

AC 2010-833: ENHANCING THE CO-OP LEARNING PROCESS

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Enhancing the Co-op Learning Experience

Abstract

The University of Louisville Speed School of Engineering operates on the premise that experiential education, specifically cooperative education, is a required and essential element of engineering education. UofL Speed School has a mandatory cooperative education program in which students alternate semesters of course work with three semesters of full-time co-op work experience. This paper describes a number of initiatives we have pursued during the last eighteen months to enhance the student's co-op learning experience:

Enhancing the Co-op Learning Experience

Cooperative Education is an 85 year-old tradition at the University of Louisville Speed School of Engineering and a key requirement of the academic experience for all Speed School engineering students. “Co-op” is an academic program that integrates classroom learning with work experience in the student’s field of study. The co-op student works full time for this time period, is paid an hourly wage, and receives academic credit for each semester of co-op training. For the student, the co-op experience provides “hands-on” engineering experiences as part of their formal education. For the employer, the co-op program provides access to a skilled, short-term cost-effective workforce, and equally important, the opportunity to evaluate and recruit potential full-time employees. The student begins co-op training in the fifth semester and works alternating semesters until three co-op training sessions are completed as shown in Figure 1 below.

Division of General Engineering Studies		PROFESSIONAL SCHOOL OF ENGINEERING		
		Division of Basic Studies		Higher Studies
First Year	Second Year	Basic Studies -1	Basic Studies -2	Graduate Program
	Academic Studies	Academic Studies	CO-OP	Academic Studies
Academic Studies	Academic Studies	CO-OP	Academic Studies	Academic Studies
Academic Studies	CO-OP	Academic Studies	Academic Studies	Academic Studies

Figure 1

The Engineering Cooperative Education and Career Development Office, working closely with the University Career Center, has a two-fold mission:

1. *Cooperative Education: experiential learning for every Speed engineering undergraduate.*
2. *Graduate Job Search Training and Placement*

Our strategy for cooperative education is straight forward: “Continually enhance the co-op learning experience.” This paper describes a number of initiatives we have pursued during the past twenty-four months to enhance the student’s co-op learning experience.

Enhancing the co-op learning experience for the student requires focus in two general areas:

- *Preparation for placement*
- *Feedback from the work experience*

Strengthening *preparation/placement* involves improving the content of the preparatory seminar, (“Co-op 101”), allowing the student the opportunity for realistic practice interviews and providing the student more companies and jobs for which to compete. The *feedback process* for the student involves reformatting and strengthening the performance appraisal of the student by his/her employer, and an in-depth exit interview that provides feedback to the student on his/her co-op report and discussion/reinforcement of the performance appraisal he/she received. Details are discussed below.

PREPARATION: Co-op Preparatory Seminar. This *required* seminar meets each week for one hour during the entire semester prior to the student’s first co-op work experience. In the past the standard curriculum included the administrative details (rules and regulations) of the cooperative education process at Speed School, and development of traditional job search skills: resume, cover letter, interview skills, etc. To strengthen the student’s preparation for the co-op work experience, the following topics were added:

Practice behavior interviewing: These interviews are conducted by trained interviewers from outside the Engineering Career Development Office. Industry management personnel are used for about 20% of these sessions. The goal is to grow this to 80%. Students are required to dress for the practice interview as if it were an actual job opportunity. The practice session lasts one hour, and consists of a forty minute interview and twenty minutes of very specific feedback. Feedback is quite detailed and includes the following: appearance/presence, communication, career direction, personality traits (enthusiasm, smiling, body language, handshake, etc.). The student leaves with a written evaluation that also is provided to his/her advisor, and a recommendation as to whether the practice session should be repeated.

Employer expectations modules: In these sessions, the balance between technical knowledge/experience and workplace leadership skills is taught. Emphasis is placed on the understanding and importance of workplace leadership skills for a student early in his/her career. *Communication* skills are covered in some depth: understanding the difference between communication to management, peers and subordinates; balancing talking and listening; using verbal and written tools effectively. *Teamwork* and how to be a team player is also discussed in detail: team success versus individual success, resolving problems on a team, seeking opinions of others, and respecting opinions of others. *Taking the initiative* is discussed: the concept of “ownership”, pitching in, not stopping at “NO” and being proactive; “self confidence,” asking questions when you don’t know, maintaining an even disposition, and viewing change as an opportunity. The importance of *attitude* and how to approach the work environment is also covered. As a follow-on exercise, and to reinforce these critical points, a separate session is held with a panel of co-op employer company representatives, who discuss what they are looking for in a co-op and answer questions from the class. A “student panel” is also held, consisting of

students who have already completed the co-op experience. These sessions have proven to be a valuable and powerful reinforcement of the need for workplace leadership skills.

Success on the job: In these sessions the keys to “getting off on the right foot” and “making the new team” are taught and discussed. The theme is “you are not in school anymore.” The realities and perils of assimilation into a new workplace environment are described, with examples. Tips on how to establish oneself, and assimilate successfully into the new environment are taught. Also covered are topics on business etiquette: meetings, e-mail, internet, and “day-one” basics. These sessions are reinforced with a student panel of returning “co-op” students who provide new co-op candidates a realistic view of the type of experiences, good and bad, that they can expect during the selection process and on the job. The students also answer questions from the class.

Technical writing skills with “Critical thinking” component: Grown from a university wide initiative, Speed School has implemented critical thinking in certain courses. While there are several critical thinking models, University of Louisville is using the Paul Elder model. Critical thinking is simply using reasoning combined with logical thinking for making decisions, drawing conclusions or solutions. We have incorporated a session that illustrates how to use critical thinking skills in preparing for the co-op experience and in writing the co-op report. Students are given an activity to demonstrate how simple it is to employ critical thinking by using elements of reasoning such as, *purpose* - what is the goal or purpose?, *information* - what information do you have?, *assumptions* - presuppositions, what do you take for granted? and *interpretation* - conclusions and solutions. To assess reasoning, students then apply intellectual standards such as *clarity* - is it clear? *accuracy* - is the data accurate and precise?, *information* - is it relevant, complete, and significant?, and *concise* - is it presented in appropriate depth? Concrete examples of using critical thinking in preparation for obtaining a cooperative experience position include selection of companies, interview preparation and selling one’s strengths to the employer. A critical thinking component has been incorporated into the co-op report faculty evaluation. The faculty evaluates the student’s critical thinking in the co-op report using standards such as, *Clarity, Accuracy, Information and Conciseness*.

Improving Co-op Job Choices: Although it may seem obvious, the success of the co-op learning experience is heavily influenced by the co-op position the student is able to find. Having a wider choice of positions for which to compete is critical. An analysis of the Speed School co-op job capacity was completed before the 2008-2009 economic downturn. The results of this analysis are shown in Figure 2 below. The vertical axis is the ratio of the number of available positions to the number of students requiring a position.

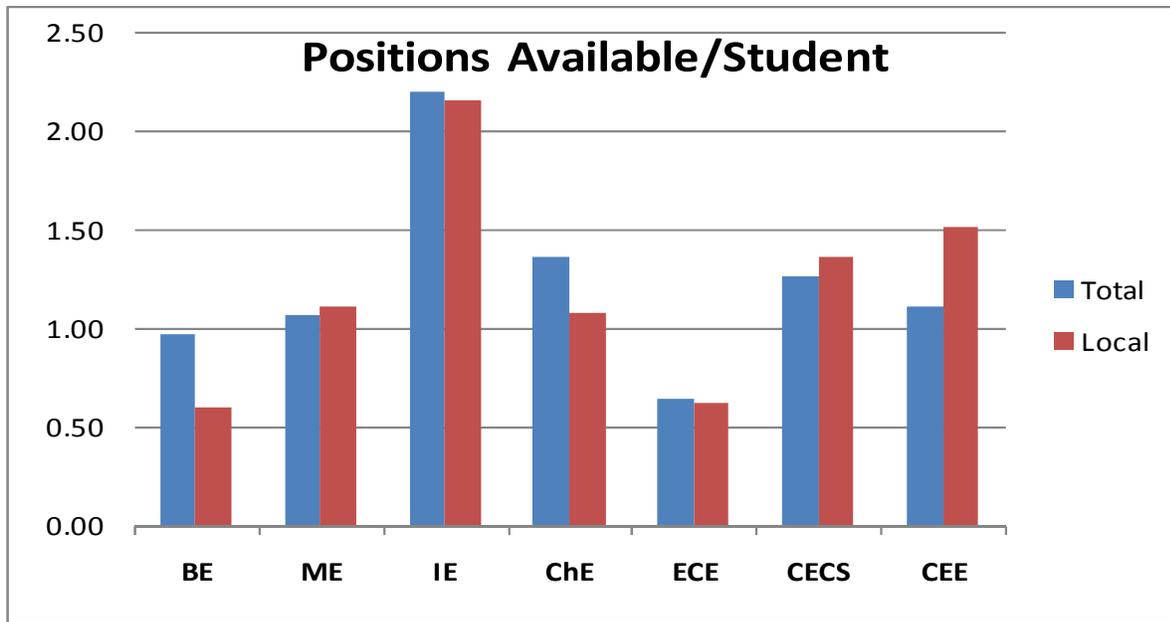


Figure 2: Co-op Position Capacity Analysis

The analysis pointed to an overall capacity ratio slightly less than 1.1 (110%). When examined by discipline and by geography constraints (driven by students unable to relocate for co-op) a significant issue surfaced. This problem manifests itself with students who are in positions not closely related to their area of interest, or are underemployed. A new goal of 150% capacity in two years was set. A formalized five-step process was implemented to systematically develop more co-op employer-partners on an on-going basis. This process leverages the use of faculty “contacts”. Developing additional companies that accept engineering co-ops from UofL Speed School of Engineering translates directly into more choices and a better fit for the student. The steps in this employer development process are straightforward:

- Step 1:** Initial contact. Create an account with profile in the Career Services Management system (Symplicity).
- Step 2:** Meeting; share program information, confirm they are interested.
- Step 3:** Create job posting in Symplicity
- Step 4:** Send resume book of candidates.
- Step 5:** Company interviews/hires our students.

This information is captured in a common database. An action date for the next step is identified and reviewed bi-weekly. Since this process was initiated in 2009, Speed School has added over 40 new employers who have hired co-ops; currently there are 92 additional potential employers in the pipeline currently being pursued.

FEEDBACK - from the Co-op Work Experience: In order to maximize the educational content of the co-op work experience, thoughtful reflection on the experience and in-depth feedback is essential. Figure 3 below illustrates how the student upgraded feedback process works.

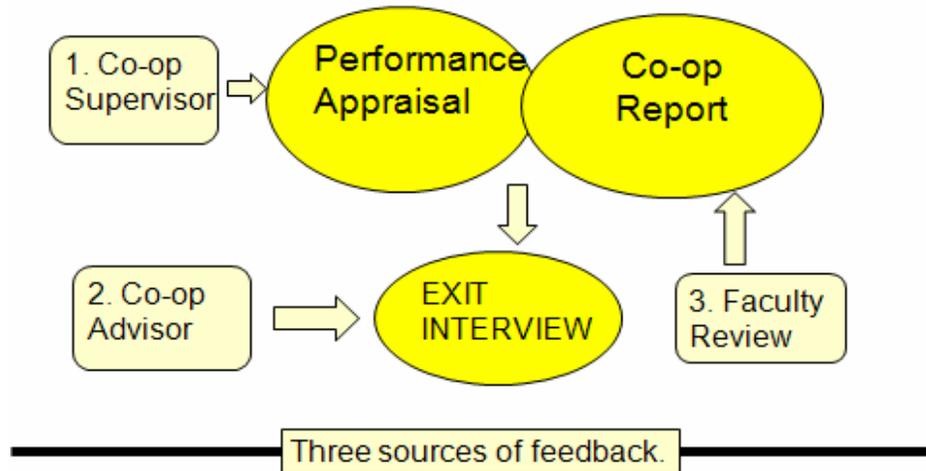


Figure 3: Student Feedback Process

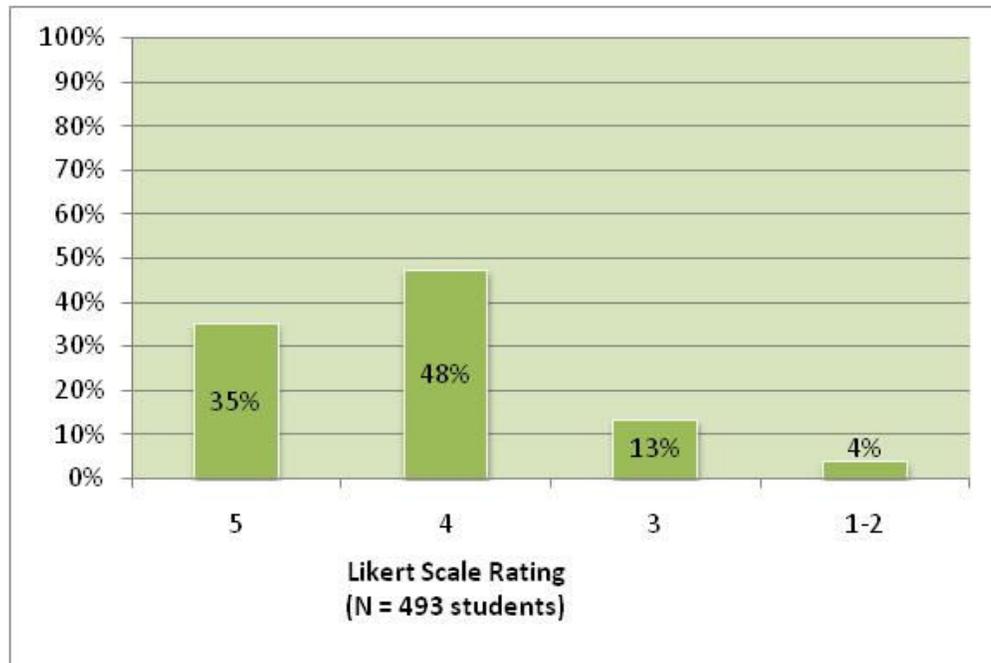
Performance Appraisal: This document is required feedback from the *workplace supervisor on the student’s performance on the job*. The format of the appraisal was improved to emphasize “soft” workplace fundamental “leadership” skills and a direct tie to ABET learning outcomes. The student provides the appraisal to his/her supervisor, which the supervisor completes and reviews with the student. The appraisal is turned in with the student’s co-op report and is discussed in detail with the student’s co-op advisor during the exit interview. A copy of the revised Co-op Performance Appraisal is included in the Appendix. The revised format captures the view of the student’s supervisor regarding the student’s performance and leadership skills as well as progress with respect to the ABET learning outcomes. *The revised appraisal format provides the ability to track quantitatively the progress a student or group of students makes against the ABET learning outcomes as he/she progresses through three semesters of co-op.*

Co-op Report: A report in a specified format is required at the end of each co-op work semester. This report forces the student to reflect on the work experience and on the results of his/her work assignment, as well as personal learning outcomes. The report requirements were revised and strengthened. A strong emphasis has been placed on keeping a log during the co-op work semester, and using the log to assist in preparing the report. The use of *quantitative information* is stressed - data about the company, the project, and the impact on the business is required. In addition, as with the performance appraisal, a focus on ABET learning outcomes using a question/answer format has been added. This approach captures and summarizes the relevancy of the co-op learning experience with respect to ABET learning outcomes, for the student and the faculty reviewer. A sample of a co-op report in the new format is included in the Appendix.

Exit Interview: Feedback to the student and reflection by the student on the co-op experience is a critical element of the learning process. An in-depth exit interview with the co-op advisor is

now a standard process. In this meeting the advisor reviews the student’s performance appraisal in detail with emphasis on low (“2”, “1”) scores indicating developmental needs that should be addressed, and high (“4”) scores indicating strengths that should be reinforced. In addition the student and the advisor discuss the Co-op Survey which the student completes and brings to the meeting. The student discusses his/her assignment, provides feedback on the ABET learning outcomes that apply to the work experience, comments on treatment by the employer (work environment, etc.) and assigns an overall assessment of the co-op experience. The student repeats this process after all three co-op work semesters. The student overall assessment is made using the standard Likert (1-5) rating scale. A copy of the exit interview student survey is included in the Appendix.

OUTCOMES: We are in the process of developing ways to measure the outcomes of the initiatives that have been implemented to enhance the co-op learning process. The most direct way currently being used is the overall rating of the semester’s co-op experience by the student, developed during the exit interview. Unfortunately, we do not have meaningful control data, which would document the students’ level of satisfaction *before the changes*. We have created a data base to gather data on the students’ level of satisfaction, *after the changes*. At this point we have captured exit interview data from approximately 500 returning students over the past three semesters across several disciplines. Student assessment of their co-op experience is shown in Figure 4 below.



**Figure 4 - Overall Student Assessment of Co-op Experience
(3: meets expectation, 4-5: above, 1-2: below)**

The initial results are encouraging but are considered preliminary. Over 80% of returning students rate their co-op experience *exceeding expectation*. The data has been examined across disciplines. There are small differences, but not statistically significant. These differences will

continue to be tracked, across engineering disciplines as well as differences between Co-op #1, #2 and #3.

In conclusion, the fundamental strategy which drives the Cooperative Education Office at the University of Louisville Speed School of Engineering is *continual enhancement of the “co-op” learning experience - for 100% of the undergraduate engineering students*. The focus has been on better preparation of the student for the co-op experience, more company positions to compete for, and improved feedback to the student on the co-op learning experience. Measurement processes are being developed to clearly track progress on overall student satisfaction with the co-op learning experience, both across engineering disciplines, and as the student progresses through three semesters of cooperative education. Also the ability to accumulate data on the student’s learning outcomes is now available - *from the employer’s perspective, the faculty/advisor’s perspective, and the student’s perspective*. In addition, as discussed earlier, progress by the student (or group of students) against the ABET learning outcomes as he/she progresses through the co-op program can also be tracked.

APPENDIX

- Co-op Performance Appraisal
- Co-op Report Example
- Exit Interview Information

CO-OP STUDENT PERFORMANCE APPRAISAL (Rev. 11/2008)		
UNIVERSITY OF LOUISVILLE		
J. B. SPEED SCHOOL OF ENGINEERING		
LOUISVILLE, KY 40292		
Student Name:	Co-op Dates:	Employer Name/Location:
Academic Dept.:	Co-op No.:	Supervisor:
Please describe the responsibilities the co-op student performed during this work session with your department.		
The student had sufficient engineering coursework to achieve the level of performance required for this co-op. Yes No		
INSTRUCTIONS: The immediate supervisor should evaluate the student's performance for the semester, and discuss with the student prior to the student signing the evaluation.		
Rating Scale: 4- Exceeds Expectations 3 - Meets Expectations 2 - Needs Improvement 1 - Unacceptable N - No basis for review		
WORKPLACE SKILLS	RATING	COMMENTS/ EXAMPLES
Prioritizes tasks to meet schedules and deadlines. Completes assignments on time. Delivers on commitments.	4 3 2 1 N	
Completes assignments accurately. Work is thoughtful, well organized and thorough.	4 3 2 1 N	
Displays a positive, "can-do" attitude. Doesn't stop at "NO." Develops multiple options to "get the job done."	4 3 2 1 N	
Suggests innovative solutions; tries new approaches to "get the job done."	4 3 2 1 N	
Proactively seeks information from internal/external resources required to complete assigned tasks. Knows when to ask questions.	4 3 2 1 N	
Accepts new tasks eagerly, and carries them out with minimal supervision.	4 3 2 1 N	
ENGINEERING SKILLS	RATING	
Demonstrates knowledge and ability to apply engineering knowledge appropriate for the student's educational level.	4 3 2 1 N	
Demonstrates ability to design and conduct experiments, and analyze and interpret data.	4 3 2 1 N	
Demonstrates the ability to participate in the design of a system, component or process, to meet desired objectives, within constraints.	4 3 2 1 N	
Demonstrates ability to work on multi-functional teams. (Pitches in as an active team member; treats team members at all levels of the organization with respect; actively seeks other points of view; respects opinions of others; develops trust and credibility with team members; settles problems without alienating team members.)	4 3 2 1 N	
Demonstrates ability to identify, formulate, and solve engineering problems. Suggests appropriate solutions.	4 3 2 1 N	
ENGINEERING SKILLS (continued)	RATING	
Demonstrates an understanding of professional and ethical responsibilities. (e.g., complies with all company policies; displays the highest degree of integrity when dealing with co-workers, suppliers and customers.)	4 3 2 1 N	
Has ability to communicate effectively. Communicates clearly, concisely, appropriately. Balances talking and listening. Communicates equally effectively with peers, management, subordinates and customers. Has ability to communicate effectively through written reports and documents.	4 3 2 1 N	
Recognizes the impact of engineering solutions in a global society. (e.g., recognizes the harmful consequences of engineering errors, and the benefits of rapid, economical solutions to problems, in the business, the community and the environment.)	4 3 2 1 N	
Accepts change and the need for lifelong learning. (Views change as an opportunity to improve performance and productivity; understands the importance of continuing to acquire new knowledge and skills in the field of engineering.)	4 3 2 1 N	
Demonstrates a awareness of contemporary engineering issues. (e.g., energy conservation, environment impacts, intellectual property, etc.)	4 3 2 1 N	
Eager to learn and use new tools, techniques and skills needed in modern engineering.	4 3 2 1 N	
OVERALL PERFORMANCE	4 3 2 1 N	
Student's Strengths:		
Student's Developmental Needs:		
Do you recommend that this student return for another co-op assignment? Yes No N/A		

CO-OP SUPERVISOR'S SIGNATURE _____ DATE _____ CO-OP STUDENT SIGNATURE _____ DATE _____

Note: The student's signature acknowledges that this evaluation has been discussed with the student. It does not indicate agreement with the evaluation.

I. EMPLOYER DESCRIPTION

XYZ, Inc. is a \$2 Billion public company headquartered in Dover, Delaware. XYZ has manufacturing locations in five states, including Louisville, Kentucky. It also has operations in Europe. XYZ has a total of 4,000 employees. XYZ is a leading producer of high efficiency pumps and components used in the global chemical processing industry. The student was assigned to the Centrifugal Pump Division in Louisville, KY in the product development department. The division has 170 employees, 25 in the engineering department, and the remainder in manufacturing operations and administration. This division produces a line of pumps with approximately 150 different models and sells them to customers worldwide. The major customers are chemical plants and petroleum refinery plants around the world and include some of the largest chemical and petroleum companies, such as Dow Chemical, DuPont, and Marathon Petroleum.

II. MAJOR RESPONSIBILITIES AND DUTIES

During this report period, the student was assigned to a product development team that was charged to develop a new version of a 50 horsepower feed pump. The student worked directly with the design engineer and draftsman, as well as the test engineer and lab technicians.

Feed pumps of this size have been manufactured and sold by XYZ for over 20 years. The current model is called the Model 1000. The new pump, which is named the “Model 2000”, added several new design concepts to increase the value of the pump to the customer. The primary objective of this project was to redesign the Model 1000 pump to increase sales and profits. The critical assumption made by the team is that increased customer value will result in higher sales volume and a higher selling price compared with the old the Model 1000. In the Model 1000 design (and in the competitors’ design), the pump vane and shaft seals are made of brass alloy. The new design proposed to use a new carbon filled polymer material for the seals which promised much lower friction and improved life in a corrosive chemical environment. The result is a new “Model 2000” feed pump that will run longer between overhauls, generate less heat loss and use less electrical power than the old design at the same operating conditions. One key issue with the new design was that the new carbon seals are more expensive than the brass seals. The initial cost estimate by the team was \$12.00 cost increase per pump. The project team decided to set a target to keep the cost of the “Model 2000” at the same level as the cost of the Model 1000. To lower the projected cost, the team decided to replace the copper winding in the motor stator with aluminum. Looking at projected commodity pricing, the switch to aluminum could save \$15.00 per pump. If aluminum windings could be used in the new pump, the overall pump cost would be slightly lower than the Model 1000 and beat the project cost target.

Specifically the student had two primary roles on the Model 2000 pump project:

1. Characterize the new seals for the test pumps when they arrived from the German supplier, and
2. Generate a data base using MatLab to record data from the motors that were placed on test.

In the first task, when the seals were received, the student logged them in, selected samples from the lot, and then tested them several different ways to see if they met specification. Specific gravity was measured using an ASTM method; heat distortion temperature and melting point were determined using Thermal Analysis instruments. Samples were sectioned and measured for carbon fiber length using a metallurgical optical microscope. This data was entered in the project data base and lab note book. The student reported a summary of this data to the project team meeting at the weekly team meeting. A data summary was also provided to the design engineer. He used the data in the ongoing Finite Element Analysis program he maintained.

In the second task involved gathering data from the new design motors on test. The technicians built the test motors, and instrumented them with thermocouples to measure temperature at 15 different points in the motor and pump. They also installed special electrical connections to measure electrical power. The student was responsible for taking data on each motor every 100 hours of operation and entered the data in a MatLab database. A summary was provided to the team at the project team meeting.

The project team meeting was very important to the project and a learning experience for the student. The meeting and discussion was multi-functional; in addition to the engineering team, there were representative from marketing, finance and legal. Marketing was interested in performance, cost and when the product could be launched to the market. Finance tracked product cost and project costs. Legal was concerned about patent protection, and whether the claims to be made about the pump performance in the product ads were legal.

III. EMPLOYER BENEFITS

As discussed in Part II, the student was assigned to the project team to develop the new Model 2000 pump. The design has progressed through production release, and currently is going through pilot runs in manufacturing. If the development testing is successful, full customer launch is planned in late 2009. The Model 2000 is forecasted to result in significant financial benefits to XYZ, Inc. Since the Model 2000 is a superior product to the Model 1000 with higher customer value, the selling price will be increased from \$2500 per unit (Model 1000) to \$3000 per unit ("Model 2000"). Sales are predicted to increase from 1500 units per year worldwide to 2000 units. The resulting XYZ benefit is increased sales of \$2.25 million/year and increased profit approximately \$450,000/year.

IV. STUDENT BENEFITS

- a) Discuss how you applied math/science/engineering knowledge. I had to apply science and engineering knowledge during the characterization of the materials used in the carbon test seal samples.
- b) Discuss experiments you conducted and how the data was analyzed. I participated with the technicians in evaluation testing the new motors, which required me to gather test data, and analyze and interpret results. I developed a data base that looked at stator temperature rise versus test time.
- c) Discuss your participation in designing a system, component, or process within constraints. Although I did not design the new pump system, I was able to work along

side the design engineer and view first hand the design of a new system within a very narrow set of project constraints.

- d) Discuss examples of working on teams. The entire design development was a team effort. Attending the weekly cross-functional team meetings gave me the opportunity to hear other points of view from team members outside engineering.
- e) Discuss your experience solving engineering problems. Several of the pump seals on test failed soon after start-up. The project engineer convened a problem resolution team. I was a member. Several root causes were being investigated when the semester ended.
- f) Discuss how you increased your understanding of professional and ethical responsibility as an engineer. The new pump had to meet various industry standards: NEMA, UL, and AIChE. It was very important for the testing to be done in strict compliance with specified test procedures so that compliance could be certified.
- g) Give examples where you had to effectively communicate. I was required to make verbal and written reports on the motor test program in the weekly team meeting.
- h) Discuss how your co-op experience increased your understanding of the impact of engineering solutions on society. The Model 2000 pumps will be used in very hazardous conditions around the clock throughout the world. An unreliable or unsafe product could result in loss of life and enormous environmental damage.
- i) Discuss how you became aware of the need for lifelong learning in your field. The older, more experienced members of the department had a lot of knowledge about brass seals, but no experience or background in carbon filled polymer or how to evaluate it for pump seals. The team had to learn about new materials properties and evaluation techniques.
- j) Give examples of encountering contemporary issues in your field. The Model 2000 feed pump addressed the need for a more efficient product that consumes less energy has increased life and reliability and protects human life and the environment.
- k) Discuss your experience in using techniques, skills, and modern engineering tools commonly used in engineering practice. As part of the Model 2000 team, I used an array of modern engineering techniques and tools: MatLab, FEA software, and state-of-the-art lab test instruments.

EXIT INTERVIEW: Co-op Survey

Name: _____ Date _____ Dept _____

Company _____ Co-op Semester _____ Co-op No. _____

Company Information:

What primary products or services do they provide?

1. Co-op Assignment:

a. What were your primary projects and areas of responsibility? What tasks were you responsible for?

b. Describe leadership experiences with teamwork, communication, taking initiative or giving presentations:

2. Check as many of the following that apply:

- (a) Did you **apply math/science/engineering** knowledge?
- (b) Did you **conduct experiments and analyze results**?
- (c) Did you **design** a system, component, or process?
- (d) Did you work on a **team or teams**?
- (e) Did you identify, formulate, and **solve engineering problems**?
- (f) Did anything happen that increased your understanding of **professional and ethical responsibility**?
- (g) Did you use **verbal and written COMMUNICATION**?
- (h) Did you understand the **impact of engineering solutions** in a global, economic, environmental, and societal context?
- (i) Did you become aware of the need for **lifelong learning in your field**?
- (j) Did you encounter **contemporary issues in your field**?
- (k) Did you have the opportunity to use **modern tools, techniques and skills**?

3. **a. Work Environment: Space:** Open room, private office, cubicle, **Dress:** business casual, dressy, or in between, **Environment:** quiet, noisy, or in between, **Communication:** formal, open and casual, feel encouraged to ask questions? Do you have a **Mentor**?

b. Does your company provide Housing or assistance and/or other benefits?

c. Did your supervisor discuss your Student Performance Appraisal or their own evaluation with you?

d. Did you have an exit interview (with HR department)?

4. **Next Co-op Term:** Are you set to return with your employer for your next co-op?

Third Time Co-ops: Has a full-time job offer with this company been discussed?

5. **Performance evaluation review:** Explanation/discussion of a score of 2 or lower.

6. **OVERALL ASSESSMENT OF CO-OP EXPERIENCE:**

Scale 1-5 (5, being the highest and 3-meets expectation)