AC 2010-199: THE MUTUAL RE-ENFORCEMENT OF CURRICULAR EDUCATION AND CO-OPERATIVE EDUCATION: A CASE STUDY

Jim Wojciechowski, Grand Valley State University

Charles Standridge, Grand Valley State University

The Mutual Re-enforcement of Curricular Education and Co-operative Education: A Case Study

Abstract

It is well accepted that curricular education and co-operative education are necessary and complimentary components for preparing job-ready bachelors-level engineers. A case study is presented concerning how one engineering student in the Bachelor of Science in Engineering degree program at a regional comprehensive university expanded his engineering knowledge and abilities through a three semester co-operative education experience at a local manufacturing company. The emphasis of the case study is on the specific ways that curricular education and the co-operative education experience influenced each other. Some support for the co-operative education experience came from individual courses such as freshman level CAD/CAM which prepared the student for a first co-op assignment on the design team where knowledge of the software tool Pro/Engineer was reinforced and expanded. This better prepared the student to use CAD concepts and Pro/Engineer in subsequent academic courses. Some support came from the general engineering knowledge acquired in multiple classes such as the use of Excel; engineering terminology, mechanisms and devices; and the engineering design process. This knowledge was applied during the co-op experience to customer relationship topics such as meeting requirements, using design standards, satisfying machine footprint constraints, and writing documentation that was understandable to all constituents. General curricular knowledge was also applied to technical issues such as calculating the thrust force of a pneumatic cylinder given its bore size, stroke length, and supplied air pressure. The professional development gained each co-op semester better prepared the student for the ensuing curricular education experience in various ways including assurance that no curricular assignment, project, or task is too challenging; realization of how much there is to learn; confidence to communicate professionally with professors, academic advisors, and other engineers; and a newly developed awareness of project scope beyond the student's direct involvement, including funding and planning.

Introduction

Since co-operative engineering education (co-op) was introduced at the University of Cincinnati in 1906, it has become generally accepted that this co-curricular activity is an essential part of preparing job ready bachelors-level engineers. Milliken and Fatehi[1] discuss how co-op is an invaluable career development tool as almost all employers first recruit new full-time employees through co-op. Furthermore, a large percent, 86% in this study, of co-op students accept full-time employment with their co-op employers.

Curricular education prepares students for the co-op experience and the co-op experience prepares students for additional curricular education. For example,

Grunther et al.[2] discuss how students with co-op, or other industrial experience, have greater knowledge of design versus student with no such experience, though this knowledge gap can be reduced by the capstone design course. Further, El-Sayed and Stodola[3] discuss the need for a formal way of ensuring that co-op and classroom education reinforce each other.

Documentation of the co-op experience, and the self-reflection required to prepare it, is an important way of confirming the learning which has occurred. Gunn[4] presents a formal report structure to accomplish this. Eastman et al.[5] discuss a student poster and presentation activity that addresses the same issue. Both papers recognize the significance of communicating the co-op experience to fellow students as well as faculty.

Another way to document the co-op experience is a case study such as the one presented in this paper, which describes the joint co-op and curricular educational experience of one engineering student at a public regional mid-western teaching-focused university with a mandatory co-op program. The co-op experience is organized on the traditional alternating semesters model: four semesters of classroom education, followed by alternating semesters of co-op and classroom education, followed by a final semester to complete course work including the capstone design project. The student worked for a design and manufacturing company in the same metropolitan area as the university. The interaction of co-op and curricular educational experiences of the student is emphasized.

The First Co-op Period

Completing an engineering curriculum, such as Mechanical Engineering, is no simple journey. The subject matter is often complicated and intense. The work load can be overwhelming. A co-op program helps facilitate the learning process and allows the student to expand professional horizons as a developing engineer. Because of this, many universities today are implementing a co-op education program. The cooperative educational experience has without a doubt benefited by expanding engineering knowledge and abilities in ways that the classroom simply cannot.

At the beginning of the first co-op period, the student reported feeling like a freshman in high school or college all over again: bombarded with the sense of never becoming capable of what his new co-workers were, an inexperienced intern whose proud college ego had been swiftly snubbed by the reality of the professional world. While realizing that he had a lot to still learn, the student knew that his first four semesters of classroom instruction had sufficiently prepared him to be of use to the company.

His schooling had introduced him to the CAD program, Pro Engineer. During the first co-op semester in the summer of 2008, he was assigned to the company Design Team. The assignment required the use of this complex software and,

over the course of the co-op semester, the student became quite proficient in it. Without that preliminary introduction from the engineering school, the transition to work that summer would have been much more trying.

Meticulously following the design process showed the student the importance of planning any design in an organized and systematic manner to eliminate error and emphasize simplicity; although somehow these machines never seem to end up too simple. It amazed the student how many details went into a machine, far more than one could imagine by just looking at it. There were ergonomic codes as well as room for numerous safety devices. The machine's footprint could not exceed specified dimensions yet it still had to encompass all the necessary components. It is a very involved process to come up with the best way to account for all of these specifications. It takes a team of people to devise the best solution. The student was constantly meeting with the customer as well as internal managers on the job.

The Second Co-op Period

For the second co-op period the student was assigned to the Quoting Department where his prior school-based experience in Microsoft Excel became significant. The cost development spreadsheet that was required for each quote used all the intricacies of Excel.

The semester of work in the Quoting department gave the student a view of the business side of engineering. While it is crucial to design a good machine, the designers will never have the opportunity if there are not any willing customers. The student discovered the method of selling something and how to make the company a profit while still offering fair and quality deals. Switching from the Design to the Quoting divisions showed the student how units within a company function independently, but still as one. The designers depend on the quoting team to retrieve jobs and projects, but the people in quoting rely on the design team to help them imagine clever and feasible concepts to sell the machine to the client.

One assignment taught the student the value of doing things the proper way in a uniform manner visible to everyone involved. The student experienced firsthand that it is of the utmost significance that all types of engineering documents remain in consistent style between companies and firms. For example, the student compiled a quote for a customer located in Germany from specific prints, a bill of materials, and data sheets specifying customer requirements. The customer attempted to provide some form of German to English translation, but it was still extremely difficult to decipher. It seemed that the two companies did not handle their drawings and other data in the same manner. If such an issue were to exist within the company nothing would ever get done efficiently or properly. Working in a standardized environment is critical at any engineering corporation.

The Third Co-op Period

For the third and final co-op semester the student was again assigned to the Quoting Department. Each semester a higher level of responsibility was granted to the co-op student. This was quite evident in this final rotation.

Although the student was in the same quoting department as the previous semester, he was given much more involved quotes to complete, which were of more significance to the company. Pricing compiled by the student reached the seven-figure range. The company surely would not have entrusted such high-cost work in the hands of a first-semester co-op student. The student was forced to develop much more intricate concepts including more detail in the summary of the proposed machine and in its potential CAD model. Extensive meetings were carried out for particular quotes that involved a collaborative effort between the quote preparers, design engineers, controls engineers, and project managers. Technical writing skills gained in the schooling semesters became extremely useful in order to professionally describe the proposed machines in the quotes.

In addition to the higher level of responsibility, the student also had the opportunity to meet with the customers on certain projects. No company would risk their good name to a client unless they trusted the person in contact with them. The student was allowed to visit local customers to better understand what they were looking for in a machine and to converse about it face to face. Nothing can replace the on-site experience of understanding a specific customer in order to better develop their quote. The student felt distinguished and honored to carry out this work for his company. The constant professionalism emphasized during the student's schooling semesters became evident and useful in dealing with the company's clients in a qualified manner.

How Engineering Education Impacted Co-op

Engineering projects at school forced the student to follow a structured engineering design process. Learning how and why it is important to follow such an approach became quite clear at work. When faced with a machine design assignment on co-op, the student was required to follow the design process reasonably and logically. School trained him in the importance of planning out and organizing the machine design structure before implementation. The co-op experience continued to reinforce the importance of following a design process.

School taught engineering language and terminology. Thus, the student was able to enter the work place and confidently talk about detailed drawings, a bill of materials, or different structural mechanisms because of classroom exposure to these topics. For example, a bill of materials for the project in electrical circuits class was required. The project consisted of designing and fabricating an electrical circuit, which successfully shot a metal projectile out of a homemade

coil gun. This project taught the relationship between an electric current and a magnetic field; principles on which the electric motor operates, essential knowledge in an engineering work environment.

The understanding of other engineering mechanisms and devices learned in school greatly aided the student during the co-op experience. Comprehending the basics of pneumatic and hydraulic cylinders was important since the company used them extensively. In an upper-level programming class for mechanical engineers, the student learned the fundamentals of programming robots and other such devices. Although this is not the student's forte, as any mechanical engineer would claim, learning these concepts and how to apply them pays huge dividends in today's computer-oriented world. At the company, the controls and computer programming engineers are separated from the mechanical engineers. Even though the student has no work connection with the company's controls department, understanding what this department does and how it works has been critical in effectively completing work assignments. Servo motors, for example, are used extensively by the company and developing a deeper understanding of how they work in a junior-level controls class was of definite use during co-op.

The student has been able to put into practice mathematical knowledge, despite having heard too many people complain in math class about how they will never use what they are learning. Calculating the thrust force of a pneumatic cylinder given its bore size, stroke length, and supplied air pressure required application of physics knowledge. The solution was never attained easily, however. Another real-life factor always came into play (such as gravity) to complicate the problem. The student thoroughly enjoyed the challenge.

How Co-op Impacted Engineering Education

Co-op work at the company has further expanded the student's familiarity and experience on certain topics as well as introducing new ideas. Co-op exposed the student to a vast engineering world, which could simply not be grasped while in school. In the first semester of work, the student was given the opportunity to go through the entire design of a machine which assembled an inner part of a car's suspension. Being given this responsibility was definitely a privilege. The student learned an insurmountable load of knowledge by going through the process for himself. By the end of the project, when the drawings were released for build, the student felt more confident than ever as a progressing engineer. The student was definitely more comfortable with the environment and felt that any assigned task could be assertively carried it. Ultimately, due to the experience on co-op, the student felt there is no assignment, project, or task in school that is too challenging to accomplish.

Through co-op, the student has gained knowledge and familiarity of countless devices and terms. The student learned what a bowl feeder is and how other vibratory mechanisms worked as opposed to conveyors as well as becoming

familiar with common manufacturing terms such as nesting, jig, tooling, and poke-yoke. The student was taught what actuators, cams, and grippers were and how exactly an indexer operated and what a die press looked like. The student was always excited when a vendor would come to the company to show off a new product because it was another opportunity to grasp additional information.

The co-op experience provided the student the opportunity to work face to face with people from other companies whether they were customers or vendors. The student was able to practice business communication skills through conference calls, GoTo Meetings, and live meetings. The student learned the importance of being confident and sure of himself when speaking with people that were higher up in the company or from outside the company. The student realized that it was always best to ask as soon as he was unsure of something or unclear on a subject. Being given the opportunities to practice these types of situations was priceless.

Summary

The co-op experience has without a doubt helped the student to grow as a soon-to-be professional engineer. Dr. Jacqueline El-Sayed[6] surely agrees: "…the classroom being a part of a university setting, not a corporate environment is limited in context and scope and can only provide a limited simulation to real life work setting of an engineer." She goes on to say, "To provide the educational experiences for producing the full desired set of outcomes and to close the gap between a graduating engineer and a real practitioner co-op education or internships are the key." The student agrees that without co-op experience, the first job experience after graduation would result in a rude awakening.

An internship or co-op lets the student know what the practice of engineering is like and verifies that it is the right fit for his or her career. Also, co-op is going to expand the student's view of the engineering world. Craig Gunn[7] focuses on these advantages saying, "With this real world experience, students have discovered that they can no longer simply learn technical expertise without the added knowledge of global issues, cultural constraints, and the need for communication skill." Aside from that, it forces you to put your education into practice and build upon it as you are still enduring the learning process. As Dr. El-Sayed[6] says, "During this type of experiential learning, engineers in the field provide the real life model of professional behaviors and practices directly to students."

It is so important with engineering, possibly more than any other major, to go through a co-op or internship. It is almost unfair for a student to receive a degree today without such an experience. Dr. El-Sayed[6] sums it up nicely saying, "co-op and classroom education are complementary and necessary components for the development of a quality engineering educations and job-ready engineering graduates."

Considering all the student has learned between school and co-op there is still so much more he is yearning to experience: to be involved in the building and repairing process of machines and structures as well as to work with his hands more intensively than in school. The student wishes to experience firsthand what it involves to physically construct a complex mechanism and the way to go about things on the shop floor as well as the best way to machine a certain part and how to use all the tools. Knowing exactly how a part was to be fabricated would allow the student to devise it with a more strategic approach. With more building knowledge and floor experience, the student could create structures that were easier to build and less prone to error. Ideally, such things would be taught in school and then put into practice on co-op. The student understands that school's main intent is learning the "why," but realizes that it is also important to know the "how."

It is ironic that the more the student has been taught at school and on co-op, the more he realizes how much new knowledge is available. By taking advanced and interesting engineering courses, like thermodynamics and materials science, the student has merely scratched the surface on a whole new world. Now more than ever the student has been taking every opportunity to learn by asking questions and reading independently, whether in a text book or online. The student is becoming increasingly fascinated everyday to discover more about automobiles and jet engines or whatever other topic happens to engulf him that day. The student developed an overwhelming thirst for knowledge that seems only to be quenched by acquiring, so watch out everyone, here comes a motivated student ready to make his unique mark on the engineering world.

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