Providing Students with Practical Experience in Quality Control Through Industry Partnerships

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Abstract
In an economic climate where manufacturing industries are seeking individuals that have both higher education and practical hands on experience, now is the time for faculty members to seek out and embrace partnerships with industry that bring active learning projects inside the classroom. At Purdue University, this is exactly what is being done in the Quality for Manufacturing course, where for the past four years, the faculty member has made efforts to bring practical, industry driven, experiential opportunities into the classroom. Through partnering with various manufacturing companies, students are now able to gain real world experiences, using mechanical drawings and parts straight from the manufacturers to complete a series of quality control measures and report back the company management team about their procedures. This includes conducting a gage Repeatability and Reproducibility study, designing and fabricating all necessary jigs and fixtures for holding/mounting the parts, and developing sample Production Part Approval Process Plans.

As this project has grown in popularity, so has the desire to introduce other technologies that students will interface with once they become professional practitioners. Therefore, during the summer of 2018, with the support of industry partners and internal grants, the School of Engineering Technology was able to develop a new 1100 sq. ft. metrology lab. This lab will provide the opportunity for students to hone skills in programming and operating various measuring equipment including three CMM machines. In collaboration with Hexagon Metrology, students will also have the opportunity to gain certification on the machines. The opening of this new space has led to more industries being interested in partnering with the faculty to provide real world parts and industry expertise, to aid in building the student's educational experiences.

This paper will discuss in more detail how the collaboration with industry partners have aided in students learning, creating an active/project based learning curriculum, provided career opportunities for students and how the new space will be leveraged to continue building off of four years of partnerships.

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Introduction

With the exception of a handful of schools that specifically offer certifications/degrees in quality assurance [1], teaching quality control is often either an afterthought or considered nothing more than a set of managerial theories that students should be aware of prior to entering industry. This is especially true in the mechanical engineering/technology discipline where many institutions only have one course dedicated to quality control, which is often geared toward a specific management theory such as Six Sigma or Lean Manufacturing. However, in the mechanical engineering/technology discipline, there is a plethora of roles which graduates may assume in industry, many of which require knowledge and skills in quality. It is critical to understand exactly what skills manufacturing industries are looking for in future employees. A quick search on any job board such as CareerBuilder or Monster will indicate that employers are actually looking for individuals that have a breadth of hands-on skills and practical experience related quality in their discipline rather than just management theories. Therefore, to adequately prepare students for a career in manufacturing, and gain the necessary skills related to quality before entering the workforce, the author suggests developing partnerships with a diverse set of manufactures to integrate practical projects into the classroom. This paper will discuss the relationships with industry and the projects that students enrolled in Quality for Manufacturing course at Purdue University undertake to gain a well-rounded understanding of the various ways that quality impacts industry.

Building Connections with Industry

As manufacturing companies continually struggle to find recent graduates with the rights skill sets to fill current openings [2], and university faculty are being encouraged to develop project-based learning courses, it became a perfect opportunity to seek collaboration from various manufacturing companies to help bridge the divide. In 2015, when overhauling the Quality in Manufacturing course curriculum to integrate more practical lab experiences, it became an ideal time to reassess what skills would most benefit students as they prepared to enter the workforce. To start, several alumni and industry professionals were contacted to discuss what existing gaps were present when it came to students understanding quality control within a manufacturing environment, as well as their willingness to aid in developing opportunities that would build the skills through hands-on, industry driven projects. From these conversations, some key takeaways included the student's lack of being able to develop a Production Part Approval Process plan, design fixtures to hold parts or measuring instruments during the inspection process, misunderstanding of data in control charts, and inability to complete a design of experiments.

With this in mind, manufacturing and quality engineers from local injection molding companies and small machine shops were asked about donating parts (good and bad), as well as the associated mechanical drawings, for students to use as part of class projects. In turn for donating parts, these representatives would be invited to campus to review the final projects and presentations. In addition, these representatives are invited to evaluate the student's work throughout the design of experiments project. Establishing this kind of collaboration allows

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students to know that the projects they are undertaking are practical and will be evaluated by professionals in the field rather than merely receiving instructor feedback. In addition, collaboration with industry opens up doors for students to meet potential employers, as well as employers to get a first-hand look at emerging talent to fill voids within their company. Finally, it allows the faculty to gain immediate feedback as to whether or not the student's performance and topics covered in the projects truly meet the needs of industry, leading to continuous improvement of the course.

Project-Based Learning

The idea behind integrating project-based learning into this course was to get students involved with collecting, analyzing, and providing an in-depth evaluation of the data to help management understand quality within their company. Therefore, the first project that students undertake includes conducting a product comparison between competing brands to determine how quality is viewed from the customer's perspective. Student's develop surveys and conduct focus groups for end users to interact with the product and collect data using a balanced scorecard approach. Throughout the exercise students must learn how to define quality in terms of dimensions and quantify the results. Upon reviewing the data, students must develop a report that explains how their results would impact their company's strategic quality management plan and whether to maintain or increase the quality of their product relative to their competitors'.

The second project, approximately 7 weeks, involves dividing students into small teams, where they are assigned to a company, and serve as new quality technicians. Furthermore, the teams complete a Production Part Approval Process (PPAP) plan for a series of parts. In preparation for completing the PPAP, students must first complete a gauge repeatability and reproducibility (R&R) study to ensure that each team member is competent in measuring the parts. This process usually takes two or three trials. In this exercise students learn the importance of developing standard work instructions along with simple fixtures to hold either the part, measuring device, or both, to ensure consistency and reduce the amount of equipment and operator variation to be within acceptable limits. Upon conducting a successful R&R study, students begin analyzing the mechanical drawings to determine at minimum 10 critical dimensions that would impact the performance of the part and identify the most appropriate measurement tool for the selected feature. They must then design and prototype any associated fixtures for inspection, including go/no-go gauges as well as mounting fixtures and develop standard work instructions needed to communicate the inspection process to others. As each batch of parts is measured, students must document the data and develop sample control charts and calculate the process capability. Students then develop a formal presentation to share with industry partners, demonstrating their inspection process, discussing their results, and highlighting the various concepts learned and challenges faced throughout the project. In turn, students get critical and practical feedback from industry representatives.

The third and final project in the term introduces students to the principles and process of conducting a design of experiments. Students first pick a manufacturing process such as using a

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CNC machine, manual lathe, injection molding machine, or 3D printing that requires a minimum of three potentially adjustable variables to be set in order to produce a quality product. They identify what the independent and dependent variables are and two possible levels for each independent variable. Students then begin conducting the experiment, randomizing the settings of each independent variable and recording the result of the dependent variable. They must then continue altering the levels of each independent variable and hone in on the solution that produces the highest quality part. Throughout the analysis process students learn how to calculate the individual impact of each variable along with the interaction effects of each variable. Students then present these results to industry experts to demonstrate their knowledge and understanding of the process, providing samples of the parts produced under the various settings chosen.

Transferrable Skills to the Workforce

With industry looking for individuals that have experience prior full time employment, and not all students having the opportunity to gain such experience, the integration of these practical projects, provide this opportunity for students to gain a diverse set of skills that are transferable to most manufacturing companies regardless of the role assumed. Students are able to comfortably discuss the topics, demonstrate their competence, and step into a role having more confidence in their ability to complete the task. Recently, Emerson Shaw, a 2018 graduate of Purdue's Mechanical Engineering Technology Program and now a Quality Engineer at Cosworth wrote an email indicating the value that this course had on his career and his interest in participating as an industry partner:

> The Quality in Industry class I took under Paul McPherson while at Purdue University was critical to obtaining my first job after graduation. Before the class, I had little to no appreciation or understanding of the role quality plays in the manufacturing industry. Beyond the technical aspects and statistical analysis operations the class covers (GR&R, PPAP, control charts and lean systems manufacturing), the overarching philosophy and history of quality control also proved invaluable in my learning and understanding of the role of quality systems in industry. Many employers I spoke with were pleasantly surprised that I had taken a quality class, saying they weren't even aware any universities offered them. The knowledge I gained throughout the course gave me a significant advantage when searching for employment, and I truly believe I would not be where I am today without having gone through the course.

In addition, Linda Clarke, the quality assurance manager from Hoffer Plastics Corporation, who participated as a reviewer for the presentation on the PPAP project highlighted some of the knowledge and skills displayed that she believes will be critical in manufacturing environments:

> They showed they clearly had a basic understanding of many elements of the APQP process, like blueprint reading, gage R&R, gage design, work instruction creation and how dimensional capability relates to the manufacturing process. They appeared to have an understanding of how these elements effect each other and the possible outcome in achieving a Quality product.

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While having this feedback from both students and industry partners, the instructor is always seeking ways of improving the course to ensure the material matches the demands of industry partners. This has ultimately led to expanding the group of industry partners to identify new content to be added and open a new metrology lab to support not only the Quality for Manufacturing course but also other MET courses.

Future Collaboration, New Metrology Lab, and Matching Industry Equipment

After running the course for several years, one of the areas where industry partners voiced concern was the inability for students to gain access to and operate a coordinate measuring machine (CMM). Without a functional CMM in the department, a grant proposal was written for a $100,000 internal instructional equipment grant from the Purdue University Provost's office. Upon receiving the grant and having critical feedback from industry indicating the need for students to have working knowledge about how to operate the equipment that they would interface with, the instructor began contacting metrology equipment companies about the possibility of partnering with the department to open a new metrology lab that would contain state-of-the-art equipment that mimics that which the students will use in industry. As a result, the department has partnered with Hexagon Metrology to install two 4.5.4 SF bridge CMMs, a Romer Arm CMM, and an Optiv 321 GL optical comparator.

The implementation of this new equipment, along with the more traditional measuring equipment of calipers, micrometers dial gauges, etc., will not only expand the capabilities available to students during the PPAP project but also lead to students being trained on equipment that will be commonplace in their professional work environment. The partnership with Hexagon Metrology has also led to the ability for the department to offer students the ability to take a certification course on each machine demonstrating their competency in programming and operating the machines. In addition, with the help of Hexagon representatives, there is a growing interest from companies wanting to tour, support, and potentially utilize the lab for professional training.

Conclusion

As educational institutions continue shifting teaching practices away from traditional lecture based instruction to more project based learning, now is the perfect time to consider developing a partnership where industry and academia collaborate, and both parties benefit. Providing these in-class opportunities where students can build their practical skill base and interface with industry representatives has proven to be invaluable to both parties. In addition to ensuring that the coursework is adequately preparing students to fill the needs of a variety of manufacturing companies, the development of partnerships with a conglomerate of companies has led to the ability to open a new metrology space, that will allow more opportunities for students to explore the field of metrology. Finally, having graduates who took the course and now work in the quality field returning with new projects from their company hoping to recruit students with the same skills they themselves acquired while taking the course will allow the course

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projects to continually expand. This has ultimately led to a self-sustaining bundle of projects for students to choose from as well as funding and support for the new metrology space.

Bibliography

[1] "Quality Assurance Schools and Colleges in the U.S." [Online]. Available: https://study.com/quality_assurance_school.html. [Accessed: 08-Oct-2018].

[2] D. G. Jensen, "Tooling Up: The Big Disconnect," *Science (80-.).*, Feb. 2012.

Biographies

PAUL MCPHERSON

As an Assistant Professor of Practice in the School of Engineering Technology at Purdue University, Paul teaches both mechanical design and quality control courses. Having recognized the importance of technical standards in industry, Paul has integrated technical standards into curricula for seven years. He is a co-Principal Investigator on a NIST funded project titled "Standards are Everywhere: An Information Literacy Approach to Standards Education."

KYLE REITER

Currently, in his second year at Purdue University, Kyle Reiter is pursuing his master's degree in Engineering Technology and is a teaching assistant for MET 102 a design specification course. Kyle received a B.S. in Engineering Physics from the University of Colorado at Boulder. His current thesis research is using graphene as an encapsulation method for lead (II) based inorganic-organic halide solar cells.

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