Reimagining Engineering Education and its integration with Research and Innovation - IDEELab

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With MS and PhD degrees earned from the prestigious Paris Tech (Ecole des Mines de Paris), Dr. El Kadiri has more than 25 years of experience in research in the field of Materials Science and Engineering with a focus on both Physical and Mechanical Metallurgy of materials microstructures behavior and formation. He authored and co-authored over 130 papers in high-impact journals, 3 patents, and 1 startup companies since 2004, which are recognized in the scientific community by an h-index of 45 with over 6636 citations. Dr. El Kadiri has led several teams in the area of multiscale modeling applied to several contemporary industrial and scientific challenges. He has been sponsored by various agencies such as NSF, DoD, and DoE, as well as multiple industries, with over $20MM in funded research and development projects. Projects included efforts to capture within a crystal plasticity framework plasticity phenomena related to deformation twinning in hexagonal metals, molecular dynamics, designing 3rd generation steels involving martensitic transformation, and high-temperature oxidation. He has a passion to identify mechanisms governing metallurgical evolving system through a fundamental understanding supported by combined characterization and modeling at the small scale and the mesoscale. He is now the Director of the Michael W. hall School of Mechanical Engineering, and PACCAR Endowed Chair Professor with a vision to partner with industries to improve the undergraduate curriculum and train students on how to create and produce market-viable technologies. As department head, he has contributed to raise more than $40MM in gifts and awards. He has a passion to formulate a long-term vision in research and service to the student, the broader communities, and the economy.

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David M. Ford is Dean of the Bagley College of Engineering at Mississippi State University. He earned a B.S. degree from the University at Buffalo and M.S.E. and Ph.D. degrees from the University of Pennsylvania, all in chemical engineering. Dr. Ford spent a year as a postdoctoral researcher at Sandia National Laboratories before starting as a faculty member in the Department of Chemical Engineering at Texas A&M University in 1997, where he received the Department of Energy Defense Programs Early Career Scientist and Engineer Award and the Presidential Early Career Award for Scientists and Engineers (PECASE). He subsequently held various professorial and administrative positions at UMass Amherst and the University of Arkansas Fayetteville, and he served as Dean of the College of Science and Engineering at Central Michigan University from 2021-25. Dr. Ford's main research areas are statistical thermodynamics, simulations of molecular and colloidal systems, and membrane-based separations. He has also led federally funded programs to increase transfer students' graduation rates and re-envision engineering curricula, and he co-founded the InSCiTE program at Central Michigan University.

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ABSTRACT

In the twenty-first century, humanity has reached a level of technological appreciation in which even marginal improvements command extraordinary economic value. Consumers willingly pay a premium for incremental gains in speed, convenience, connectivity, or performance. As a result, economic impact scales with technological advancement, so that even a modest early lead can translate into dominance across entire industries, leaving other nations economically locked out through irreversible losses of talent, investment, and supply chains. In these winner-takes-all markets, America faces an unprecedented global rivalry that threatens its long-held preeminence as the vanguard of technology.

At the heart of this struggle lies engineering education. The next generation of technological creators must be cultivated not as passive learners of closed-ended methods, but as active inventors capable of transforming open-ended problems into tangible solutions. Preparing students to innovate, think critically, build creatively, and collaborate across disciplines has become a national imperative. Yet while technology is conceived, matured, and deployed in industry, industry contributes on average only about six percent to university research and development, leaving academic programs structurally detached from the primary environment of innovation. As a result, students graduate with strong theoretical foundations but limited readiness to participate effectively in modern innovation cycles.

This paper introduces a model implemented within the Innovation Design and Engineering Education Laboratory, IDEELab, to bridge this divide by embedding industry physically within the educational ecosystem. Industry partners conduct high-value technology innovation projects alongside faculty, undergraduate, and graduate students inside IDEELab. In this co-productive environment, industry derives substantial value by collaborating with a new breed of faculty and students to develop novel technologies and engineering solutions on university premises. From these active innovation efforts, rigorous real-world class projects are derived and integrated across the undergraduate curriculum. In this structure, industry innovation generates curriculum content, ensuring that classroom learning is continuously driven by authentic development. Such engagement accelerates students' transition into the professional world and reestablishes universities as engines of technological renewal, vital to restoring the United States' leadership in the global innovation landscape.

For this model to succeed, we fundamentally reengineered university processes, policies, and incentives. The existing system, rooted in federally driven R&D priorities, proved incompatible with sustained industry collaboration. As we transition to a paradigm in which the student is the customer of the university and industry is the customer of the student, new incentive frameworks emerged: Faculty of Innovation and Graduate Innovation Assistants. Their success is measured not only by publications, but by intellectual property creation, engineering impact, and industry partnership outcomes, aligning academic purpose with the nation's innovation imperative.

1. INTRODUCTION

In the twenty-first century, technological leadership increasingly determines national economic strength, geopolitical influence, and societal well-being. In many technology-intensive sectors, early advantages compound rapidly, producing winner-takes-all dynamics that leave lagging nations excluded from critical supply chains, talent pools, and markets. Concerns regarding the ability of the United States to sustain leadership in technology creation over the past two decades have intensified, particularly in advanced manufacturing and engineering-intensive industries (Tassey, 2014; Pisano and Shih, 2012; Mazzucato, 2018). Historically, U.S. universities played a central role in national technological advancement. Following World War II, federal policy emphasized scientific discovery as the primary driver of innovation, a model formalized in Science, the Endless Frontier (Bush, 1945). While this approach generated extraordinary scientific progress, research-intensive universities increasingly emphasized scientific knowledge production, often at the expense of sustained engagement with engineering practice. Because technology innovation occurs predominantly in industrial environments, universities that seek to teach engineering practice must partner deeply with industry. Although research collaboration provides a natural mechanism for such engagement, prevailing science-oriented research paradigms remain poorly aligned with the deliverables, timelines, and experimental realities of practicing engineering. As a result, engineering programs excel at developing analytical proficiency but are less effective at preparing students to define and solve open-ended, real-world problems, a gap consistently documented in prior studies (Jonassen et al., 2006; Hatano and Inagaki, 1986; Litzinger et al., 2011) and reflected in industry evidence showing that newly hired engineers often require extended onboarding before contributing productively (Sheppard et al., 2009; Passow and Passow, 2017). Industry behavior reflects this structural misalignment. Despite being the primary employer of engineering graduates, industry contributes only a small fraction of university research and development funding (6%). Studies of university–industry collaboration suggest this pattern is driven not by lack of interest, but by incompatibilities between academic incentive systems and industrial needs for deliverables, timelines, and applied experimentation (Perkmann et al., 2013; Ankrah and Omar, 2015). Consequently, industry increasingly directs development work to third-party organizations rather than universities.

Drawing on the concept of visionary organizations articulated by Collins and Porras (1994), this paper argues that engineering education within research-intensive universities has gradually drifted from its core purpose. Research expectations originally intended to strengthen engineering practice have become dominated by science-driven paradigms weakly coupled to industrial technology development. Over time, faculty evaluation systems, research priorities, and curricula increasingly favored basic research and publication output, often at the expense of sustained engagement with engineering practice (Stokes, 1997). As Collins later emphasized, organizations that fail to distinguish what must change from what must never change risk long-term decline (Collins, 2001). For engineering education, the erosion of engineering practice within the university represents precisely such a risk.

This paper advances the argument that restoring engineering practice within universities requires a fundamental reconfiguration of faculty roles, research engagement, infrastructure, and industry partnerships. It proposes a new model that treats students as customers, recognizes industry as the customer of the customer, and systematically integrates real-world engineering practice into undergraduate and graduate education. The paper further presents an implementation framework designed to enable continuous curriculum renewal, faculty development, and sustained industry engagement without reliance on external accreditation mandates.

2. PROBLEM STATEMENT

Understanding why these challenges persist requires examining how engineering colleges function as systems. Following Collins and Porras, institutions can be understood through four foundational pillars: customers, products (or deliverables), processes, and people. Figure 1 illustrates these pillars as applied to engineering education. In this framework, students are the primary customers of engineering colleges. The degree constitutes the product, representing both knowledge acquisition and readiness to practice engineering. Processes include curriculum design, teaching, laboratories, governance, research, and as it should, every single process in the university. Faculty constitute the people who design and execute these processes.

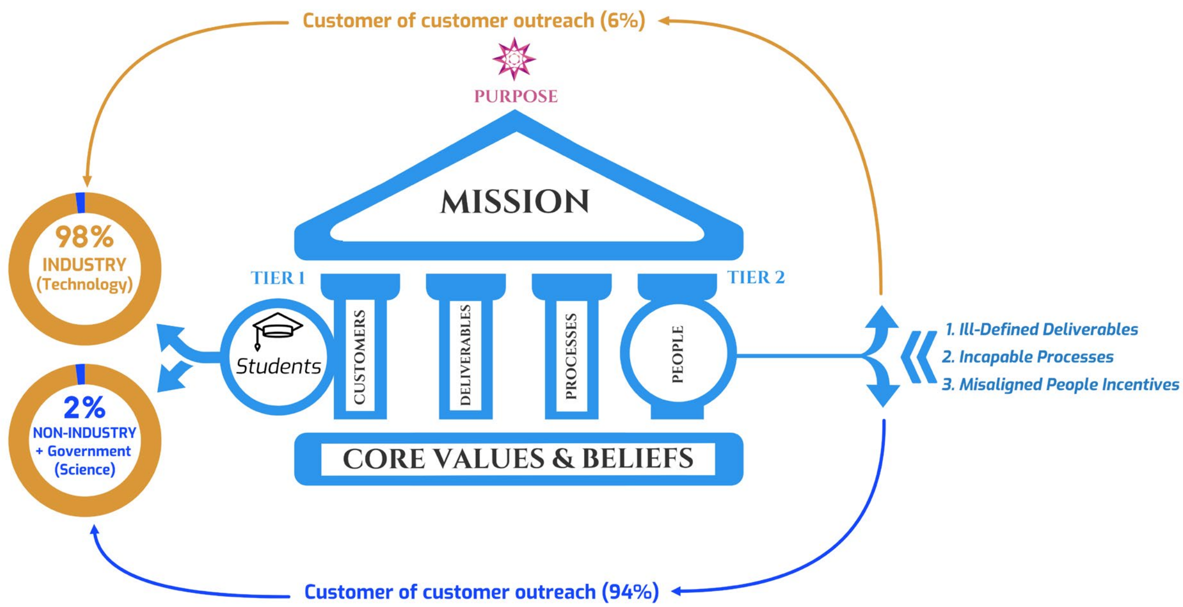

Figure 1. The four foundational pillars of an engineering education institution: customers, deliverables, processes, and people. Importantly, students should be viewed as customers and industries as the main customer of the customer placing universities as Tier 2 institutions.

A defining diagnostic question for any Tier-2 organization is whether its customer has a customer. In the context of research-intensive engineering universities, the answer is unequivocal: the customer of the student is industry. Most engineering students pursue their degrees to enter professional practice, and nationally the majority of graduates ultimately work in industry. In principle, research and development should serve as the mechanism through which faculty remain connected to industrial practice and translate that knowledge into education. In practice, however, funding patterns reveal a persistent disconnect. According to NSF data, only about 6% of university R&D funding originates from industry, despite industry employing most engineering graduates. This imbalance produces predictable consequences across the core functions of engineering education. Educational products increasingly emphasize theoretical mastery rather than readiness to practice. Academic processes prioritize publications and grant acquisition over deliverables, timelines, and system integration. Faculty incentive structures reward scientific output while undervaluing engineering development and sustained industry engagement. Industry behavior reflects this misalignment. Less than one percent of industry R&D spending flows to universities, while substantially larger investments are directed to third-party organizations better equipped to deliver results on industrial timelines. In direct discussions, industry representatives frequently cite limited faculty familiarity with deliverables, lead times, and applied experimentation as barriers to collaboration. Collectively, these dynamics manifest as four structural gaps. First, the educational product becomes ill defined, as degrees increasingly certify analytical proficiency rather than the ability to translate ideas into working systems under real-world constraints. Second, academic processes become poorly suited to producing practice-ready graduates, with teaching and laboratories emphasizing closed-ended problem solving over open-ended design, integration, and iteration. Third, faculty incentives become misaligned, discouraging high technology- and manufacturing-readiness work despite its importance to workforce preparation. Fourth, leadership pathways increasingly favor academic and political credentials over deep industry experience, further distancing institutional decision-making from the realities of technology development.

3. PROPOSED SOLUTIONS

To address the four structural gaps identified above, this paper proposes an integrated set of solutions that collectively realign faculty incentives, student pathways, infrastructure, and industry engagement around the practice of technology innovation.

3.1 Faculty of Innovation: A New Tenure Track Rank

The first and most critical intervention is the creation of a new tenure-track faculty rank, referred to here as Faculty of Innovation. This role is designed to reward and hold faculty accountable for sustained industry engagement and technology development outcomes. Evaluation criteria emphasize extramural funding from industry, translation of ideas into commercial technologies, creation of intellectual property, and documented contributions to solving pressing engineering problems, including outcomes that may not result in patentable inventions. As emphasized by industry partners, faculty compensation structures must be modernized to reflect the economic value of technology innovation in today's capital-driven economy. To prevent the loss of highly capable faculty to industry or faculty-founded startups, the Faculty of Innovation role must include eligibility for supplemental compensation tied to innovation outcomes, such as royalties from licensed intellectual property, revenue sharing through technology transfer, and structured equity participation in startup ventures to which faculty contribute intellectually. To preserve academic focus and avoid conflicts associated with direct business management, startup companies originating from university innovation activities should be operationally led by Graduate Innovation Assistants following graduation (cf. Section 3.2). These individuals possess both the technical depth and time commitment required to advance early-stage technologies toward commercial viability, while Faculty of Innovation remain focused on technology creation and mentorship as non-managing stakeholders.

In the instructional domain, Faculty of Innovation contribute directly to curriculum enhancement by generating real-world engineering projects derived from ongoing development work conducted in dedicated, on-campus, industry-sponsored laboratories. These projects expose students to authentic engineering constraints, deliverables, and timelines, ensuring that teaching remains closely aligned with contemporary engineering practice.

3.2. Graduate Innovation assistant Student Incentive Alignment

On the student side, the model introduces a new graduate role, the **Graduate Innovation Assistant**, whose incentives are explicitly aligned with those of the Faculty of Innovation. Graduate Innovation Assistants participate directly in industry sponsored development projects, contribute to technology translation activities, and are evaluated on outcomes relevant to innovation rather than solely on publications.

3.3. Innovation Infrastructure

Effective implementation of this model is enabled through the establishment of the Innovation Design and Engineering Education Laboratory (IDEELab), a purpose-built infrastructure that mirrors the operational environment of modern industry innovation laboratories, but adds an integrated workforce development component. IDEELab is organized around two complementary and integrated spaces. The first is a shared Advanced Maker Space, equipped with manufacturing, rapid prototyping, testing, control algorithm development, system integration capabilities, etc. This space is jointly defined by multiple industry partners and supports efficient resource utilization, cross-sector collaboration, and hands-on experiential learning across the curriculum.

The second space consists of a collection of individual, physically separated industry-sponsored laboratories housed within IDEELab and governed by confidentiality agreements. These laboratories enable faculty and students to work on sponsor-specific technology development challenges while protecting proprietary information and respecting industrial constraints. Together, the Advanced Maker Space and the industry-sponsored laboratories enable rapid iteration, support high technology readiness and manufacturing readiness activities, and provide sustained exposure to real-world development constraints for both students and faculty.

3.4. Embedded Industry Partnerships and Co-Production

Industry partnerships are redefined under this model to emphasize physical presence and sustained engagement, where industry representatives are consistently present within the on-campus laboratories they sponsor. This arrangement allows industry to influence project definition and execution while benefiting from the creative, high technology readiness environment cultivated within the IDEELab.

Real world projects are systematically generated by Faculty of Innovation, Graduate Innovation Assistants, and Professors of Practice from active development efforts. These projects form the backbone of experiential learning across all the lecture-based courses, laboratories, and design courses, ensuring that students encounter authentic engineering practice throughout their education. The projects created are reviewed by the ABET committee to ensure proper implementation. This is what constitutes the Development & Education (D&E) model.

In this framework, real world project creation constitutes the primary product for the university, but a co-product for industry. Conversely, advanced technology development becomes the primary product for industry, but a co-product for the university.

3.5. Early Talent Development and the Innovation Student Pipeline

Finally, several industry interlocutors emphasized the importance of early identification and preparation of high performing students capable of working with industries and faculty of innovation to undertake technology innovation projects. To address this need, the model includes the formation of a selective, summit style student organization (called Advanced Manufacturing Society) focused on developing project management, design, and hands on manufacturing skills during the sophomore and junior years. Top performing students from this group are invited to participate directly in industry laboratories alongside Faculty of Innovation and Graduate Innovation Assistants during their senior year. These students may then elect to pursue graduate innovation program through the GIA PhD novel program model, creating a continuous and intentional pipeline of innovation focused talent.

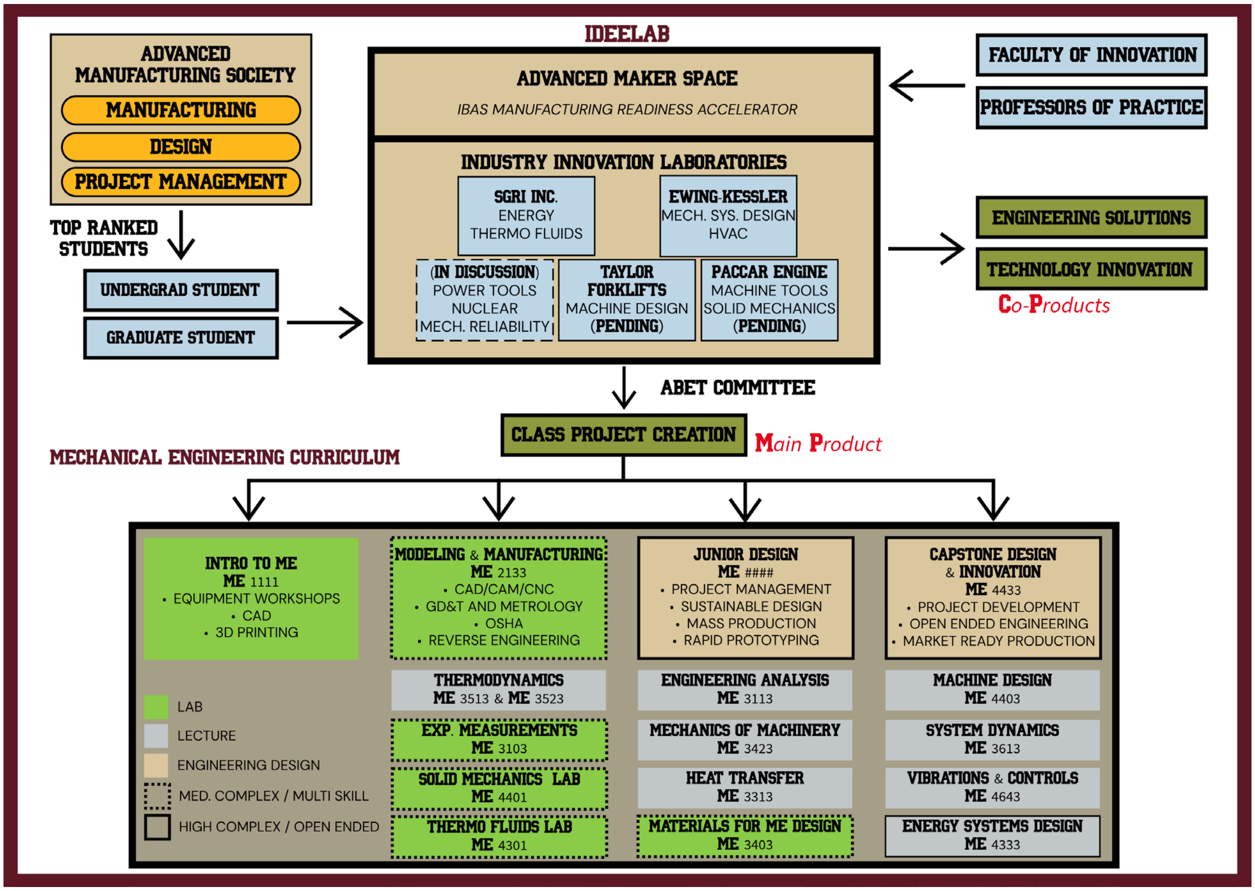

Figure 2: IDEELab integrated innovation and workforce development pipeline.

Figure 2 illustrates the Innovation Design and Engineering Education Laboratory (IDEELab) framework, which integrates faculty roles, student pathways, infrastructure, and industry engagement into a unified innovation pipeline. Within IDEELab, Faculty of Innovation lead industry sponsored technology development activities conducted across industry sponsored laboratories while making use of the Advanced Maker Space for rapid prototyping. Graduate Innovation Assistants participate in these efforts as part of a redefined graduate training model explicitly aligned with technology translation and development outcomes. Undergraduate students engage through real world engineering projects derived directly from ongoing IDEELab development activities, supported by Faculty of Innovation, Graduate Innovation Assistants, and Professors of Practice. A selective early engagement pathway identifies high performing undergraduate students who receive advanced preparation in project management, design, and hands-on manufacturing, forming a continuous pipeline into graduate innovation roles. Embedded industry representatives participate directly within IDEELab laboratories in project definition, execution, and mentoring, ensuring alignment with real world constraints, deliverables, and technology readiness requirements. Together, these elements create a closed loop system in which real world project creation serves as an important educational tool of the university, while technology development constitutes the primary outcome for industry.

4. RESULTS & PROGRESS

This section presents a summary of implementation outcomes associated with the Development and Education (D&E) model within the Michael W. Hall School of Mechanical Engineering at

Mississippi State University. Results are organized around physical implementation, faculty structure, industry engagement mechanisms, curriculum realignment, student workforce development, and measurable program impact.

4.1 IDEELab Renovation and Physical Implementation in the Patterson Building

Implementation of the D&E model required substantial physical renovation of space within the Patterson Building, converting traditional academic laboratories into industry-grade development environments. Motivated by our vision, industry contributions to renovation and equipment purchase through philanthropy exceeded $10M.

Renovation activities included electrical and power upgrades, compressed air and utility distribution, safety systems, floor reconfiguration for industrial equipment, and creation of secure zones to support industry-sponsored laboratories operating under confidentiality agreements. Each renovation phase was directly tied to an industry endowment and aligned with specific instructional and technology development capabilities. These renovations represent tangible evidence that the IDEELab model progressed from concept to fully operational infrastructure supporting instruction, sponsored development, and workforce training to achieve the IDEELab model presented in Figure 2.

4.2 Faculty of Innovation and Graduate innovation Assistant

A central pillar of the D&E model is the creation of a new tenure-track faculty role, referred to as Faculty of Innovation (FOI), within the Michael W. Hall School of Mechanical Engineering. At the time of writing this paper, the School is in final preparation stages to engage in discussions with the Faculty Senate to fully formalize and implement this new tenure-track rank.

Because this model represents a fundamental departure from traditional academic roles, several challenges are being addressed as part of the implementation process. One key challenge is the identification of appropriate external reviewers for tenure and promotion. After a five-year probationary period, FOI candidates will require evaluators who are themselves successful technology innovators with significant post-tenure professional experience. Given the novelty of this model, the national pool of such individuals remains limited, as few professionals have yet advanced through comparable academic innovation-focused career pathways. Developing clear criteria for reviewer selection and building this reviewer ecosystem is therefore an ongoing effort. Compensation represents a second major challenge. Faculty of Innovation are expected to hold terminal degrees, possess substantial industry experience, demonstrate the ability to translate ideas into economically viable technologies, and maintain a record of intellectual property generation and technical documentation. These qualifications command salaries that often exceed traditional academic norms. As a result, faculty compensation structures, including base salary and supplemental income mechanisms, are currently under intensive discussion at the Dean level. Parallel conversations are planned with state governing bodies to explore adjustments to state-supported engineering funds to better reflect the market realities associated with recruiting and retaining FoIs within the university.

As an interim and enabling measure, the School modified its Promotion and Tenure (P&T) policy in 2021 to ***redefine research as one or a combination of scholarly work or innovation work toward economically viable products***. This broadened definition provided a policy foundation for recruiting faculty aligned with the FOI vision prior to formal creation of the new rank. Under this revised policy, the Department hired Dr. Gang Li in 2023 as a faculty member whose profile closely aligns with the Faculty of Innovation model. Since joining Mississippi State University, Dr. Li has demonstrated the intended outcomes of this approach, securing three U.S. patents (US Patent Nos. US12,287,028 B2; US11,859,716 B2; and US11,686,388 B2), and multiple awards from NSF TIP program and Department of Energy. Building on this trajectory, Dr. Li is serving as the primary faculty lead working with Taylor Machine Works in the upcoming industry-sponsored technology laboratories within IDEELab. His case provides early evidence that redefining faculty incentives and evaluation criteria can successfully attract and retain individuals capable of advancing both engineering practice and student workforce development. To support the Faculty of Innovation role and ensure continuity of technology development activities, the D&E model introduced the concept of Graduate Innovation Assistants (GIAs). GIAs are graduate students whose training, funding, and evaluation are explicitly aligned with the objectives of the Faculty of Innovation. Unlike traditional graduate research assistants, GIAs focus on advancing industry-sponsored technologies, documenting engineering solutions, mentoring undergraduate teams, and supporting the translation of ideas toward higher technology readiness levels. GIAs play a dual role. Academically, they fulfill degree requirements through sustained engagement in IDEELab development activities. Operationally, they function as technical leads within industry-sponsored laboratories, providing continuity across semesters and serving as the primary interface between Faculty of Innovation, undergraduate students, and industry partners. This structure enables faculty to scale their impact while ensuring that students experience authentic engineering practice throughout their training. The effectiveness of the GIA model has been tested with a PhD student Trey Leonard supervised by a faculty, Dr. Whittington and the first author, undertaking a major innovation task with an industry within the IDEELab. The work led to an offshoot technology and concrete innovation and commercialization outcomes. This work resulted in 3 US Patents (US Patent App. 18/364,726, US Patent App. 18/791,898, US Patent 12,409,540), and a commercialization pathway of offshoot technology that led to the creation of a standalone company, Standard Mechanics LLC, which has reached approximately $1 million in revenue to date.

4.3 Master Industry Agreement (MIA) and Intellectual Property Handling

To enable scalable and repeatable industry participation, Mississippi State University implemented a Master Industry Agreement (MIA) governing all IDEELab-based collaborations. The MIA is a standardized legal and operational framework designed to remove contracting friction, clarify intellectual property ownership, and enable rapid initiation of engineering development projects involving students.

Key elements of the MIA framework include clear distinction between background and foreground intellectual property, flexible ownership models including industry-owned, student-owned, and jointly owned IP, explicit coverage of patents, copyrights, trade secrets, and proprietary know-how, and protection of sponsor confidentiality while enabling appropriate educational use. A critical educational mechanism embedded within the MIA framework is the Direct Individual Study (DIS) course model. Undergraduate and graduate students (top AMC students – cf. Section 4.6) participating in industry-sponsored development activities enroll in DIS courses formally linked to IDEELab laboratories operating under the MIA. This structure ensures that student contributions to sponsored technology development are academically supervised, credit-bearing, and fully integrated into the curriculum, while maintaining transparent intellectual property management. The DIS model also enables sustained, multi-semester participation, which is essential for addressing complex, high-TRL engineering problems. Complementing the MIA, the D&E model introduced a philanthropic engagement framework that allows industry partners to endow laboratories within IDEELab, creating sustainable infrastructure that supports engineering practice and student education beyond individual project timelines.

Shady Grove Roads Investments LLC (SGRI) was the first industry partner to adopt both the Master Industry Agreement and the philanthropic engagement model. Through this dual commitment, SGRI invested in the first technology laboratory within IDEELab, establishing proof of concept for on-campus industry-sponsored development integrated with the curriculum. This initial adoption validated the D&E model and catalyzed broader industry participation. Each endowed laboratory serves three interconnected purposes:

- Sustaining advanced infrastructure for hands-on engineering education
- Enabling industry-relevant development work that generates real-world class projects
- Supporting long-term faculty engagement and workforce preparation

Industry response has continued to expand. Several new industry partners are in advanced stages of engagement, including Taylor Machine Works, Ewing and Kessler, and PACCAR, with commitments pending formal pledge execution.

4.4 Preparing the Curriculum for Industry-Embedded Engineering Practice

Implementation of the IDEELab model required deliberate realignment of the undergraduate curriculum to support integration of real-world class projects derived from industry-sponsored technology development. Rather than treating these projects as isolated experiences, the curriculum was restructured to progressively prepare mechanical engineering students for engineering practice across the four-year program. This approach enables students to engage meaningfully with IDEELab-based development activities well before graduation and ensures that industry-derived projects are deployed coherently across multiple courses with increasing technical depth, responsibility, and realism. Three representative curricular changes are summarized below.

Figure 3: Schematic describing the addition of industry practical competencies to new educational objectives in the Modeling & Manufacturing class

Modeling and Manufacturing

The Modeling and Manufacturing course was enhanced to tightly couple analytical modeling with manufacturing execution. As documented in Figure 3, students now develop predictive models that directly inform manufacturing decisions, including process selection, tolerances, tooling strategies, and production constraints (This course is a precursor to all IDEELab hands-on activities). Expanded laboratory components require fabrication and validation of modeled designs using industry-grade equipment housed within IDEELab, reinforcing design-for-manufacturability principles. The lab was supported by an endowment from PACCAR of approximately $1M including to buying all required equipment.

Despite the increased complexity introduced through hands-on learning, student performance indicators remained high (Appendix A), comparing favorably with prior offerings that lacked experiential components. These results suggest that hands-on instruction aligns with student expectations for mechanical engineering and increases engagement and effort. Student feedback reinforces this conclusion, with strong interest expressed in expanded CNC use, CAD instruction, computer-aided manufacturing, and design for manufacturability. Additional evidence is provided in Appendix B, which documents student certifications earned following implementation of the PACCAR Lab model. As noted by Raymond Purnell, Advanced Project Manager at PACCAR Engine Company, integrating real-world problems into the classroom sparked a strong student identity around manufacturing, hands-on learning, and industry engagement.

Materials for Mechanical Engineering Design.
The Materials for Mechanical Engineering Design course was revised to emphasize materials selection under realistic industrial constraints, including manufacturability, cost, supply chain considerations, sustainability, and lifecycle impacts. Real-world components derived from IDEELab development activities are now incorporated as case studies, enabling students to evaluate material tradeoffs in multidisciplinary contexts. Consistent with observations from the Modeling and Manufacturing course, performance indicators remained high despite the increased complexity of hands-on and applied content, indicating strong student engagement and alignment with student expectations for mechanical engineering practice.
Several additional courses, including Thermodynamics I, System Dynamics, Mechanics of Machinery, and Vibration and Control, are being enhanced through the integration of hands-on laboratory components to better support real world projects originating from IDEELab.

Junior Design and Restructuring of the Design Sequence.
A new Junior Design course is being introduced to shift traditional design content earlier in the curriculum. This course emphasizes problem formulation, requirements definition, system architecture, risk assessment, and early-stage design iteration. As a result, the traditional Senior Design course is being repositioned to focus on technology maturation, commercialization, and entrepreneurship. Senior design teams now address higher technology readiness level challenges, including validation, intellectual property strategy, market assessment, and pathways to commercialization.

4.5 IDEELab as the America's Cutting Edge (ACE) Hub
As IDEELab vision gained momentum with state, federal, and industry sponsors, it was designated as the America's Cutting Edge (ACE) Hub for the State of Mississippi. ACE is a national workforce development initiative funded by the U.S. Department of Defense and administered through the Institute for Advanced Composites Manufacturing Innovation, with the mission of rebuilding U.S. machine tool and manufacturing capability through standardized, hands-on machining education.
Designation as an ACE Hub signifies that IDEELab meets national standards for infrastructure, safety, instruction, and industry alignment. ACE training is embedded directly into engineering coursework and applied to IDEELab development projects rather than delivered as stand-alone certification.

4.6 Advanced Manufacturing Society
To prepare students for working on technology innovation project with industries, it was necessary to extend IDEELab engagement beyond formal coursework to qualified students. As such, a summit club was created under the name of the Advanced Manufacturing Society (AMS). This is a student-led organization aligned with the D&E model that operates as a structured training platform with progressive skill development tied to measurable outcomes.

As described in Figure 2, AMS serves as the primary training and selection platform feeding IDEELab technology innovation labs. High-performing students, typically identified in the sophomore year, transition into industry-partnered development teams after the junior year, and should continue into graduate school as Graduate Innovation Assistants, where they lead innovation efforts and pursue commercialization of offshoot technologies. Because of the exciting experiences that these students get to have with industries, the AMS serves as an elevator inspiring all students to work hard and perform better during the undergraduate studies. We are currently assessing the impact AMS on student grades. However, as of now, an important external indicator of program impact is student performance in competitive manufacturing venues. Teams trained through IDEELab, AMS, and ACE-aligned coursework contributed to Mississippi State University winning the Manufacturing SEC Championship, reflecting sustained improvements in design execution, manufacturability, and team-based engineering practice.

4.7 Undergraduate Enrollment Growth

IDEELab implementation has driven sustained enrollment growth with a cumulative freshman enrollment exceeding 50% since 2022. This growth caused the ME school to become the largest undergraduate major at Mississippi State University by Fall 2025, marking the first time this has occurred in the institution's history. Because the majority of the enrollment increase has consistently occurred at the freshman level, undergraduate enrollment is projected to surpass 1,300 students by Fall 2027. This level of enrollment may be unusually high when considered in relation to the state's population.

5. **CONCLUSIONS**

This paper presented the conception, implementation, and early outcomes of the Innovation Design and Engineering Education Laboratory (IDEELab) model within the Michael W. Hall School of Mechanical Engineering at Mississippi State University. Developed by the first author, the model addresses a long-standing misalignment between traditional engineering education and the practice of engineering in industry, particularly in technology innovation, manufacturability, and commercialization. IDEELab reframes students as the primary customers of the university while explicitly recognizing industry as the customer of the customer. This perspective drives a realignment of faculty roles, curriculum design, and laboratory infrastructure toward engineering practice. Central to the model are the Faculty of Innovation and Graduate Innovation Assistants, which leverage existing academic mechanisms while redefining incentives to emphasize technology translation, intellectual property creation, and real-world class project development. Implementation required coordinated changes across multiple dimensions, including policy revisions, establishment of the Master Industry Agreement, deployment of a philanthropic engagement framework, integration of industry-sponsored development laboratories, and renovation of facilities within the Patterson Building. These elements enabled industry-sponsored technology development to occur on campus while being systematically integrated into undergraduate and graduate education. Curricular realignment was essential to operationalizing the model. Enhancements to Modeling and Manufacturing and other core courses prepared students progressively for engineering practice. Early outcomes demonstrate the effectiveness of the approach. IDEELab became the America's Cutting Edge Hub for the State of Mississippi, expanded industry participation with more than $30 Million financial contributions within 3 years, supported intellectual property generation and startup activity including Standard Mechanics LLC, contributed to Mississippi State University's Manufacturing SEC Championship, and coincided with sustained enrollment growth, indicating increased program relevance and student demand.

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APPENDIX A – Student Outcomes and Performance Indicators for Modeling and Manufacturing

This appendix summarizes student performance outcomes for the Modeling and Manufacturing course following the introduction of enhanced hands-on and experiential learning components. Assessment was conducted using four ABET Student Outcomes and six associated Performance Indicators (PIs)**.** For each performance indicator, achievement is defined as the percentage of students scoring above 75% on the corresponding assignments and activities.

ABET Outcome 2

An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

- **PI-1 (Fabricate)**
  Students create models and engineering drawings using relevant engineering and manufacturing technologies.
  Achievement level: ***79.1%***
- **PI-2 (Measure)**
  Students apply appropriate dimensional tolerances to CAD models and engineering drawings.
  Achievement level: ***95.6%***
- **PI-3 (Assemble)**
  Students demonstrate appropriate use of fits and tolerances in mechanical assemblies.
  Achievement level: ***93.4%***

ABET Outcome 3

An ability to communicate effectively with a range of audiences.

- **PI-4 (Professional Communication)**
  Students utilize appropriate technical vocabulary to effectively communicate with machining practitioners and manufacturing personnel.
  Achievement level: ***95.6%***

ABET Outcome 4

An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, considering global, economic, environmental, and societal impacts.

- **PI-5 (Safety)**
  Students describe and follow appropriate safety regulations and procedures in a manufacturing environment.
  Achievement level: ***93.4%***

ABET Outcome 5

An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

- **PI-6 (Fabricate and Prototype)**
  Students apply knowledge of manufacturing processes and project management to operate machinery and develop a functional prototype as part of a team-based project.
  Achievement level: ***92.3%***

APPENDIX B – Certificates Awarded by Modeling and Manufacturing

Certification	**Certificates Awarded**
SOLIDWORKS Design Associate (CSWA)	474
SOLIDWORKS Additive Manufacturing Associate (CSWA-AM)	255
SOLIDWORKS CAM Professional (CSWP-CAM)	4
SOLIDWORKS Design Professional (CSWP) Full exam	33
SOLIDWORKS Electrical Associate (CSWA-E)	2
SOLIDWORKS Sheet Metal Professional (CSWPA-SM)	1
SOLIDWORKS Simulation Associate (CSWA-S)	2
SOLIDWORKS Surfacing Professional (CSWPA-SU)	1
SOLIDWORKS Sustainability Associate (CSWA-SD)	5
America's Cutting Edge (Machining)	343
Geometrical Dimensioning and Tolerancing (SolidProfessor)	328