Leveraging Industry Partnership for Experiential Learning and Laboratory Improvement

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Abstract

The College of Technology (COT) at Purdue University Northwest (PNW) has developed and implemented several methods to collaborate with small, medium, and large size regional companies over the past few years. The faculty of the Engineering Technology department have taken advantage of these collaborations which has resulted in improved and innovative laboratory facilities and students' experiential learning through real life projects. This paper explains how, and through which channels the faculty and the department have worked with companies in different industries. Furthermore, the mutual benefits of these collaborations to students, faculty, academic programs, and industry are discussed.

Academia collaborations with Industry has a long standing history. However, unlike some collaborations that were initiated by academia through certification programs or industry input for academic curriculums, this paper is about industry projects done by faculty and students and customized training for industry. In particular, three different types of collaborations are discussed: 1) a long term collaboration with a large regional industry and how it has helped the department furnish manufacturing laboratories with state-of-the-art, industry-scale equipment; 2) Short term collaborative projects and how they have helped undergraduate students to understand concepts learned in their courses through real-life engineering projects; and 3) year-long projects for graduate students which mutually helped the industry with improvements in their operations and students with industry-type thesis.

Introduction

In recent years, there has been a substantial increase in Industry-University Collaboration in several countries, including United States, Japan, Singapore, and Eastern European Countries.[1]

The vision statement of the COT at PNW is "By 2021, the College of Technology Will be the "College of Choice" for both students and ***Industry***. As emphasized in its vision statement, COT encourages every faculty in the college to work with at least one industrial partner. Following this goal, faculty keep in constant contact with the College's industrial partners and continuously conduct training or complete large and small scale projects for regional industries.

The industrial base of the region is known for its steel, refinery, and durable goods manufacturing. The steel industry has been negatively impacted in recent decades due to foreign trade practices (Why It Matters: Foreign trade impact on U.S. economy, NWI Times, 2016). However, according to Northwest Indiana economic development organization, "… companies from around the world have chosen Northwest Indiana not only for its proximity to major markets and affordable commercial space, but also for its highly qualified workforce.[2]" This has also been of concern to Indiana's neighboring state of Illinois, as there has been a recent influx of companies moving to the Northwest Indiana (NWI) region from Illinois to take advantage of a favorable tax, and labor climate.[3] All these developments have been favorable to college of technology at PNW as it provides more companies for faculty to collaborate with.[4]

This paper covers only three types of these projects, contracts, or collaborations, discussing their benefits to faculty, students, industry, and more importantly, the opportunity these projects provide to the college to enhance its laboratories and experiential learning of the students.

Long Term, multi-year, Collaboration

Purdue University Northwest department of Engineering Technology has had an "Apprenticeship Training" contract with BP since 2017. The annual contract has been as low as $38,000 to as high as $264,000, depending on training needs of BP of America. The base contract provides BP training space for their Machinist Apprenticeship program for up to 40 weeks per year, where the training is done by BP employees, using Purdue equipment. Depending on BP training needs in Computer Aided Drafting/Design, Hydraulics, Instrumentation Control, Surveying, or Piping, training materials have been developed by Purdue Northwest faculty and delivered to BP employees at Purdue's facilities, using Purdue's equipment. As shown in table 1, the residual for contracts with this company has been over $710,000 in the last 11 years.

Year	Total Contract	Total Residual
2007	$215,000	$127,491
2008	$135,131	$45,225
2009	$38,000	$3,810
2010	$54,500	$15,537
2011	$92,500	$37,200
2012	$264,500	$78,630
2013	$156,000	$54,820
2014	$151,000	$75,000
2015	$157,120	$62,300
2016	$166,000	$83,000
2017	$164,000	$81,390
2018	$128,930	$47,486
Total	$1,722,681	$711,889

Table 1. Annual contracts between COT and BP

This training has had several mutual benefits:

- BP employees received their training outside the facility, therefore avoiding any distraction that could have been caused by being on the plant and getting a call to attend a work-related matter
- Since part of the contract was to provide a student help during the (minimum) forty-weeks training, students were employed in the laboratory to help the instructor(s). This provides a minimum of 1600 hours of internship, every year, for students in the COT, where they are working, learning, and helping industry folks with their daily tasks.

- The contracts with this company alone, over the last few years, have brought in about over $700,000 of residuals that the college and the department re-invested mostly in the laboratory equipment and faculty development. This contract along with many others are the reason that the COT laboratories at PNW are the state-of-the art laboratories, benefitting students and faculty.

One-year collaboration

A leading manufacturer of packaging equipment, whose CEO is in the COT Dean's Advisory Board, has a heat tunnel to shrink wrap products at high speed. This process consumes energy to shrink the external packaging. However, the energy losses can be significant, and several factors contribute to the heat losses. In order to design future generation energy efficient tunnels, it was important to understand the factors that contribute to the heat losses and the contribution of each factor such as conveyor speed, size of package material content, residence time etc. The project goals were to,

- Construct a *Design of Experiments* (DOE) model to investigate the factors at two levels, high (+) and low (-) levels.
- Gather experimental data from the DOE model
- Identify the significant *factors* that contribute to the heat losses from the oven during operation.
- Provide a final report.

The factors and levels are given in Table 2. Due to the nature of the problem, and since it involved research and innovation, helping the company to design its future generation tunnel, it was decided that this was a Master's Degree level directed project. A graduate student was recruited by the faculty-in-charge who received the small grant from the Company to perform this research. The student traveled to the industry few times a week to collect data. The data collected were analyzed and a summary of analysis is given in Table 3. This project was a two phase project for the student, as he performed a literature survey and data collection during the first semester and did the analysis and report preparation in the second semester. This project, as mentioned was the student's master's degree project.

Factors	**Name of the independent variables**	***Levels***	
A	**Number of Flaps**	**Low**	**High**
B	**Conveyor Speed**	**Low**	**High**
C	**Blower Speed**	**Low**	**High**
D	**Insulation**	**Low**	**High**

Table 2 Factors and levels of the DOE

Factors	DF	SS	MS	F-value	P-value
A	1	6022.5	6022.5	330.9429	0.0001
B	1	16.5	16.5	0.9067	0.3514
C	1	9556.5	9556.5	525.1401	0.0001
D	1	69.0	69.0	3.7916	0.0649
AB	1	2.5	2.5	0.1374	0.7129
AC	1	504.0	504.0	27.6954	0.0001
AD	1	7.0	7.0	0.3847	0.5409
BC	1	5.3	5.3	0.2912	0.5957
BD	1	1.5	1.5	0.0824	0.7746
CD	1	205.0	205.0	11.2650	0.0029
Error (LOF) (Pure)	21 5 16	382.16 94.66 287.50	18.198 18.932 287.5		

Table 3 ANOVA (analysis of variance)

A regression model was developed, and the summary of results are shown below.

$$x_1 = \frac{A-(A_{Low}+A_{High})/2}{(A_{High}-A_{Low})/2} \qquad x_3 = \frac{C-(C_{Low}+C_{High})/2}{(C_{High}-C_{Low})/2}$$

$$x_2 = \frac{B-(B_{Low}+B_{High})/2}{(B_{High}-B_{Low})/2} \qquad x_4 = \frac{D-(D_{Low}+D_{High})/2}{(D_{High}-D_{Low})/2}$$

The regression model for predicting the time (the heater is on) (in seconds) is given by:

$$\hat{y} = 144.16 - 13.72x_1 + 0.72x_2 + 17.28x_3 + 1.47x_4 - 0.28x_1x_2 - 3.97x_1x_3 + 0.47x_1x_4 - 0.41x_2x_3 - 0.22x_2x_4 - 2.53x_3x_4$$

The regression model with the significant factors gives:

$$\hat{y} = 144.16 - 13.719x_1 + 17.281x_3 - 3.9688x_1x_3 - 2.5313x_3x_4$$

The project had mutual benefits for the company, faculty, and graduate student:

- The graduate student used the project to complete his master's degree and get almost a year of industrial experience where he completed an industry project
- The University received a grant from industry which is always beneficial to the institution and the faculty
- The industry received some direction on the design of its next generation of heat tunnels at a relatively low-cost

Short-term partnership

Since the spring of 2018, Purdue University Northwest has partnered with a large utility company that services all of northern Indiana's gas and electric services. The Company has purchased "Glass Insulators" that are imported from a foreign country and are being used across the region. The purpose of these glass insulators is to prevent large electrical currents from flowing freely along power lines as they support and separate electrical conductors without allowing current through themselves[5]. Previously, these insulators were made from porcelain. There has been a push towards glass due to its high dielectric strength and resistivity[6]. While the glass insulators have performed well, the energy supplier wanted to verify the strength of these insulators and assure that they satisfies ANSI standards for glass insulators. Purdue Northwest faculty was provided 9 of such insulators for testing. The deliverables for this industry grant are:

- Design and build fixtures for the Tinius Olsen Machine to hold glass insulators in place for tensile testing.
- Testing of nine samples for strength, taking pictures and recording videos during the test.
- Have the energy company representatives observe some of the tests.
- Provide a comprehensive report of tensile test results.

This partnership was brought about by two of Purdue Northwest's Mechanical Engineering Technology alumni who currently work for the Company. Using ANSI C29.2-2012 standards, Purdue Northwest is to perform tensile tests using the Tinius Olsen machine. As seen in Figure 1, some preliminary testing has been done by the time of writing of this paper. These tests were performed by the faculty along with three undergraduate students as they will work the duration of this project.

Figure 1: Glass insulator loaded in the Tinius Olsen Tensile Testing Machine

This project has a plethora of mutual benefits as outlined:

- The Company will know the tensile strength of the glass insulators they ordered and will be using in the Northern Indiana region. Thus, they will know the loads these insulators can take on and have a better idea of how to efficiently place them.
- Faculty can use these examples in class. Not only is this a great example to share in a Strength of Materials class, but it can also turn into a laboratory experiment. Students can perform these tests to observe the tensile properties of something other than a standard specimen they generally work on. They can see failures up close and personal and connect what they learn in the classroom to a hands-on experience as seen in Figure 2.
- This is a perfect example of experiential learning for the undergraduate students. Students are performing industry projects and can become familiar with industry standards and are performing potential tests they may encounter in the field. This particular project also allows students to use design concepts they learned in class to create fixtures for the Tinius Olsen machine to keep the samples in place. Being subject to this work can help students become engaged in such projects for internships or potential job opportunities.
- The visit by the Company engineers to observe the project opens up many prospects. For one, it leads to a better connection between the university and industry and opens the door for future collaboration. It also allows students to connect with potential employers, and the company will be more apt to hiring Purdue Northwest graduates.

Figure 2: Failure and point of fracture is observed in a practice run of testing.

Summary

College of Technology at Purdue University Northwest has made the partnership with industry an important part of its strategic plan and goals. The college is considered the "Engagement Arm" of the PNW with regional industry. To this extend, each faculty is encouraged to identify one industry and work with them. Faculty do work with industry to train the employees on the existing tools and technology common to that industry as well as working on projects with them and leading them to the new technology which will affect that industry in the near future. The partnership has had mutual benefits for both the university and the industry it serves. On almost all these projects, students are involved with industry professionals which helps students to collaborate with professionals in their field either during training or as they work with their professors to solve industry problems or complete industry projects. The University and College have benefited tremendously from these partnerships as they have been able to keep the laboratories equipped with the state-of-the-art equipment. In some of the long-term-trainings, the Company moved its equipment to the University and even left it for students' use after they left. Students have benefited as the funds generated from industry contracts have been primarily used to create state-of-the-art laboratories for the programs, benefiting students, or used for faculty development, therefore benefiting the faculty, industry they work with, and students as the class material is up-to-date an on par with new technology and industry needs.

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Biography

Afshin Zahraee is currently a Visiting Instructor of Mechanical Engineering Technology at Purdue University Northwest and PhD Candidate in the Department of Civil, Architectural and Environmental Engineering at Illinois Institute of Technology. His research is in the areas of structural condition assessment and health monitoring. He has twice been the recipient of ACSE Outstanding Teaching Assistant Award (IIT Chapter), President for Chi-Epsilon civil engineering honor society (IIT Chapter) and is an associate member of ASCE.

Dr. Lash Mapa is the Professor of Mechanical/Industrial Engineering Technology at Purdue University Northwest. He is a member of ASQ and a certified Black belt (CSSBB) and a certified Quality Engineer (CQE). He has assisted several industries in Lean six Sigma projects and trained Green and Black belts.