place and learning more about the company itself." (**(Mechanical Engineering/Economics)**

"I believe my Rose-Hulman education was put to great use on this venture." **(Mechanical Engineering/Economics)**

"The classes that helped me out the most were Engineering Statistics and my previous mathematics classes. I used a lot of different formulas to aid in calculations for various projects. I learned how the things in the classroom apply in the real world and although I didn't use everything, I was able to better understand the concepts taught in the classroom." **(Mechanical Engineering/Economics)**

"[The] project . . . enabled me to see the interdisciplinary requirements of such a project: from Chemical engineering to electrical engineering to computer engineering to computer science. (I credit this appreciation to the extensive application of the teamwork oriented environment in the IFYCSEM program)." **(Chemical Engineering)**

"I took-hour class on fundamentals of diesel engines. I also tried to take a 20-hour class on geometric dimensioning and tolerancing; however, the class was cancelled and I tried to pick up the information through self-study." **(Mechanical Engineering)**

"…I feel this was very valuable because I was in charge of all aspects of each project." **(Mechanical Engineering)**

"Improved my communication skills for both everyday business and engineering communication and formal written or oral communication. I also learned how to work effectively with a team or individuals with different personality types." **(Mechanical Engineering)**

"My co-op experience is as valuable as my classroom education and it has provided me with a set of skills that are not available in the classroom. The co-op assignment takes the theory that you have learned in school and provides practical examples of how it is really used." **(Mechanical Engineering)**

"[My co-op experience] has given me an opportunity to work with different projects, structure my time, deal with the stress of life, work with groups, and prepare for the real world. The ability to adapt to software, measure correctly, and use common sense along with creativity are the qualities that make a good engineer." **(Mechanical Engineering)**

"The skills I exercised and the things I learned would be applicable to any field of study. The skills I used everyday on the job were skills of interpersonal relations and time management." **(Mechanical Engineering)**

"What the job does require is lots of common sense, good problem solving ability, decent computer ability, and great communication skills." **(Mechanical Engineering)**

"By dealing with a wide variety of union and non-union employees and through dealing with vendors I have improved my communication skills and developed a higher confidence level." **(Chemical Engineering)**

"The entire program was done in visual basic for excel, which meant that I had to teach myself how to program in that language. Again, I derive great pleasure being able to think that something that I did is being used by people in industry." **(Chemical Engineering)**

". . . I feel that the experience was an extremely valuable one. It was good to see the company from the non-engineering sales perspective, and to be able to observe first hand, Arvin's interaction with the Ford Motor Company." **(Chemical Engineering)**

"Working with people twice and three times my age, I was able to develop my interpersonal skills and develop a rapport with my co-workers." {ME}

"Before taking my co-op opportunity I did not realize the total importance of an education from Rose-Hulman Institute of Technology, and how we as students are on a higher level than that of most other students from other schools. Not only did this first session open my eyes professionally, it gave me the opportunity to evaluate my life and eventually reorganize my lifestyle." {ME)

"I was held accountable for nearly all of the mechanical testing criteria, and the fabrication being completed on time. I worked eleven hour days and took working lunches nearly every day to get the design and construction done in the allotted time. I lived and breathed this project for nearly 60 hours every week. The result was respect from my department, respect from the union labor, and a free JSF polo shirt." {ME}

"I was able to observe how different types of engineers work with each other and also how people from different departments interacted." "I believe this session is a key step in my preparation for the engineering field." {EE}

"Often times I would help out the other departments for a couple of days, or read about the paper making process in order to have a better understanding of the way the machines worked." (ME)

" . . . I felt that my co-op experience was invaluable from anything I could have received from school alone. I gained knowledge of 'office politics', union relations, and a better insight into my engineering career field altogether." (ME)

"One thing I did is I used the company as a resource in a lot for my projects and papers for classes at Rose-Hulman. And because of this I have a better understanding of materials and production methods used to manufacture jet engine blades and vanes than most seniors." **(Mechanical Engineering)**