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Innovative Engineering Technology Program development to improve Diversity and Inclusion through Industry Partnerships in Kentucky

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Abstract

Large-scale manufacturing has been located in the state of Kentucky. Kentucky is currently home to 4,276 manufacturers employing 289,822 workers. Key manufacturing industries serve as a cornerstone of bringing broader industry investment and new jobs across Kentucky. Community and technical colleges and universities in Kentucky have faced challenges recruiting students to their programs in advanced manufacturing, tailoring to the Kentucky industry due to partially the perception of manufacturing by the younger generation. A new computer engineering technology and lean systems engineering programs have been proposed and developed at the University of Kentucky, consolidating technical and recruiting components from 2-year technical colleges and 4-year universities. Two new programs are designed based on innovative pedagogical approaches of Reimagining Engineering Technology Education, a strategic and industry-integrated multi-disciplinary training program to propel these innovative pathways that link these institutions. A new curriculum supporting disadvantaged student groups and more diverse student groups promotes the enrollment of minority group students, which is significantly higher (46 %) than other programs (17 %) in the Pigman College of Engineering at the University of Kentucky.

Keywords

Engineering Technology, Industry Partnership, Curriculum Development, Computer Engineering Technology, Lean Systems Engineering

Introduction

large-scale manufacturing in the past decades. Key manufacturing industries serve as a cornerstone of bringing broader industry investment and new jobs across Kentucky. These manufacturing sectors traditionally include automotive, aerospace, pharmaceutical and medicine, heavy metal and machinery as well as new industries such as batteries and information technology (IT) [1-2]. However, the main challenge is the deficiency in the workforce with technical expertise to fill a number of jobs available in advanced manufacturing that requires thorough technical training.

The manufacturing industry is constantly evolving and adapting to new technologies, processes, and customer demands in Kentucky and beyond. However, this also poses significant challenges for the technical training of the workforce, especially in terms of skills development, knowledge transfer, and quality assurance. Some of the main challenges in the Kentucky manufacturing industry supporting technical training are:

- The gap between the current skills of the new graduates from colleges and workers and the emerging skills required by the industry. This gap can lead to reduced productivity, increased errors and safety risks, and lower employee satisfaction and retention. To bridge this gap, the technical training needs to be aligned with the industry standards and best practices and the specific needs and goals of each organization and employee.

- The difficulty of delivering practical and engaging technical training in a remote or hybrid setting. Due to the pandemic, many manufacturing organizations have shifted to remote or hybrid work models, which can limit access to physical equipment, facilities, and instructors. To overcome this difficulty, technical training needs to leverage digital tools and platforms, such as virtual reality, augmented reality, simulation, gamification, and e-learning, that can provide realistic and interactive learning experiences for the workers.

- The complexity of measuring and evaluating the impact of technical training on the performance and outcomes of the workers and the organization. Technical training is not a one-time event but a continuous process that requires regular feedback, assessment, and improvement. To measure and evaluate the impact of technical training, the specialized training needs to define clear and relevant indicators and metrics, such as skill acquisition, knowledge retention, error reduction, quality improvement, and customer satisfaction, that can demonstrate the training's value and return on investment.

Due to these challenges, both 2-year technical colleges and 4-year universities in Kentucky have faced challenges recruiting students to their programs in advanced manufacturing, tailoring to the Kentucky industry due to partially the perception of manufacturing by the younger generation. Although there have been localized attempts to recruit students to meet the industry's needs, this has been sporadic.

New engineering technology programs in computer engineering technology and lean systems engineering have been proposed and developed at the University of Kentucky (UK), consolidating technical and recruiting components from 2-year technical colleges and 4-year universities. Through strong collaboration with advanced manufacturing industries in Kentucky, we find an inventive way to engage with industry partners to bring hands-on and experiential learning projects to students in the Fujio Cho Department of Engineering Technology at the University of Kentucky. Based on extensive hands-on training, a new curriculum is designed to solve practical problems at its center to prepare the future workforce. Most importantly, a new curriculum supports not only disadvantaged student groups but also more diverse and underrepresented student groups than other programs in the Pigman College of Engineering (UK-COE).

Demand for New Engineering Technology Programs

Advances in Industry 4.0 are merging operational, information, and communication technologies with cyber-physical systems, enabled by advanced wireless communication and the Industrial Internet of things (IoT), leading to an explosion of smart, cost-efficient, automated advanced manufacturing plants producing large volumes or highly customized products. This requires a highly skilled and knowledgeable manufacturing workforce with the agility and flexibility to adapt to these continuously changing needs of Industry 4.0 [3-5]. The 2018 Manufacturing Institute Skills Gap and Future of Work Study published by Deloitte, titled "The jobs are here, but where are the people?" [6], highlighted an expected shortage of 2.4 million skilled manufacturing workers in the next decade. Three years later, the McKinsey Global Institute's 2021 report Building a more Competitive US Manufacturing Sector [7] highlighted a new sense of urgency and new opportunities that could give the manufacturing sector and its educational partners the necessary momentum to address the need for a highly skilled technical workforce. Additionally, the COVID-19 pandemic has underscored domestic manufacturing's role in providing products critical to health, safety, national security, and the continuity of multiple industries. It also revealed the extent to which global supply chains are exposed to shocks and disruptions, all of which occurred at a moment when new technologies, process innovations, and demand growth were reshaping the manufacturing sector worldwide [6, 7].

Programs Integrated with Industry Training

Such a transformed workforce can only be developed by a comparable redesign of postsecondary engineering technology programs; the development of both students and faculty within an agile engineering technology department that is adaptive, inclusive, and innovation driven. The Pigman College of Engineering at the UK heard similar questions and projections from manufacturing partners in Kentucky and created a new department, Fujio Cho Department of Engineering Technology (ET) within Pigman College of Engineering, which launched in the fall of 2021, to help fill the skilled manufacturing gap in the Commonwealth. The ET department was developed in partnership with the Bluegrass Community and Technical College (BCTC) and offers two 2+2 programs that will not only help fill the talent gap facing advanced manufacturing industries in Kentucky but also aim to broaden the pathway and thus the representation of underrepresented groups in engineering students and the engineering workforce. The programs provide an additional and innovative STEM educational pathway for Kentucky students. After fulfilling the Associate of Applied Science in Integrated Engineering Technology (AASIET) and the Associate of Applied Science in Computer Engineering Technology (AAS-CET), students will be awarded with the Bachelor of Science in Lean Systems Engineering Technology (BS-LST) and the Bachelor of Science in Computer Engineering Technology (BS-CPT) at the UK. The ET program took an innovative approach to support a seamless transition for students by aligning the curricula between both institutions. In these 4-year pathways, students must begin their education at BCTC, earning a set of stacked credentials and an AAS degree in either IET or CET before transferring to UK to complete a BS degree in either LST or CPT. The UK-BCTC ET programs offer multiple industry-recognized certificates, consisting of a sequence of coursework that support skill attainment and employment and allow stackable credentials accumulated over time to provide career pathways for students:

Pathway 1: Integrated Engineering Technology/Lean Systems Engineering. The Associate of Applied Science in Integrated Engineering Technology (AAS-IET) is the feeder program into the Bachelor of Science in Lean Systems Engineering Technology (BS-LST) at the UK. The program prepares students for a career in advanced manufacturing by leading them through a mechatronics approach to designing, maintaining, and troubleshooting highly automated and complex manufacturing systems, including programmable logic controllers, robotics, various types of drives, sensors, photo eyes, electro-hydraulics, and electro-pneumatics. Students attain skills to improve quality output, streamline processes and reduce waste, preparing them to thrive in a highly competitive global marketplace by developing advanced skills in just-in-time manufacturing, problem-solving, project management, lean enterprise development, logistics & supply chain management, material & information flow charts, built-in quality, and productivity improvement. Students can earn Certificates in Electrical Engineering Technology and Mechanical Engineering Technology.

Pathway 2: Computer Engineering Technology. The Associate of Applied Science in Computer Engineering Technology (AAS-CET) is the feeder program into the Bachelor of Science in Computer Engineering Technology (BS-CPT) at UK. The program prepares students to pursue careers in hardware and software design and maintenance, as well as in digital systems network development and testing and basic database programming and maintenance. It provides in-depth knowledge in industry-standard approaches to application software development and state-of-the art problem-solving techniques for developing application code and firmware, including networking and web operations. They learn an architectural understanding of computer systems from low-level gate design to high-end embedded systems, including in-depth design and analysis of combinational logic, sequential logic and state machines, microcontroller systems, microprocessor systems, and state-of-the-art computer technology. Students can earn Certificates in LabView, A+ Prep, Computer Tech Basic, Informatics Programming, Net+ Prep, and Computer Maintenance Technician.

The ET at the UK and BCTC is designed based on innovative pedagogical approaches of Reimagining Engineering Technology Education (RETE), a strategic and industry-integrated multi-disciplinary training program to propel these innovative pathways that link these institutions. RETE is built through strategic collaboration and inquiry-driven learning to create an engaged and diverse community of practice among all stakeholders and sustain new ways of thinking, interacting, teaching, learning, and working. The ET department at the UK and the 2+2 arrangement with BCTC is a foundational step toward meeting the vision. Though designed around hands-on practice, the current ET curriculum utilizes traditional pedagogy, including laboratory classes, industrial projects in the capstone classes, and additional practical experience opportunities through co-ops and internships. The RETE program, though, will allow UK to take the new department further, revolutionizing the educational approach and allowing BCTC and UK to collectively create a more robust ecosystem with industry partners, including a broader introduction to professional skills and a sense of professional practices. This will give students significant industry exposure in their sophomore and junior years of training and an earlier idea of what it means to become an engineer.

A common issue in engineering technology education is that learning is not always "conditioned" to application contexts, thus resulting in "inert" knowledge that fails to retrieve in practice [20]. The separation of the theory and industry practice affects not only students' knowledge attainment but also their motivation to learn. Moreover, "school" projects are often well-defined and lack real-life complexities [21]. Students with this kind of learning experience may later join the workforce with an epistemic mentality that underestimates or overlooks complexities at work [22]. The RETE program radically shifts engineering technology education by incorporating industry experience into the classroom environment via three critical and overlapping knowledge and experience domains (Fig. 1): (1) Learning and Innovation Factory (LIF), (2) Immersive and Integrated Industry Experience (3IE); and (3) Professional Behaviors and Practices (PBP). Fig. 1 illustrates the RETE program's three critical and overlapping experience pedagogical foci: LIF, 3IE, and PBB. The approach is a significant culture change for students and faculty in fostering educational collaborations with industry.

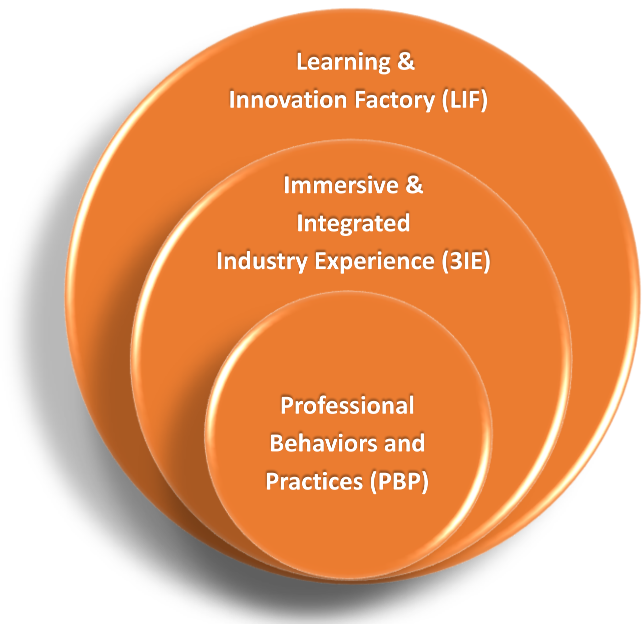

Figure 1. RETE Program: Learn it and Live it.

Enhanced Diversity and Inclusion

RETE advances professional engineering behaviors that meet employer expectations by redesigning study modules and developing industry-based projects that prepare students for careers in Industry 4.0 [23]. These RETE innovations are a shift from theory-driven lectures with end-of-year tests [23] to more practical learning where students interact and are involved in industrial projects [24].
RETE will expose students to the complexities of the manufacturing environment, the required social skills to succeed [25], and an immersive industry experience by creating a supportive and positive ecosystem [26]. Using these acquired skills in industry settings will reinforce students' understanding of computer skills, core engineering science, and knowledge and provide the practical experience to implement innovation and adaptation [27]. Studies indicate that working on an applied project encourages students to manage and finish their tasks [26], ensures the acquisition of skill sets to use in their careers [25] and provides a sense of realism that dramatically contributes to the inclusion of commonly accepted industry practices into academic courses. RETE will help industry stakeholders use student projects as a low-risk, low-cost, and quick method of testing their ideas while connecting students with potential future employees. RETE enhances students' enthusiasm, motivation, and persistence, as part of a broader engineering community, particularly for underrepresented minorities and women who are not exposed to a varied knowledge of manufacturing careers available in their communities and who may struggle to identify role models in those fields [29]. RETE also targets the recruitment of these critical groups, underrepresented minorities and women, who were disproportionately impacted by the COVID-19 pandemic [30]. The ET department's inaugural cohort, who started in the academic year 2021/22 shows the following demographic breakdown compared to the UK-COE and the UK shown in Table 1. The demographic breakdown of the first cohort (Class of 2025) of 24 students enrolled in the ET program at BCTC in the second semester of their first year is four females (17%), 19 males (79 %), and one unspecified (4%), compared to the UK College of Engineering (UK-COE) breakdown of 22 % female and 78% male students.
New learning approaches are essential to provide education and training adapted to the needs of manufacturers. This innovative redesign is best accomplished by integrating the educational and training processes as close as possible to actual industry practice to develop a more agile, adaptive, and inclusive workforce. This redesign will be achieved through iterative conceptualization, implementation, and evaluation of a systematic and sustainable academy-industry collaborative

curriculum development model. The model is conceptually built upon the social theory of learning (STL) framework [31]. STL stipulates that learning necessitates four interrelated dimensions that can be closely aligned with the needs and ideals of today's engineering technology education. RETE transformative engagement with industry partners to help develop an engineering technology curriculum designed around the STL framework of (1) meaningful, industry-oriented learning experiences, (2) progressive engagement in industry practice, (3) promoting identity building as engineering professionals (4) foster a sense of belonging in the engineering community.

Table 1: Demographic data: ET compared of UK-COE (AY2021/22)

Demography	ET		UK-COE	
	# of Students	Percent	# of Students	Percent (rounded)
Total	24		3080	
Non-white	11	46 %	535	17 %
White	13	54 %	2545	83 %
Breakdown				
American Indian	0	0 %	6	0.2 %
Black/African American	4	17 %	109	4 %
Hispanic/Latino	4	17 %	161	5 %
White	13	54 %	2545	83 %
Asian	1	4 %	170	6 %
Two or More Races	1	4 %	89	3 %
Unspecified	1	4 %	--	--
Male	19	79 %	2,402	78 %
Female	4	17 %	678	22 %
Unspecified	1	4 %		

Based on current applications and interest in the programs, the projected enrollment for the 2024/25 academic year (AY) is 75 students, with the five-year projections shown in Table 2.

Table 2: Five-Year Enrollment Projections

	AY 2024/25	AY 2024/25	AY 2025/26	AY 2027/28	AY 2028/29
Enrollment Projections	75	100	150	200	300

Conclusions and Future Work

Two new engineering technology programs in computer engineering technology and lean systems engineering are designed based on the unique pedagogical method of Reimagining Engineering Technology Education (RETE). The curriculum of these programs focuses on a strategic and industry-integrated multi-disciplinary training program to propel the innovative pathways that link these institutions. RETE is built through strategic collaboration and inquiry-driven learning to create an engaged and diverse community of practice among all stakeholders and sustain new ways of thinking, interacting, teaching, learning, and working. With the strong support and collaboration with Kentucky Industries, an innovative ET curriculum paths the way to improve the current skill gaps between the recent new college graduates and the modern skill sets required by the ever-evolving manufacturing industry in Kentucky. The preliminary data analysis suggests that the student enrollment at the Fujio Cho Department of Engineering Technology at the University of Kentucky is on the right track, benefiting the industry, technical colleges, and universities in Kentucky.

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