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Sustaining Industry-Embedded Laboratories: A Case Study of The Upstate Experience

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Abstract

Developing a novel Industrial Engineering program in a region rich in manufacturing offers a unique opportunity: the ability to place students directly in a real factory setting rather than replicating it on campus. This paper is a case study of how a regional campus's industrial engineering (IE) program has created, maintained, and developed relationships with 10 manufacturing partners: Dräxlmaier, Sage Automotive Interiors, OPmobility, Spartanburg Steel, Oshkosh Defense, Rhino Tool, Keurig Dr. Pepper, Milo's, AFL, and SEW-Eurodrive. This paper also discusses how these embedded labs, coined "Labs-in-Industry", were designed to allow students to experience meaningful manufacturing tasks, engage in structured reflection, and have industry partners become engaged stakeholders in educational design.

At each partner site, students performed tasks aligned with manufacturing practices, such as cycle-time studies, lean/TIMWOODS assessments, material staging, quality testing, Automated Guided Vehicle operations, and interactions with Manufacturing Execution Systems, among others. Prior to visits, lectures were aligned to cover manufacturing processes seen at each site, and students completed prelab quizzes confirming the site, safety rules, and clothing/PPE requirements. After each visit, students completed structured feedback surveys assessing clarity, process exposure, safety compliance, and opportunities for improvement they observed.

The university and IE faculty treat partner companies as a living advisory ecosystem. Effort is made to incorporate the content seen in labs directly into lectures. The IE program offers industry partners early access to student intern or co-op pipelines and ensures that the curriculum addresses their hiring needs.

While no data was explicitly collected, this case study provides qualitative and observational evidence related to the lab-in-industry program and maintenance. Preliminary outcomes on the first Manufacturing course to use the lab-in-industry model are reported alongside the program's protocols for interacting with and maintaining relationships with industry partners. This partnership-centric, academically grounded lab-in-industry model demonstrates that embedding manufacturing laboratories within regional industry networks is feasible if approached systematically.

Keywords: Industry Collaboration, Lab in Industry, Educational Program Development

1 Introduction

As regional universities and engineering programs go beyond the campus to improve student learning, literature regarding partnership between university and industry demonstrates that industry involvement while developing a program can strengthen educational quality and align student skills to industry needs [1]. Shah & Gillen (2024) reviewed such partnerships and found that successful partnerships share characteristics such as clear goals and expectations, the development of new engineers, and mutual benefits for students and industry partners. Early successful models, such as Penn State's Learning Factory, exemplify that industry-embedded labs can enhance the ability of students to apply classroom knowledge to real problems and build strong communication and teamwork skills, though this model is closer to senior capstone projects [2]. The University of South Carolina Upstate's "lab-in-industry" (LI^2) concept, which hosts engineering labs at local advanced manufacturing facilities, shows much promise due to its bridging of industry and academia, as recommended by literature [1], [2].

1.1 Regional context and program origins

The Upstate region of South Carolina hosts a diverse set of manufacturing companies, including suppliers to BMW and other advanced manufacturers. Many firms operate at an Industry 4.0 level, employing automation, robotics, and data-driven decision-making. USC Upstate's industrial engineering program was developed to train graduates to work in advanced manufacturing environments, supply the region with locally trained engineers, and keep students in the area after graduation. Due to the university's limited resources, particularly in facilities and capital to establish conventional laboratories at the outset, administrators partnered with industry to host labs in local facilities. More information on the creation of the program is available in another conference proceeding [3]. The emphasis of this paper is on the structure of LI^2 and on how industry partnerships are maintained and nurtured.

1.2 Literature guidance on sustaining industry partnerships

Engineering education literature provides guidance on maintaining university–industry collaborations. Fournier and Gaudet (1999) outline a four-step process for creating and sustaining partnerships: (1) define the role that industry should play in program development, (2) identify and contact companies willing to commit time and expertise, (3) actively involve industry personnel while developing opportunities to augment student education, and (4) cement the relationship by developing long-term commitments [1]. Their study notes that firms that join advisory committees, offer internships, and host field trips often become long-term partners. The systematic review by Shah and Gillen (2024) likewise stresses the importance of early communication and shared expectations. The review concludes that some best practices include aligning student projects with both academic and industry needs, using project management documentation, recruiting qualified industry speakers, and creating industrial advisory boards [2]. These sources suggest that sustained collaboration depends on mutual benefit, clear communication, and a formalized structure.

1.3 Equivalent Industry Partnerships with Academia

While senior capstone projects involving industry partners are a mainstay of most accredited engineering programs, the LI^2 model described in this paper differs from traditional capstone collaborations by embedding laboratory exercises from core engineering courses across multiple industrial settings each semester. Rather than partnering with a single company at the end of their undergraduate curriculum, LI^2 recruits a network of local manufacturers and service firms across multiple industries and integrates hands-on lab activities throughout the course sequence.

A few parallel programs with similar structures are documented, such as the collaboration between Oral Roberts University (ORU) and John Zink Company LLC. This partnership involves adjunct professors from industry who teach mechanical engineering courses and serve on industrial advisory boards [4]. Students gain from instruction by experienced engineers, while the industry benefits through potential future recruitment. Students also engage in challenging industrial senior design projects and may co-author technical papers, thereby acquiring substantive practical experience beyond traditional academic settings. Western Kentucky University, a smaller institution with limited resources in civil engineering technology and construction management, established a partnership with Scotty's Contracting through a $100,000 gift to support the development of the Construction and Engineering Technical Assistance Center (CETAC) [5]. This collaboration facilitates professional consulting between faculty and students, access to advanced laboratories, and opportunities for faculty to work with industry partners on joint projects. Conversely, the firm benefits from access to faculty expertise, student engagement, and recruitment prospects. The partnership effectively bridges academia and industry, providing students with practical experience, faculty involvement in industry practice, and sustainable financial resources to enrich engineering education [5]. While similar in concept, most such collaborations do not maintain the level of integration proposed by the LI^2 model.

2 Setting up labs-in-industry

2.1 Partner recruitment and vetting

Recruitment began in 2024 at USC Upstate when Don Bent, the Executive in Residence, used his professional network to compile a list of 30 potential partners from various industries and firms in the region. Because faculty were still to be hired and syllabi were being finalized, Mr. Bent used the general course descriptions as guides to selecting industry partners for classes. In the case of Introduction to Manufacturing Processes, the firms: Dräxlmaier, Sage Automotive Interiors, OPmobility, Spartanburg Steel, Oshkosh Defense, Rhino Tool, Milo's Tea, AFL, and SEW-Eurodrive, were selected with the hope that their processes would align with anticipated course content. The model was flexible enough to substitute Keurig Dr. Pepper (KDP) when one partner needed to cancel their commitment due to unforeseen circumstances. Companies with strong safety and advanced manufacturing practices were prioritized. Mr. Bent's initial outreach prioritized contacts willing to participate at no additional cost and enthusiastic about engaging with faculty and co-developing curricula, thereby acting as an advisory ecosystem for the program.

2.2 Establishing communication and expectations

Successful collaboration requires transparent communication and alignment of expectations. At USC Upstate, once partners expressed interest, a communication schedule was established: companies were contacted six months in advance of a semester to solicit participation, and follow-up reminders were sent at six weeks, one month, two weeks, and one week before the scheduled lab. This structure ensured that on-site liaisons could confirm dates, develop a site-specific hands-on activity, and clarify safety requirements. Each company provided a written description of its planned lab activities, safety protocols, personal protective equipment requirements, prohibited items, parking instructions, and liaison contact information. The course syllabus incorporated these protocols to prepare students. This detailed coordination reflects the recommendation from Shah and Gillen (2024) to set clear expectations, deliverables, and roles.

2.3 Lab-in-Industry design and logistics

For this round of LI^2, four students were in the group. Each lab was a 2-hour-45-minute visit over 11 weeks (about 2 and a half months). There were also two on-campus labs specifically for metrology. The hands-on activities in the lab are based on skills that industry partners believe students would benefit from knowing. The LI^2 sessions occur once per week during the semester and follow a consistent structure:

1. *Pre-lab Preparation*. Lectures leading up to LI^2 visits would prioritize the manufacturing processes featured at those sites when feasible. Prior to each visit, students complete a digital quiz to verify their understanding of the site's location, safety rules, PPE requirements, and prohibited items. Students also review the company's processes and prepare questions (Appendix 1).
2. *On-site Visit*. Lab locations within 30 minutes of travel are prioritized for accessibility, and travel time is factored into scheduled lab times (per campus schedule) and coordinated on-site start times. Students arrive individually at the facility and sign in, completing all required disclosures and safety preparations. Generally, the visit starts with a safety briefing, then a tour, followed by a hands-on activity such as cycle-time measurement, a TIMWOODS waste identification walkthrough, material staging, quality testing, or component assembly.
3. *Post-lab Reflection*. Students complete a structured reflection assignment to connect the lab experience to lecture material, identify potential engineering interventions, and propose improvements. Although student reflections are not analyzed in this paper, they help maintain a feedback loop with partners and serve as quality improvement data for faculty (Appendix 2).

Companies commit to hosting a three-hour session per class each semester, allowing them to plan ahead for minimal disruption to their operations.

2.4 Mutual benefits and partner engagement

Mutual benefit is essential for maintaining partnerships. Industry partners gain access to potential interns and hires, opportunities to shape curriculum content, and marketing value from association with the university. Partners also benefit from “fresh eyes,” receiving thoughtful suggestions for improvement from students’ reflections and end-of-lab debriefs. The University benefits through access to industry-grade equipment and processes, free or low-cost lab experiences, and ongoing input on curriculum relevance. In return, the program offers to showcase partners on social media, provide early access to student résumés, and recognize partners through awards.

Table 1: Description of tasks and learning objectives related to lab in industry visits

Site	Processes Observed	Hands-on-Activities	Connection to Manufacturing Curriculum
Dräxlmaier	Injection molding, plastic welding, thermoforming, and automated door assembly.	A time study of an assembly cell. Waste (TIMWOODS) walkthrough observing a finishing cell	Reinforces concepts related to plastic forming. Connect lecture concepts to real flow constraints (waiting, motion waste). Identify layout/transport inefficiencies.
OPmobility	Injection molding (IM), automated inventory management system, robotic painting/handling of parts (e.g., bumpers), final assembly, and finishing.	Shadowing IM cell operators, recording tact time, and identifying pain points. Recording cycle time for a 14-step finishing cell.	Reinforces concepts related to plastic forming. Identify process bottlenecks and quality/handling constraints. Demonstrated finishing operations and the cost of rework if defects are identified too late.
Sage Automotive	Fabric/foam cutting, lamination, and spooling. Discussed systems for scrap/defect identification. Practical uses for scrap.	This site was visited twice. Students observed a new manual fabric sheet-cutting operation and returned with presentations on how to improve it.	Parallels can be drawn to certain metal sheet cutting, stamping, and forming/welding operations. However, textiles are atypical materials in manufacturing curricula.
Spartanburg Steel	Metal forming/processing: punching, welding, shaping, drawing.	Discussion of risk management and experimentation on joining techniques used for composite steel products.	Direct connection to metal forming and welding processes.

Table 1: Description

Site	Processes Observed	Hands-on-Activities	Connection to Manufacturing Curriculum
Oshkosh	Vehicle/mail truck assembly. Automated guide vehicle (AGV) routing for a multi-step frame-painting process. Use of digitally controlled hand tools tied to a Manufacturing Execution System (MES).	Hands-on break system assembly activity in the employee training area. Remote 5-axis robot arm operation. Manual override and control of AGVs used for material flow in the plant.	Direct connections to metal shaping, joining, painting, finishing, and assembly stress-testing.
Rhino Tool	This was an on-campus demonstration of robotic systems/tooling, cell automation logic, and automated guide vehicles.	Using lift assist tools. Controlling modular AGVs. Hands-on testing of PLC-controlled miniature assembly line components.	Connects to material transport content. Not as directly related to core manufacturing, as we are a tooling solutions company.
Keurig Dr Pepper (KDP)	Coffee-related production/packaging. Fully automated K-Cup assembly and packaging process. Quality testing by brand.	Coffee brew testing. Students engaged in an interactive activity to identify coffee-brew-related defects and learn how to detect them.	Loosely related to particulate processing and powder metallurgy (equipment used for coffee served similar functions). Tied to quality/inspection and process control.
Milo's	Tea brewing, bottling/filling/packaging. Fluid transportation and storage systems. Refrigerated storage systems.	Time study of the empty bottle unloading and bottle filling line loading processes.	Loosely related to liquid metal processing and shaping, but food-grade liquid processing is an atypical industry in most manufacturing curricula.

Table 1: Description

Site	Processes Observed	Hands-on-Activities	Connection to Manufacturing Curriculum
AFL	Optical fiber/cable-related manufacturing. Stranding, sheathing, stainless-steel tubing forming (cable casing), and cable drawing.	Students shadowed frontline workers and attempted to replicate wire feeding operations while discussing the value of hand tools with operators.	Directly related to drawing, shaping, glass extrusion, and sheathing processes.
SEW-Eurodrive	Autonomous picking, assisted assembly, testing, painting, and packing of gear reducers and motors. Inspection of spiral-bevel gears and pinions.	Students assembled a gearbox at an ergonomically organized workstation in the facility's training space.	Related to CNC machining, GD&T, metrology, design-for-assembly, and high-end automation.

3. Discussion

3.1 Sustaining and scaling the partnerships

Maintaining long-term relationships requires continuous attention. USC Upstate plans to:

- *Rotate and Expand Partners* – As the program grows and new courses are added (human factors, quality control, logistics), additional partners will be necessary. Having a large selection of companies to rotate through reduces the burden on any single partner and exposes students to diverse technologies.
- *Schedule Alignments* – Future semesters will better align lab visits with lecture topics, as more data becomes available about course pacing, processes, and potential activities available at each site, and company availability. Scheduling will also avoid shift changes to allow students to observe peak production when possible.
- *Document Hands-On-Activities* – Cataloging and sharing of hands-on activity structures and student feedback with industry partners can reduce the barrier to entry for new partners while creating an avenue for faculty to refine LI^2 visits with current partners.
- *Formalize Advisory Structures* – The program intends to create a formal industry advisory board to institutionalize partner input and ensure that collaboration persists beyond individual relationships.

3.2 Limitations and Future Work

This case study is limited by its reliance on a single program's experience and the short duration of the partnership thus far. Student feedback, while positive, is still anecdotal and cannot yet demonstrate long-term learning outcomes. The IE program itself is still in its infancy, with small class sizes and larger cohorts arriving as early as the Fall of 2026. Current LI^2 structures will need to adapt to accommodate larger groups. Our first attempt at the LI^2 Model came with expected growing pains. Industry partners did not fully grasp the course's educational sequencing needs, so some concepts had to be taught out of sequence, as scheduled lab and industry dates conflicted with the sequenced teaching of Manufacturing Processes (an introductory manufacturing course). Some industry partners covered similar topics due to personnel, time, and resource availability, which were out of the university's control, and one site had to cancel its visit due to plant schedule changes. In some cases, the scheduled time for LI^2 coincided with shift changes, so some components of visits occurred during a facility's downtime. Due to the nature of course scheduling and the breadth of industry partners that participated, shifting times per lab session and finding a time that did not involve downtime for all our partners was not feasible.

Additionally, the program is yet to face a semester with multiple LI^2 courses running simultaneously. Scaling and coordination will need to be considered here as well. Currently, future labs have been scheduled as 2 separate sections, each capped at 16 students. These lab groups will visit the same site on different days each lab week or visit 2 different sites with similar planned hands-on activities (e.g., time studies will be at a cable manufacturing company and a plastic molding company during time study week). The groups of 16 will break down into smaller groups at the partner sites and rotate through tour segments or hands-on activities coordinated by the faculty in charge and the industry partner. Future research could compare student competencies with those from traditional lab models and investigate solutions to improve scalability. The program also aims to regularly survey industry partners to assess satisfaction with the long-term benefits of being a LI^2 partner, including changes in hiring patterns and the preparedness of engineers who come out of the program.

4. **Conclusion**

Maintaining a LI^2 program requires careful attention to partner recruitment, clear communication, logistical planning, and the creation of mutual benefits. Engineering education literature underscores that sustained partnerships rely on defining roles, selecting appropriate partners, involving industry in educational design, and formalizing long-term commitments. USC Upstate's case demonstrates that even resource-constrained programs can deliver high-quality laboratory experiences by leveraging regional industry and building relationships responsive to both academic and corporate needs. With continued refinement and effort to address the barrier to scaling, this model could serve as a blueprint for other institutions seeking to embed laboratories within industry networks.

5. **References**

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6. Appendix

Appendix 1

The following is the layout for the prelab questionnaire. Question 1 asks students where they are going. Question 2 asks students to acknowledge the specific safety requirements for each site visit. It should be noted that the syllabus for the lab has all safety, location, and parking instructions listed.

Prelab Quiz

Where will our lab visit take place this week?

1. Draexlmaier – Duncan, SC
2. Milo's – Moore, SC
3. Rhino Tool - On Campus
4. Spartanburg Steel – Spartanburg, SC
5. SEW-Eurodrive – Lynman, SC
6. Benteler – TBD
7. AFL – TBD
8. Oshkosh – Spartanburg, SC
9. Sage Automotive Interiors – Spartanburg, SC
10. OPmobility – Greer, SC

Question 2

Which of the following are required for this site visit? (Select all that apply)

- Closed-toe, closed-heel shoes required
- Steel/composite-toe shoes required
- No jeans permitted
- Long pants required (must cover ankles)
- No riveted clothing or belts
- No skirts, capris, or dresses
- No excessively loose or baggy clothing

- No sleeveless shirts (short or long sleeves required)
- No jewelry (rings, watches, earrings, belt buckles)
- No purses, bags, or personal items
- No hoop-style earrings
- No open-style gauged ear holes (must use solid plugs)
- Nail polish must be covered with gloves (provided)
- Safety glasses required (provided if needed)
- Gloves required (provided when necessary)
- Reflective vests required (provided)
- Smocks or coveralls required (provided)
- Earplugs required (provided)
- Arm sleeves required (provided)
- PPE provided on site as required (general)

Appendix 2

This covers the questions that were asked to students for the site reflection and how what they learned ties back into class and overall learning objectives. Example student answers are provided for the post lab quiz. Points were assigned to each answer as follows:

Points

- **Excellent (2 pts):** Clear and detailed; distinguishes familiar vs. new; uses technical language.
- **Good (1 pt):** General mention of processes with limited depth.
- **Needs Improvement (0 pts):** Minimal or incorrect process description.

Post Lab Quiz

Question 1

Describe the key manufacturing processes you observed at this facility. Which process was most familiar from class lectures, and which was most surprising or new to you?

Example answer: At SEW-Eurodrive, we observed the manufacture of spiral bevel gears and pinions, including turning, machining castings, and heat-treating. We also saw automated gauging stations for quality checks and how 3D printing is used for custom tooling. The turning and machining processes were familiar from lectures, but seeing how automation and additive manufacturing support tooling was new and exciting.

Question 2

How did what you observed reinforce or challenge what we've discussed in lectures and readings? Give at least one concrete example.

Example answer: This visit reinforced our lectures on machining, finishing, and quality control. Watching gears move from turning and heat-treating to automated gauging showed how process integration ensures precision. It also connected to our discussion of statistical quality control, since SEW used digital gauging to verify tolerances in real time.

Question 3

Identify one area where an industrial engineer might contribute to improving efficiency, safety, or quality at this facility. What evidence led you to this conclusion?

Example answer: An IE could work on improving tool changeover efficiency in machining cells or analyzing workstation ergonomics during gear inspections. I noticed operators frequently repositioned heavy parts when loading them into gauging stations—automation or fixture redesign could reduce strain and improve cycle time.

Question 4

What did you personally find most interesting or valuable about this visit? Did it affect your perception of manufacturing careers in any way?

Example answer: I was impressed by SEW's combination of traditional machining with modern automation and 3D printing. It showed how industrial engineers contribute to keeping legacy manufacturing relevant through innovation and precision. I now see manufacturing as more advanced and technology-driven than I expected.

Question 5

Have you already provided your feedback on the site visit?

- Yes
- No