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WIP: Developing Hands-On Semiconductor Fabrication and Testing Courses Through Industry-University Partnerships in a Teaching-Focused Undergraduate School

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Abstract

This paper addresses the challenges local companies face in hiring and retaining talented engineering students, particularly in regions with limited access to skilled engineers. It highlights how a small, teaching-focused private university can build effective partnerships with local companies by introducing high-demand semiconductor fields through field trips, industry engagement, and market-driven courses. The paper explores efforts to align semiconductor engineering curricula with industry needs, enhancing students' hands-on skills through real-world applications and impactful course development. By fostering collaboration with companies of varying sizes, the authors present a win-win strategy that prepares students for semiconductor careers while addressing workforce needs, offering recommendations for holistic partnerships to support students, strengthen local industries, and contribute to regional workforce development.

Introduction

Recently, with the introduction of the Texas Chips Act [1] and the growth of the semiconductor industry, the demand for engineers has increased significantly. However, a shortage of skilled professionals remains, and providing semiconductor education requires substantial infrastructure to adequately prepare students for the industry. Various approaches have been developed to address these challenges and accommodate the diverse needs of semiconductor education. These range from initiatives at the high school level [2, 3, 4] to two-year community colleges [5], specialized certificate programs [6, 7], and university-level courses and curriculum development for semiconductors [8, 9]. Efforts include both domestic single-institution programs and international multi-institutional collaborations [9, 10]. Depending on the type of school and the target audience, semiconductor education employs different formats, including modular courses, full-semester classes, specialized semiconductor tracks, and independent curricula [11]. In engineering education, local workforce development faces significant challenges, particularly in addressing the shortage of skilled engineers. This talent gap makes it difficult for companies, especially small to mid-sized businesses in high-demand fields like semiconductors, to find and retain qualified professionals. The lack of a robust talent pipeline directly impacts the growth and competitiveness of these companies, an issue that is particularly acute in smaller towns where advanced technologies and capabilities exist, but access to skilled engineers remains limited. Despite city-wide efforts to attract more businesses [12], certain industries, such as

semiconductor testing and electrical engineering, struggle to recruit a long-term, skilled, and dedicated workforce. For example, Local Company A, located in Tyler, TX, is no exception. Despite its leading-edge semiconductor testing technology, it faces significant difficulties in attracting and retaining skilled engineers. To address these challenges, fostering strong partnerships between universities and companies is crucial. Such collaborations can bridge the gap between academia and industry, aligning educational outcomes with workforce needs and ensuring a steady supply of well-prepared professionals to meet the demands of evolving industries. On the other hand, LeTourneau University, a small, teaching-focused, 4-year private university without a doctoral program, also faces its own set of challenges. Teaching-focused institutions in non-metropolitan areas often experience unique difficulties in establishing relationships with local industries. These challenges arise due to their geographic location, which, while not entirely rural, lacks the dense industrial networks commonly found in major metropolitan regions. The primary obstacles include 1) Limited Local Industry Presence with a smaller pool of industries, 2) Competition with Larger Universities which often dominate industry collaborations due to their resources and reputation, and 3) Student Attraction and Retention with a perceived lack of opportunities which discourage students from enrolling or remaining in such programs. This paper outlines how LeTourneau University is leveraging industry partnerships to develop hands-on semiconductor fabrication and testing courses, equipping students with the skills necessary to meet industry demands while addressing workforce shortages. These efforts reflect recent national funding initiatives, such as the Texas Chips Initiative, and the push to expand manufacturing and semiconductor businesses, which have created opportunities for more active collaboration between universities and industries.

University-Industry Collaboration Model

Every university has its unique strengths and weaknesses, along with varying conditions. LeTourneau University possesses a distinctive legacy and practice with its excellent hands-on engineering program. However, as a four-year college, it faces challenges due to the lack of extensive infrastructure often required for semiconductor education. Small four-year universities must explore strategies to overcome these challenges and integrate such curricula and courses effectively. The authors have major two prompts along with the semiconductor opportunities.

Prompt I: How can a small university overcome challenges related to locality, limited resources, and the infrastructure required for semiconductor education?

Prompt II: What kind of collaborative model and strategy can be implemented using a university-level holistic approach?

The authors introduce the term "LeTourneaurize" to highlight that the efforts described below were specifically tailored, applied, and personalized to address the unique challenges and opportunities of LeTourneau University. Table I outlines the potential considerations for establishing a SWOT analysis and strategies to develop a unique educational program at LeTourneau University, based on a literature review of case studies from other universities discussed in the introduction.

TABLE I. Strategic Map for LeTourneaurized Semiconductor Initiative

School Type	Single vs. Multiple institution involvement	Semiconductor Contents	Major Activities	U.S. Domestic vs. International collaboration
High School	Homeschools + Local High school	Introduction Hands-on	Summer Program	N/A
2 year community college	Local community college (Kilgore College)	ATE (Automatic Test Equipment) Mixed signal testing	1) Certificate program 2) Bridging Course Provision	N/A
4 year college / university without doctoral program	CCCU network	1) Basic Fabrication 2) Mixed signal testing 3) IC layout design	1) Certificate program 2) Course module & curriculum development	Sister schools in Korea – faculty sabbatical year, program co-development
4 year college / university with doctoral program	Local and Global Universities (Texas A&M, etc.)	1) Course share 2) Seminar	1) Course module & curriculum development 2) Seminar 3) Consortium	Sister schools in Korea – Faculty individual sabbatical year with industry & institutional network

In 2022, a field trip to Local Company A was organized as an independent class effort, which helped strengthen the relationship between the company and LeTourneau University, leading to internship opportunities and hiring of LeTourneau University students. Recognizing the value of the semiconductor industry and higher education, the ECE department at LeTourneau University initiated a course titled Fundamentals of Semiconductors. This course not only covers theoretical concepts but also incorporates hands-on learning experiences. Additionally, senior design projects focused on semiconductor fabrication have been introduced to foster collaboration and integrate the semiconductor program into the department. The authors summarize these efforts in

the following three aspects: 1) Field Trips and Industry Engagement 2) Hands-On Competencies 3) Market- and Industry-Driven Courses. A key challenge in this model is the development of coursework and hands-on experiences within a low-cost framework suitable for a non-research-driven, undergraduate teaching-focused university. The purpose of organizing field trips to local semiconductor companies is to enhance engineering students' exposure to real-world operations and workplace expectations. Table II outlines the milestones of these collaborative efforts, which began earlier, showcasing the progress and achievements. Local Company A's CEO and engineering team have been particularly supportive, not only by recruiting LeTourneau University students but also by encouraging the development of future engineers.

Table II: Building on Milestones: Present Successes and Future Goals

Year/ Semester	Course	Key activity	Note
2022 Fall	CPGR 2102 Intro. to Comp. Eng.	Local Company A site visit	Company visit / discussion for collaboration
2020 Spring	(Open Elective)		Discussion for collaboration
2023 Fall	CPGR 2102 Intro. to Comp. Eng.	Local Company A site visit	Company visit / discussion for collaboration
2024 Spring	(Open Elective)	Texas CHIPS + Longview/Kilgore City + LETOURNEAU UNIVERSITY ECE	University Leadership Engagement (Office of Global Initiatives & Industry Engagement)
2024 Fall	CPGR 2102 Intro. to Comp. Eng. EEGR4943 Fundamentals of Semiconductor ENGR4951 ECE Senior Design eGen	Local Company A site visit (Planned Nov.) Course Development with Local Company A equipment	Graduate-level course extension
2025 Spring	Curriculum Development Certificate program planning Funding Proposal with multiple stakeholders	Mixed Signal Testing with ATE	School-wide collaboration Stakeholders include LeTourneau University, Local Company A, regional economic development corporations, and users of Local Company A testing equipment
2025 Summer	Equipment acquired from Local Company A	Mixed Signal Testing with ATE, Lab development	Local Company A's equipment training and operation
Cont.			

2025 Fall	Mixed Signal Testing new course Continuous Senior Design & new Senior Design project (with Local Company A) Semiconductor internship program launched and promoted	Mixed Signal Testing with ATE (Course)	Evaluation & Feedback Students prepare for summer internships in the semiconductor industry

The development of a curriculum that aligns with industry needs is a key focus of the department. Examples include courses specifically designed to emphasize the practical applications of semiconductor theory. The instructor and department chair collaboratively designed these pilot courses to support the department's efforts to secure additional resources and initiate a partnership with Local Company A. These courses highlight the importance of experiential learning and lab-based education, offering students real-world experiences to prepare them effectively for industry roles. Through these initiatives, the curriculum bridges the gap between academic theory and professional practice, equipping students with the skills and knowledge necessary to excel in the semiconductor field.

Case Studies and Examples

To equip students with the real-world skills needed to thrive in the semiconductor industry, LeTourneau University has developed innovative courses and projects that bridge theory with practical application. These efforts aim to ensure students are not only academically prepared but also possess hands-on experience that aligns with industry demands. Key examples of innovative courses and projects include the introduction of the Fundamentals of Semiconductors course, which combines theoretical knowledge with practical insights into semiconductor technologies. This course explores topics such as quantum mechanics, device physics, and the principles of semiconductor fabrication, providing students with a comprehensive understanding of the field. The curriculum emphasizes lab-based learning, enabling students to work with advanced tools and materials reflective of current industry practices. Design projects integrated into coursework challenge students to solve real-world problems, fostering creativity, critical thinking, and teamwork. Additionally, partnerships with leading companies allow students to engage in industry-relevant coursework, including internships, facility tours, and mentorship programs that bring the professional environment directly into the classroom. Through these initiatives, LeTourneau University’s semiconductor courses prepare students to meet the evolving needs of the industry while equipping them with the skills and confidence to excel in their future careers.

Student Success Stories

How students applied theoretical knowledge to practical scenarios (e.g., collaborations with local companies, industry internships). Outside the classroom, LeTourneau University requires all engineering students to complete Senior Design, a one-year project that is often industry sponsored and presents the students with opportunities to partner with external entities such as companies or other universities. One such project, Project Electrogenesis, serves as LeTourneau University's pioneer footstep into the semiconductor industry. The project's ongoing goal is to develop simple processes and procedures that allow efficient and cost-effective fabrication of semiconductor devices. The team, composed of five senior members, one junior member, and one sophomore member, is thoroughly investigating safety procedures and researching and purchasing the required materials and chemicals to accomplish this goal. After tedious trial and error, the team successfully fabricated a resistor on a Silicon wafer. One member in particular, Author C, was able to apply the information he learned in Fundamentals of Semiconductors directly to his understanding of the components and devices being fabricated. The other students on the team are quickly learning many aspects about semiconductors and the complexity and vastness of the semiconductor industry. E-Gen's team members have realized the significance of the contributions they are making to LeTourneau University as they continue to immerse themselves in one of the many well-equipped engineering labs, gaining hands on experience with something new and extremely relevant. Similarly, the team had exposure to the different aspects of the semiconductor industry. For example, LeTourneau University partnered with Texas A&M to discuss strategic external partnership development for the ECE department. Another example is the field trip tour of Local Company A, as the students got a glimpse into the world of PCB and semiconductor testing. Finally, the most beneficial aspect of the project was that the students were given the chance to prove themselves and apply the skills they learned in the classroom directly to the project, including problem solving, technical calculations, time management, detailed documentation, quality presentation, and effective networking. All these skills culminated to spur productivity, teamwork, and professionalism.

A Win-Win Strategy: University and Industry Collaboration

With these ongoing efforts, this section addresses three major points: 1) Benefits for Students, 2) Benefits for Local Companies, and 3) Benefits for Regional Development.

Benefits for Students

LeTourneau University excels in preparing students for careers in the semiconductor industry by improving their readiness and enhancing their understanding of industry expectations and skills through direct engagement. The university provides numerous networking opportunities, allowing students to connect with professionals who have extensive industry experience. These opportunities give students a detailed understanding of the various aspects of the semiconductor

industry and its operations. This year, the Electrical and Computer Engineering (ECE) department introduced a new course, Fundamentals of Semiconductors, to further enrich student learning. This course covers the theoretical underpinnings of how semiconductors work at quantum and atomic levels while also providing practical insights into the semiconductor industry. To complement classroom learning, the university partnered with Local Company A, a leading company in semiconductor technology, and organized a facility tour in Tyler, TX. This partnership offered students first-hand exposure to industry practices and the opportunity to engage with professionals who provided valuable guidance on the skills and knowledge required to succeed in the semiconductor field. Furthermore, when the relationship and curriculum is fully developed between Local Company A and LeTourneau University, graduating students will experience a relatively smooth transition into the semiconductor industry with enhanced skills and understanding of their new employer and industry. Due to this enhanced skill and knowledge, graduating students will have competitive employment and salary options commensurate with experience.

Benefits for ECE Department

The LeTourneau University's ECE department emphasizes a hands-on approach to connected courses. Faculty members teaching related subjects, such as Advanced Electronics and Engineering Technology for analog circuit studies, are considering the use of multipurpose testing equipment to enhance course integration, ensuring greater cohesiveness across the curriculum. This initiative fosters faculty collaboration in creating a more continuous and interconnected learning experience.

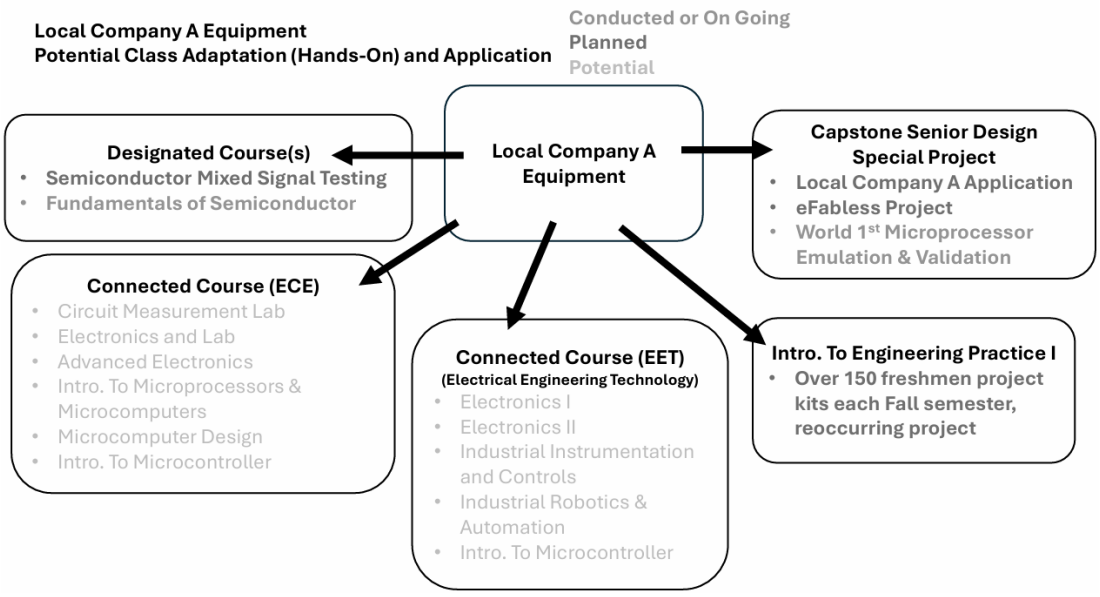

Figure 1. Broader and cohesive adaptation of the Local Company A equipment into various course works

Additionally, the testing equipment can be utilized in other courses, such as Introduction to Engineering Practice, where Automated Test Equipment (ATE) can validate over 150 freshman project kits each Fall semester, and this is a reoccurring project. This not only reduces faculty debugging efforts but also promotes local companies while providing students with practical exposure to advanced ATE technology.

Benefits for Local Companies

Local companies benefit significantly from their partnership with LeTourneau University, gaining access to a pool of well-prepared, job-ready engineering graduates. These graduates are equipped with the technical skills and practical experience needed to contribute effectively to the workforce almost immediately. Currently, Local Company A estimates two years of training for recent engineering graduates before they are ready to make a substantive contribution to the company. With the partnerships between LeTourneau University and Local Company A, the goal is to cut the training time down for recent engineering graduates to only a few months before the employer receives valuable contributions from the new engineer. Semiconductor companies that receive well-prepared, job-ready engineering graduates will gain exponential savings on several levels over the coming years by hiring these graduates. Additionally, companies have opportunities to collaborate with the university on workforce development initiatives. These partnerships allow companies to help shape the curriculum to align with their industry-specific needs, ensuring a steady pipeline of skilled engineers to meet their operational and strategic demands. Furthermore, reciprocal relationships are developed as LeTourneau University engages with companies and other types of companies within the same industry begin to benefit from the partnerships. For example, LeTourneau University provides semiconductor testing education using specific equipment from Company A. Company B purchases equipment from Company A and LeTourneau University supplies qualified engineering interns and graduates to both Company A and Company B. This reciprocal relationship may be expressed as seen in Figure 2.

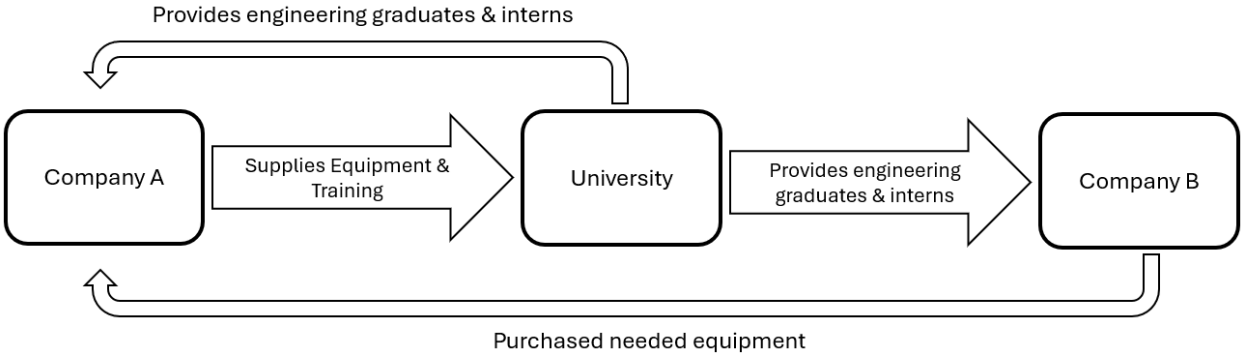

Figure 2. Reciprocal relationships between industry and the university

Benefits for Regional Development

Strengthening connections between schools and industry is essential for fostering long-term regional workforce development. Smaller universities like LeTourneau University play a critical role in this process by offering personalized education, workforce development, and community engagement. LeTourneau University emphasizes hands-on learning, small class sizes, and accessible faculty, which nurtures each student's potential and prepares them to meet the evolving demands of the semiconductor sector. The Office of Industry Engagement at LeTourneau University supports departments and faculty by acting as a liaison between the city, regional economic development corporations, various companies and industries, and academia. In this way, faculty and staff can focus on education and implementation while the Office of Industry Engagement ensures alignment with city and economic development goals, develops the relationship with key industries, and creates the infrastructure necessary for formal partnerships to be sustained and flourish. Through collaboration with industry leaders, LeTourneau University ensures that its curriculum reflects real-world challenges, equipping graduates with both technical expertise and practical experience. It is crucial for LeTourneau University to understand the economic development plan for the city and region in which it is located. Understanding this plan allows LeTourneau University to align its industry relationships with the broader strategic regional goals. This builds mutual support between LeTourneau University, the industry partners, the city, and the region. This support may lead to LeTourneau University receiving additional economic development funding to help foster the necessary reciprocal relationships. Additionally, LeTourneau University's Office of Industry Engagement acts as a community anchor by building partnerships with semiconductor companies, attracting semiconductor related companies to the region, hosting workshops, and supporting STEM initiatives that contribute to regional economic and technological growth. These efforts demonstrate how smaller institutions can create a collaborative and impactful model that not only benefits students but also supports the future of the semiconductor industry and regional development.

Conclusion

Addressing the challenges of hiring and retaining engineering talent requires innovative approaches that bridge the gap between education and industry. Small universities, such as LeTourneau University, play a critical role in aligning education with industry needs through practical, hands-on learning and industry-relevant curriculum development. By fostering meaningful university-industry partnerships, these institutions not only prepare students for real-world roles but also contribute to strengthening local economies and workforce development. Looking ahead, sustainable partnerships can be achieved by expanding collaborative networks, including inviting instructors from other universities to create a more diverse teaching pool and bring fresh perspectives to the classroom. Additionally, connecting with a broader range of

industries will foster greater collaboration, enabling the development of tailored programs that meet evolving industry demands. As part of this ongoing effort, our vision is to cultivate a collaborative ecosystem among educators, schools, and industries to drive workforce development and strengthen regional initiatives. By building strong networks among educators, we create seamless learning pathways that prepare students for high-demand fields like the semiconductor industry. Strengthening school-industry partnerships ensures students gain hands-on experience, mentorship, and job opportunities that bridge the gap between education and the workforce. Regional collaboration with community leaders and economic organizations aligns education with industry needs, driving sustainable growth. Beyond technical skills, we emphasize holistic development through leadership training, ethical grounding, and exposure to arts and culture, ensuring our graduates are well-rounded innovators and leaders. As a work in progress, the authors will continue efforts to conduct an effective assessment of student outcomes, incorporating more quantitative data, such as the number of students participating in field trips, coursework, and senior design projects. Additionally, interviews with former students regarding their internships and involvement will be included. A change model applicable to LeTourneau University's business model will also be introduced and implemented.

Invitation for Future Collaboration

The authors propose three key aspects for companies and educational institutions to consider when developing a new semiconductor program. Building stronger collaboration requires not only the dedication of individual faculty members but also support at the departmental and institutional levels. Collective curriculum development helps reduce the burden on individual faculty members within each institution and benefits from industry support, such as the provision of equipment and the integration of industrial needs directly into coursework, to better prepare students for careers in semiconductors. Holistic regional efforts are also essential, as the growth of the semiconductor industry cannot rely on a single major player. Instead, a collaborative infrastructure with specialization is necessary to strengthen the roles of unique companies, institutions, and organizations. The authors are eager to collaborate and welcome opportunities to initiate or participate in proposals with other stakeholders.

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