Leveraging Industry Partnerships to Create New Educational Focused Laboratory Facilities

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Brad Harriger has over 30 years of experience teaching automated manufacturing and has authored/co-authored several related articles. Professor Harriger has served in several leadership roles with Society of Manufacturing Engineers and the American Society for Engineering Education, and is a founding member of an international Aerospace Automation Consortium, serving on its steering committee for several years. He has invested over twenty-five years in the development and maintenance of a multimillion dollar manufacturing laboratory facility complete with a full scale, fully integrated manufacturing system. Professor Harriger has been a Co-PI on two NSF funded grants focused on aerospace manufacturing education and is currently a Co-PI on the NSF funded TECHFIT project, a middle school afterschool program that teaches students how to use programmable controllers and other technologies to design exercise games. Additionally, he co-organizes multiple regional automation competitions for an international controls company.
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Abstract

This paper details an innovative partnership between academia and multiple manufacturers, distributors, and vendors within the process control industry leading to the design and installation of new industrial-grade laboratory infrastructure in an undergraduate capstone experience.

The multi-year collaboration between academia and industry resulted in the development of a year-long student-driven project centered on the design, development, and installation of new laboratory infrastructure on a scale beyond the budgetary resources of the host institution or any individual industry partner. The resulting installation is a permanent education and demonstration system constructed to industry standards, utilized in the delivery of concepts related to process control, measurement, and communications in undergraduate coursework while also providing a platform for interdisciplinary research within academic schools outside of its engineering technology host program.

This paper presents the formation and history of the partnership as well as an overview of initial interactions and planning that lead to a large-scale collaborative effort between academia and industry. Also detailed are the upfront commitments of academia and industry required to launch an open-ended project of this scale and the challenges associated with the dynamic nature of project scope, instructional delivery, timeline and budget. This examination includes a focus on the roles of faculty and industry participants during all stages of the project including pre-planning, budgeting, instruction, design, sourcing, procurement, implementation and troubleshooting. Additional reflection includes a summary of the short- and long-term benefits of the experience and resulting infrastructure from the perspectives of both academia and industry participants.

Overview

Collaboration between academia and industry in engineering programs has a strong history primarily driven by and through research partnerships. While significant interactions have long existed at the graduate level, interactions at the undergraduate level are more limited. Though this trend is beginning to change; some challenges facing both industry and academia are prompting an increased level of interaction and new models of collaboration\textsuperscript{1,2}.

Technical programs, such as those found in applied engineering domains, have primarily focused on developing students readily capable of participating in the workforce upon graduation. Hiring companies directly benefit, as these programs provide industry relevant experiences and knowledge that significantly reduce the training development time and costs to provide similar experiences in-house. This model has worked well for decades but is challenged by rapid technical advances, reduced academic funding, and an expanding impetus to maintain affordability in undergraduate education.

This confluence of factors has the potential to impact the ability of universities to keep facilities at a state representative of current industry practice, possibly resulting in a transition toward simulation-based experiences and a reduction in equipment-based experiences. Programs suffer
as they lose attractiveness to students and employers and as a result, the talent pool within certain industries has reduced at the same time that industry needs for those individuals has expanded.

Two tightly connected industries that are specifically impacted by these challenges are the process manufacturing and process automation industries. The process industries turn raw materials into products via processes that mix, heat, store and chemically induce changes in the raw materials (e.g. agricultural materials into food or petroleum products into chemicals). The automation industry supports the process by providing automation solutions to support manufacturing operations. Such solutions include process measurement devices (i.e. instrumentation), process actuation (e.g. pumps, valves, motors, etc.), and process control hardware and software to effect the control.

Process automation and process manufacturing both suffer from a lack of awareness and visibility; possibly due to the limited application of high profile manufacturing equipment like robots and computer numerical control machines. When presenting the domain of manufacturing to the general public, news and publications often limit their coverage to dynamic and visually appealing applications, as in the production and assembly of products like automobiles and electronics. Additionally, most applied engineering and engineering technology programs, except chemical engineering, have not traditionally focused on process automation or process manufacturing in their curricula. Thereby, even students pursuing automation studies often only get direct exposure to machine control and motion. Increasing student exposure to process automation as a discipline and to industry partners’ methods and products will help in recruiting talented students to exciting and rewarding careers.

Companies within the process automation industry face a double challenge as they compete with others for technical talent: a shrinking labor pool with retiring baby boomers carry thousands of years of collective knowledge out the door each day coupled with rapid expansion in industries and technologies requiring workers skilled in process automation. Actively promoting awareness of the field and employment possibilities can aid in increasing the size of the industry’s talent pipeline.

**Background and Planning**

The Manufacturing Engineering Technology program at Purdue University, which hosts the automation and industrial control major, has a long history of collaboration with automation suppliers, integrators, and distributors. This history includes over two decades of continuous interaction between faculty and industry representatives leading to valuable guidance and generous equipment donations, no-cost industry sponsored faculty training and invitations to promote program majors at industry-sponsored trade shows.

As many university educators and industry representatives know, industry-academia partnerships do not evolve overnight. As with any relationship, mutual benefit, and trust must be established and that often takes several years to develop and additional years to foster and maintain. Once established, a partnership of this nature can be instrumental in improving and advancing educational curricula and laboratory capabilities, as well as serve a practical industrial showpiece used for development, education and possible research opportunities.

The Manufacturing Engineering Technology program at this institution was created in 1984 and acquired its first real industrial relationship in approximately 1986 with a large, well-known
computer company and the second in 1990 with Rockwell Automation, an industrial controls company. While some partnerships have since dissolved, the Rockwell Automation, one remains exceptionally stable. Lessons learned with these first two partnerships, significantly contributed to the development of guiding principles used by our faculty when organizing associations today. These principles include:

1. Intently listen to all advice and direction given by partners and potential partners of the program
2. Attempt to follow and implement ideas provided by partners
3. As appropriate, involve and engage partners in the education process through guest lectures, industry advisory boards, and student/faculty projects
4. When requesting equipment and donations from partners develop a full or mini-proposal/statement of work that thoroughly outlines the needs and benefits to all parties
5. Develop and innovate ways to recognize and promote the partnership
6. When possible, work together with partners to leverage partnerships into new partnerships with other companies

Over a multi-year period, the academic/industry partnership was forged through a series of both informal and formal meetings that eventually lead to serious planning discussions for this year-long collaborative project. Brainstorming began with general talks in the spring (2014) between faculty, school, and key industry administrators which resulted in a general agreement to seek opportunities for significant collaboration. The primary process industry partner, based in close vicinity to campus, provided a tour of their newly completed training center which showcases the range of their technology to assist in promoting conversation to determine the best method of presentation for these technologies in an educational laboratory setting. Faculty provided a tour of existing laboratory space to a group comprised of industry administration, engineering and project management heads.

The proposed location for the new installation provided the first significant constraints as the available space was significantly smaller, had limited infrastructure and provided limited accessibility for the delivery of equipment on the scale of the industrial process model. The visit prompted the process engineering representative to determine that the current industry vision of an implementation would not work, and a new, specialized plan would be needed. Additionally, it was determined that a viable instructional facility would require significant resources and manpower, beyond the resource capabilities of the host university or any single company.

At this time, planning slowed significantly, and the conversation diminished. However, the development and staffing of a new position focusing on academic engagement within Endress + Hauser, a primary industry sponsor; sparked a renewal of stalled conversations and proved to be a pivotal moment in moving the project forward. They organized an onsite meeting at Endress + Hauser attended by all relevant parties from within their home organization and invited representatives from two distribution partners (a collaborating supplier and a distributor). The focus of the meeting was to brainstorm the best path forward to promptly implement the laboratory facility.

The meeting generated several ideas though each had limited feasibility for a range of reasons. A revisiting of previously mentioned scenarios and ideas focused on a system that was a small clone of the existing industrial process facility which would be designed and implemented with industry and contractor support. While the process partner had agreed to pick up a significant
portion of the cost through component donations and monetary support, this solution once again required a capital expenditure significantly beyond the budget of the host institution. Subsequently, participants determined that the proposed scaled-down version of the industry system would be unfit due to the required scale of installation and logistical challenges of university course scheduling.

Ultimately, it was determined that the highest impact solution required the development of a new model, designed and implemented in a year-long senior capstone course jointly utilizing the skills and resources of industry and academia (including students) while sharing the burden across multiple partner companies and the host institution. The academic mission, facilities management, partner solicitation, integration, and troubleshooting were facilitated and executed by faculty with industry partners overseeing project management, partner recruitment, procurement, logistics, specialized fabrication and engineering.

The two primary industry sponsors, aided by a looming fall semester start, elected to commit fully to the project through donations of all the main automation and process measurement components and some additional infrastructure. Concurrently, faculty began locating funding and initiating an upgrade of electrical, water, drainage and pneumatic facilities within the laboratory space. At this point in the project, a range of supporting componentry, storage vessels, and specialized piping were not sponsored. Faculty and industry partners each agreed to seek out additional parties to assist in these areas through donation or significantly discounted pricing. School and department members worked with existing contacts and their university development office while industry representatives began to contact their suppliers and distributors.

The scale of the proposed installation required a broad range of componentry and expertise from numerous sources. Coordination of this effort was outside the regular role of faculty and required a high degree of availability. The process sponsor was intimately familiar with all aspects of launching, coordinating and executing a project of this nature as it closely mirrored one recently completed at their facility. Industry elected to treat the project in the same manner as an external revenue generating activity, assigning dedicated management roles within the organization. The process sponsor agreed to serve as the lead industrial liaison on the project with responsibilities including facilitation of communications between partners, coordination of sponsor deliverables and responsibilities, maintenance of project timeline, scheduling of component ordering and facilitation of expert support in the design and instruction of process specific topics. Multiple individuals within the company provided skills, advice, and effort to support the commitment. For continuity and efficiency, a single point of contact was established to coordinate interaction between industry and academia.

The balance of this paper will focus on the joint academia/industry management model employed to complete the project. The academic component of the capstone course tasked with design and implementation will be detailed in other works.
Execution and Management

Faculty, university development, representatives from the primary process and automation sponsors and representatives from two partner distributors participated in a conference call the week before the initial capstone course meeting in the fall semester. The process sponsor’s team included the director of technical talent development, the head of engineering and the head of project management/logistics.

The proposed project provided two unique educational opportunities: The first, an industrial grade design and implementation experience for capstone students; the second, a living facility purposely designed to allow for interactive instruction in process automation in future courses. The faculty presented an overview of the range of desired capabilities of the completed facility and the envisioned role of the completed facility as an educational platform for future coursework.

Focus shifted to the immediate concerns of the capstone design and implementation course. Faculty presented a brief timeline of the major milestones and deliverables required of the course, a short background of their experiences and skills and their roles in the project. Additionally, time was devoted to informing all industry representatives of the level of knowledge students were expected to have and the types of experiences held in their previous laboratory coursework. This conversation included an overview of specific knowledge and skills highlighted in the capstone experience and details of evaluation methods and procedures.

Engineers at the process sponsor had reworked an existing design to scale to the available space while also addressing the need for multiple instructional stations. The team agreed that the engineering group’s reference design should serve as a benchmark for conversation, with modifications applied as necessary to address student-led changes in the design process. The model was only to act as a method of determining the feasibility of student proposed design elements. Participants agreed that the model would be confidential, limiting the possibility of the inadvertent influence of the student effort. Additionally, the group delineated multiple fixed components and elements required for the installation and discussed which areas had few degrees of freedom for modification due to size, lead time or budget concerns.

Industry representatives were mainly concerned with the best way to interact with students, especially in the realm of the level of information and opinion to convey in the design process. After some debate, it was determined that representatives would provide general overviews of technology, standards and practices within their domain. As requested, students (or faculty) would be provided with additional training on specialized software or integrations, options within their product catalog (with some perspective on appropriateness), specific limitations of options and a discussion of lead time for delivery. In every sense, students were treated as a qualified customer who was a technical novice the in the area.

A weekly conference call was established to maintain communication between faculty and industry sponsors throughout the course of the project. The liaison from the lead industry sponsor organized and led the meetings while also maintaining full minutes which were distributed shortly after the conclusion of each session. The consistency provided by a single key figure from industry has been particularly helpful as events including domestic and international travel, mandatory meetings or university holidays and breaks impacted faculty’s ability to participate in every meeting.
The liaison served as the primary for all scheduling and project management activities. He coordinated with their company’s internal project management and budgeting team to create an active account devoted to the project and tasked the team with determining the lead time for critical path items. This team evaluated each addition or change within the student-generated design to determine the impact on the timeline and budget.

The engineering team within the lead industry partner was tasked with determining sources, lead times and the feasibility of design features being decided by students. When needed, they would work directly with students to talk through possible solutions. The engineering team also worked to determine critical materials and components outside their company catalog, established points of contact and solicited contributions or reduced price bids with the assistance of faculty.

As the project progressed, the list of industry sponsors grew through the efforts of industry outreach, faculty connections and the university’s development department. The team would approach prospective partners with a need, a timeline and the desired level of technical support. Often these requirements would be determined by real-time discoveries in the classroom and conveyed through the industry network. Routinely, the advice of an expert in a particular technical area would be required. Participating organizations actively supported release time and travel expenses for them to speak with students.

At times, the selected resource or assembly would be beyond the reach of industry sponsors, especially smaller companies. In these cases, they would seek out another partner, usually without prompting, to share the burden rather than decline sponsorship. An example includes the procurement of custom stainless steel piping assemblies where one company supplied raw materials and fittings and another supplied manufacturing and welding expertise. Students were continually amazed at the pace of industry in addressing issues and finding responses. By example, their efforts helped to instill within students a greater appreciation of personal responsibility and reinforced a sense of timeliness.

Faculty worked with the development office to plan a formal ribbon cutting ceremony to showcase the efforts of students and show appreciation for all industry sponsors. The event included an on-site lunch for all contributors with presentations from university administration, sponsors’ management teams, faculty and most importantly the students who worked on the project. Press releases, news coverage, and campus newsletters detailed the event and the role of industry sponsors.
Figure 1(a)- Student Pre-rendering of Proposed Design and 1(b)- Final Showcase of Completed System

Benefits

The newly completed facility provides several immediate advantages for the host program and is envisioned to provide an increasing benefit over time. The first benefit supplied by the new laboratory infrastructure allows for an expansion of existing undergraduate curricula to include a new laboratory course focused on fundamentals of industrial process. Additionally, the laboratory fixture is visually engaging and serves to draw interest from prospective students and visitors, prompting increased interest in manufacturing programs within the school.

Industry partners know that when graduating students go to work in process plants, or the engineering firms that design such plants, they are more likely to select familiar equipment brands and devices. This familiarity starts with name recognition but extends to their comfort level in interacting with such devices and their confidence in the reliability of said devices.

Further, the use of this laboratory asset in coursework has the potential to produce more qualified customers who understand the technology in client industries. It is a common complaint in process plants that even the control engineers have incomplete knowledge of, or rarely think about, the process measurement devices used in their systems, considering them little more than inputs in a control scheme. The lack of understanding commonly results in the improper selection of components, installation issues or neglect of routine maintenance which can impact the validity of their measurements, compromising the entire system.

The presence of an attention-getting, attractive and colorful laboratory visible through hallway windows to all visitors will undoubtedly spark many “what IS that?” conversations. Industry partners hope this will cause more students to think about process automation, more visiting parents to suggest it, more visiting faculty to think about wanting to do similarly, and more visiting industry representatives wanting to be part of something like this – on this campus, or another.

We would also submit that the partner benefits enumerated in this paper can be used by other academic institutions to promote their industry partnership ideas for laboratories in their locales. And our industry partners would encourage it, even if it involved other companies—as the talent shortage is industry wide and needs many companies investing in the solution. In fact, the primary process partner in this capstone experience project has already held a short seminar on such collaboration for its industry’s member association.
Faculty and students greatly benefitted from this collaboration. The project allowed for an extremely relevant capstone experience and provided a continuing platform for meaningful educational experiences beyond simulation. Students greatly benefit from access to a new range of internship, cooperative learning experiences and employment possibilities within process automation companies.

Additionally, the willingness of industry to sponsor a project of this scope served as a sharp reminder to the school of the need for, and the importance of teaching process automation topics within the program. Applied engineering programs are continually challenged to maintain relevant “state of the practice” knowledge across a broad range of areas and greatly benefit from enhanced access to expert practitioners. This project opened the door to a new network of industry experts who are willing to provide information on the rapidly changing practices within the industry.

Industry partners started to see benefits even before the completion of the permanent laboratory asset. The first was in getting practice at working with other companies. Where one lacked resources, another stepped up. When obstacles existed, financial or other, high-level contacts (who did not want to be the one partner causing the project to fail) made the tough decisions that did not always align with their original plan or budget. This project was, for most industry partners, their first foray into a university partnership beyond the traditional career fair engagement or training center activity.

This collaboration engaged many employees at many companies. At the primary partner, and perhaps others, employees jumped at the chance to assist, to make a difference, and to do something for the greater good. They also took pride in their being asked to share their expertise. These sorts of experiences can increase job satisfaction as well as collaborative competencies.

Frequent interaction with students by various modes (phone, email, personal visits to both academic and corporate campuses) gave both sides the chance to experience the other’s world and test drive one another as a future potential employee or employer.

The collaboration process also exposed students to more than technology, but also to how real work happens – collaboratively, with no single right answer. Of course, this benefits the students, but industry partners benefit from both the long lever of impacting the talent pipeline, but also from the shorter lever of seeing how millennials engage differently with people and technology, helping industry learn to match their needs.

The faculty impressions that result from such partnerships are also beneficial to industry in that instructors are likely to speak positively about the partners to a long succession of students. Press coverage around the completed laboratory appeared in the trade press, in academic publications, and in the partner companies’ local press outlets.

Finally, at the primary partner company, the collaboration sparks new ideas about how next to collaborate, about how to better attract employees, how to expand the scope of its philanthropy and also how to ensure continuity of support for the institution when presented with conflicting annual and fiscal year environments.

To that point, we are given to understand this is a common problem in schools. Our solution was through a corporate philanthropy fund. Even small companies for whom a formal corporate
foundation is impractical to implement have access to local community organizations where they can open a corporate fund. Deposits to these funds from annual budget dollars do not vanish at the end of the corporate budget year but remain for use across the span of an academic year, or it can compound with next calendar year’s deposits for an anticipated larger project that no single budget year could afford. Further, if first-quarter corporate revenues do not go as planned, there is no risk of rethinking the decision to keep spending philanthropic dollars—those dollars were already spent (i.e. deposited elsewhere) early in the fiscal year.

**Future Plans**

The ability to provide basic training on process measurement at scale can provide significant experiential benefit to an undergraduate audience in majors outside the host school including chemical engineering, food science, and pharmaceutical manufacturing. Efforts are underway to highlight the new facility across campus and increase interactions at the undergraduate level which have the potential to boost collaboration between faculty and students in programs across campus in both education and research.

The design of the facility was purposefully guided to allow for ease of expansion, and a long-term plan to incrementally add features to the existing facility is under development. Planned additions to undergraduate and graduate programs are the primary guide for future use, but allowances exist to open the facility to new usage scenarios facilitated through graduate research efforts.

Faculty envision the facility will be used to provide faculty and industry training workshops on specifics of process automation. The industrial-grade laboratory provides the capability to provide training at scale and present scenarios difficult to observe outside of a live manufacturing environment. Efforts in this area would include a focus on increasing exposure to process concepts to support workforce development.

**Conclusion and Recommendations**

The project has been deemed a significant success at multiple levels by both academic and industry supporters. It has substantially impacted the focus of ongoing undergraduate curricular discussions, increased administrative support for the program and helped with recruitment efforts. Industry participants have benefitted through increased interaction with faculty, students and other companies within their field, having worked together with established and new acquaintances in an experience not driven by monetary goals.

The success of this effort was attributable to two main factors: the support of key leadership within the industrial and academic organizations to see the project to completion regardless of unexpected challenges and the separation and ownership of roles between industry and academic partners.

As in any large project, the initial plan rarely matches the final form. Unexpected challenges and the identification of new possibilities or constraints can significantly impact the original vision, timeline, and budget. Absolute rigidity to the initial plan would have resulted in a failure of this project and likely affected future interactions between all parties. Pointedly, all parties appreciated the challenge posed by this experimental interaction and were willing to make significant adjustments when needed to ensure completion. Many instances illustrate this commitment including allowing a range of highly skilled personnel to commit many hours
(internally or traveling) to the project instead of focusing on revenue generating activity and finding extra sponsor funding to acquire components outside their product catalog. Also, addressing and accommodating the unexpected through providing additional donated components to replace those damaged by students in the learning process and the securing of additional internal funds to bring physical facilities up to necessary specifications.

The decision to separate the roles of industry partners and faculty associated with this effort was critical to its success. Navigating the worlds of industry and academia requires skills and is best accomplished by those most familiar with their unique qualities. The realities of economics, hard deadlines, and fixed commitments drive industry while academia is a world of discovery more comfortable with flexible timelines and the high likelihood of variance in planned deliverables. As such, it was expedient to limit the roles of participants to those focused on their host environments with all significant cross-communications facilitated through a single liaison from the primary industry sponsor.

The collaborative model used for this system was very successful, and a capstone course project to upgrade existing discrete manufacturing laboratory infrastructure will be attempted using a similar methodology. Though the project includes a different set of industrial sponsors, faculty believe that this structure will provide another successful outcome that benefits all involved.

References


