Lessons Learned Creating a BSET with a Regional Campus Model

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Kathryn Kelley serves as executive director of OMI; she has more than 20 years' experience in program leadership and strategic communications at industry-oriented higher education, economic development and statewide technology organizations. She collaborates with state and national partners to develop regional and national public policy to support manufacturing innovation, advocate for small- and medium-sized manufacturing needs within the supply chains and remove barriers between academia and industry.

Activities include:

- Working with Ohio Development Services Agency and Ohio MEP affiliates on a roadmapping pilot project to determine manufacturing needs and technical solutions by manufacturing processes - Serving as principal investigator on the Defense Manufacturing Assistance Program to support companies and communities affected by defense spending cuts - Helping to develop the human network for the Ohio Innovation Exchange with the Ohio Department of Higher Education on a research expertise portal project that will connect Ohio academic and technical institutions with industry partners - Producing a "Manufacturing Tomorrow" podcast series on iTunes University to highlight innovative manufacturers and the partnerships that propel their efforts (www.mfgtomorrow.org) - Collaborating with state and national partners on advanced manufacturing education pathways and manufacturing engineering technology programs - Organizing industry-focused events such as the Central Ohio Manufacturing Resource Forum - She is dedicated to researching and issuing action-provoking reports on advanced manufacturing trends, workforce development and disruptive technologies.

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Work in Progress: Lessons Learned in Creating a new BSET Program

Premise

This paper is the first of what is expected to be a multi-year analysis of a new degree proposal development process for a Bachelor of Science in Engineering Technology (BSET) program at an established higher education institution that has previously only granted Bachelor of Science in Engineering degrees. This new degree will be offered at Ohio State University's regional campuses, which have traditionally been feeder campuses. The purpose is to share the lessons learned from this program development with others in the engineering education and technology space as a joint learning exercise.

Research – Program Rationale

With the current resurgence of manufacturing, the largest economic sector in the region, today's need for technical talent has outpaced Ohio State's ability to provide enough students to meet workforce demands. Technological change, global competition, and a protracted economic downturn combined to usher in and hasten the era of shop-floor digitalization and automation of manufacturing. Combined with the Great Recession's impact on human resource planning, the growing "silver tsunami" of retiring skilled workers and the lack of a curricular emphasis on applied learning in some sectors [1] and we have now reached crisis level in much-reduced pool of ready, skilled workers available to manufacturers.

Observing the U.S. Bureau of Labor O*NET skills employment growth and replacement data through 2024 [Figure 1], we can determine how the lack of a pipeline for technologists and manufacturing managers due to recession and current educational trends that are averse to "hands-on" manufacturing have resulted in a dearth of skilled workers.

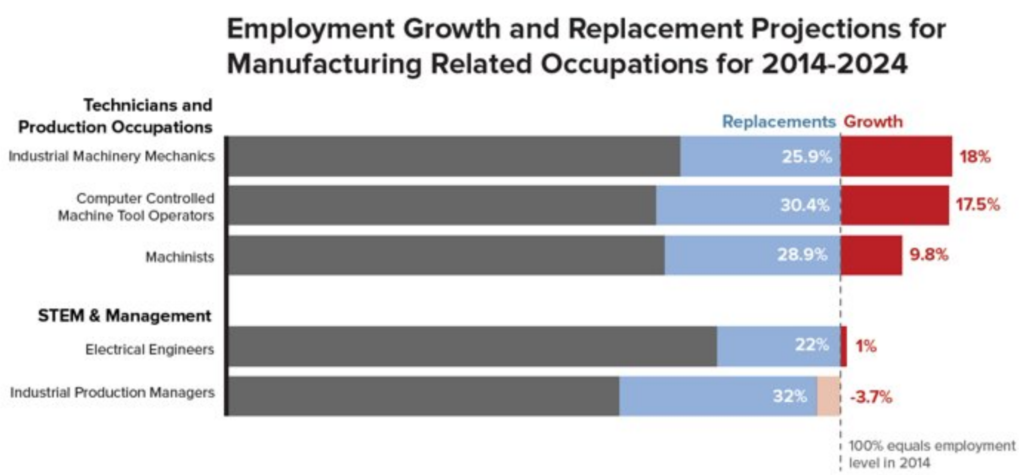

*Figure 1: US Bureau of Labor O*NET Employment Growth and Replacement Projections*

Nationwide, the Bureau of Labor projects manufacturing employment to decline by 6.7 percent in the decade from 2014 to 2024 with increasing adoption of robotics and automation. Although the number of workers engaged in many traditional production occupations, such as assemblers, machine setters, and mold makers, is projected to continue to decline over the coming decade, several other employment fields that enable and support the modern, automated manufacturing facility are expected to surge.

During 2016-2017, a series of six focus groups conducted with regional manufacturers revealed three broad, immediate, and near-term concerns in finding workers with the skills they need to operate and grow. The manufacturers identified specific technical skills that align more with the curricular focus of associate's level engineering technology degrees, including the ability to program, operate, maintain, and repair increasingly complex computerized machines and preparing food, beverage, chemical and biotechnology process-manufactured goods. Skills linked to a bachelor's degree emphasized operational and management skills, such as the ability to interpret and implement new processes that arise out of new products, understand business challenges, and basic readiness and interpersonal skills, such as communicating within a team and being prepared for workplace expectations.

In the focus groups, manufacturers reinforced the growing demand for workers in both discrete and process manufacturing. Those who can operate and program computer numerically controlled (CNC) machines are sought after, as well as industrial production managers, industrial machinery mechanics, and first-line supervisors of mechanics, installers, and repairers. And, given the strength of the polymer and chemical industries in the Midwest, focus group participants called attention to the importance of workers with process engineering skills. In general, manufacturers also revealed concerns over a broader base of engineering-related occupations and concerns over basic workforce readiness skills at a time when top-tier engineering schools have largely veered away from engineering technology or applied engineering programs.

At the same time, manufacturers demand workers who not only demonstrate prowess in technical skills but also exhibit interpersonal aptitude and other soft skills [3]. More and more, a triumvirate of skills, mobility, and leadership will be seen as critical in new hires and incumbent workers. Not surprisingly, the skills identified during the analysis of the O*NET skills database and 2016-17 employer focus groups are aligned with the data collected in previous research studies by a team led by Paul Nutter, Ph.D. that included a survey of manufacturers using SME's Four Pillars of Manufacturing Knowledge from 2012 [4]. *Curricula 2015; A Four Year Strategic Plan for Manufacturing Education*, produced by the Society of Manufacturing Engineers is an effective resource that further supports the conclusions of this study [5].

An opportunity exists for long-term strategic collaboration among manufacturing employers and educational providers to develop a broader and deeper pool of new and incumbent talent to meet rapidly changing needs. With the current resurgence of manufacturing as the state's largest economic sector, developing a program that addresses the need for applied engineering talent by manufacturers today that also adapts for the future will allow the university to educate diverse, highly qualified students to meet workforce demands. The above research outcomes formed the genesis of the engineering technology degree program.

A new Bachelor of Science in Engineering Technology (BSET) degree program, to be offered in Autumn 2020, is being developed in response to the growing needs for highly skilled college graduates who possess broad training in manufacturing engineering technology for industry leadership roles. This groundbreaking interdisciplinary, integrated program will be administered by the regional campuses, with a strong history of supporting the needs of their surrounding communities, in coordination with the university's engineering college. The program will involve collaboration with co-located community or technical colleges and area manufacturers to support students and inform faculty instruction.

In order to address the needs of area manufacturers, the BSET program will help the university meet this critical demand. As the number of students applying for admission to the main campus has increased, the competitiveness of the admission process has also grown. Limitations in classroom and instructor capacity are constraining enrollment for engineering majors. At the same time, greater numbers of academically qualified students are now being admitted to the regional campuses. The regional campuses are building a strong track record in engineering. They have hired local clinical faculty to teach first- and second-year engineering courses; during Autumn 2018, the three of the campuses enrolled 142 students in first-year engineering courses.

Curriculum Development

Based on the input from manufacturers and Labor data, a task force of industry, academic and curriculum experts, including a representative from the University Center for the Advancement of Teaching (UCAT), spent 18 months developing the BSET program goals, outcomes and the proficiencies the students would demonstrate upon completion. A "backwards design" methodology was used to align curriculum goals to the courses using a beginning level, and intermediate, and advanced level skill assessment [6]. With substantial help and guidance from a university center dedicated to curriculum design, a full analysis of the proposed BSET program's learning goals, outcomes, and proficiencies was completed and mapped to the proposed courses using UCAT's curriculum design process. A signature part of the BSET degree is the development of an integrated set of courses that combines applied physics, math and engineering which will be developed in the near future for delivery in Autumn 2020.

The proposed BSET is designed to meet the program educational outcomes for accreditation by ABET from the Engineering Technology Accreditation Commission (ETAC) of ABET. Accreditation will be assessed once students have graduated, in keeping with ABET accreditation protocol.

Under the BSET program, graduates will be expected to possess the following skills as they enter the workforce:

1. **Systems Thinking and Problem Solving:** The successful student will be able to effectively solve problems by applying the appropriate engineering technologies, tools and techniques within systems of equipment, controls and people.
2. **Professional Skills/Communication:** The successful student will be able to demonstrate, appreciate, and master interpersonal communications skills in the modern workplace.

3. **Business:** The successful student will be able to understand business terminology, analyze the value of alternatives, and communicate their business, societal and global impacts effectively.
4. **Continuous Improvement:** The successful student will be able to optimize processes and systems with respect to quality, timeliness, and continuous improvement.

Additional information about the proficiencies is available in Appendix A.

The new four-year engineering degree program combines aspects of several traditional engineering areas that are most relevant to the current and future challenges faced by manufacturing workers. Engineers working in manufacturing plants today increasingly need to possess a broad, applied skill set that includes electrical, mechanical, and industrial engineering training, because manufacturing technologies frequently combine core elements of these various disciplines in synergistic ways. Engineers in manufacturing also need management skills. The BSET program will be highly technical, giving students hands-on knowledge and expertise in multiple disciplines so that graduates will be able to support the needs of manufacturers in leadership roles. The program will prepare students to use systems-based approaches to engage effectively in problem solving within complex, fast-paced manufacturing plants. The curriculum in Table 1 was drafted from the student goals, outcomes and proficiencies that were established by the BSET task force.

	Autumn Semester		Spring Semester	
Year	Class	Hrs	Class	Hrs
1	Graphical Design	3	GE 1: Communications and Professional Skills	3
	Manufacturing Processes 1	3	Applied Technical Math 2	3
	Foundations of Engineering Technology	4	Applied Physics 2	3
	Applied Physics 1	3	Electrical Circuits 1	3
	Applied Technical Math 1	3	Electrical Applications and Design	4
2	Engineering Material Science w/ Applications	3	Statistics with Applications	3
	Computer Apps. for Eng. Tech. (CSE2112)	3	Industrial Controls and Automation (PLC1)	3
	Manufacturing Processes 2	3	Business Tools for Engineering Tech (ISE2040)	3
	Project Management for Eng. Tech (ISE3800)	3	GE3: Case Studies in Eng. Tech. / Engineering Ethics	3
	General Education 2	3	General Education 4	3
3	Data Collection and Analysis for Quality	3	Lean Six Sigma - Tools and Applications	3
	Problem Solving and Troubleshooting	3	Programming - C++	3
	Industrial Controls and Automation (PLC2)	3	Robotics - Operation and Control	3
	Mech. Processes (Hyd./Pneum./Gears/Cams)	3	Facility Layout and Work Measurement	3
	General Education 5	3	GE 6: Technical Writing 2	3
4	Capstone 1	3	Capstone 2	3
	Operations Mgmt-Reliability & Sustainability	3	Technical Elective 2	3
	Industrial Safety and Risk	3	Electrical Application in Industry	3
	Leadership and Change Mgmt. (ISE5800)	3	Manufacturing Process Design Studio	3
	General Education 7	3	General Education 8	3

Table 1: Bachelor of Science in Engineering Technology Curriculum Map

General education courses will encompass the social and behavioral sciences, history, writing, and English courses required for graduate from the university. These courses are in the process of being updated to the following fundamental subjects to include writing and information literacy, mathematics and quantitative/data analysis, literature, visual and performing arts, history, natural science, social & behavioral science, and diversity issues.

Regarding the timeline to roll out the program sequence, students admitted in Autumn 2020 will enroll in the first-year curriculum; the following year (2021-22), the first two years of the curriculum will be offered; and in 2022-23, the first three or possibly all four years of the curriculum will be offered, if warranted by enrollments.

Expected Challenges

We seek to leverage or create experiential programs that not only provide students with the skills and education they need to gain employment in industry but also to recruit and promote a diverse workforce. Already, the diversity levels of the regional campuses match or exceed those of the main campus. Below are student statistics from one of the regional campuses compared ot main campus:

- 19.5% Students of Color (18.6% main campus)
- 41% First generation (20.4% main campus)
- 47% Pell Eligible (16.7% main campus)

The proposed BSET program will facilitate the growing need for business-oriented engineering technology leaders by aligning the skills diverse student populations are learning at the regional campuses to the region's and state's industrial requirements. We are working to develop a program that provides a sense of inclusion through real-world, problem-based learning that provides a set of instructional strategies that empower learners to conduct research, integrate theory and practice, and apply knowledge [7]. This approach can be used for effective self-directed learning, goal setting, and collaboration. Through the curriculum that is developed, students heading into the workforce will learn that the strength of their collective differences creates strong teams that drive business goals.

We seek to adopt methods of grounded theory and correlational analyses to examine how components of project-based learning (PjBL) - such as small group work, hands-on activities, interdisciplinary teaching, and "real world" connections - impact students', particularly women's, interest in and attitudes about an introductory engineering curriculum. PjBL has seen positive impacts in the following:

> 1) both men and women benefit from small group work, hands-on activities, and interdisciplinary teaching;
> 2) projects with 'real world' connections enhance the effects of small group work, interdisciplinary teaching and hands-on activities with regard to student interest and participation in engineering.

The negative effect of the PjBL approach is that some women experience higher anxiety in courses that use this approach [8].

Other factors that will be considered as the BSET program takes shape are as follows:

- Research more institutions' approaches to supporting low-income and minority students. We are also beginning to partner with minority-serving institutions (MSIs) to investigate approaches to attract and retain an increasingly diverse student body.
- Reduce costs by sharing faculty via distance education modules when possible. Another major consideration is the cost and logistics of offering online and hybrid courses across all campuses. We will look to best practices around the globe to determine models that are the best fit with the goals and outcomes developed.
- Evaluate options to enroll nontraditional student populations. While technical and career centers as well as community colleges are adept at educating both high school students and incumbent workers, this will be a relatively new foray for a large research university. Internal exceptions are an existing master's program in engineering leadership and a few business and engineering courses that may be completed online.
- Develop methods to achieve consistency across multiple campuses. Even though five full-time clinical faculty are estimated for each regional campus with an annual teaching load of 21 credit hours per year, the goal of consistency in the course quality will also need to be monitored.
- Effectively use joint lab space with community colleges. Even though lab space and instruction may be shared with community colleges, these will require constant communication and collaboration in order to maintain mutually beneficial relationships.
- Determine pathways for traditional engineering students and its potential impact on main campus. Eventually, we foresee a number of main campus students deciding that this major is an attractive educational pathway. The concern that the engineering technology program may poach students from traditional engineering classes is a factor to consider.
- Evaluate capacity constraints on regional campuses. The concern is that demand will overtake the enrollment spots available for the BSET. Students will be admitted into the BSET program according to the same protocols by which students are currently admitted to other major programs that do not require a competitive application process. If student demand exceeds capacity, then initially admission will be limited by course-by-course enrollment caps on a first-come, first-served basis. If demand continues to exceed capacity, then an application process will be developed using similar criteria to those used by other competitive majors.
- Flex curriculum to meet the needs of local employers. Being mindful of the needs of specific companies while maintaining a manufacturing generalist educational program will be a balancing act that has already been negotiated among firms providing early input about the degree program.
- Determining approaches to take with companies to create a culture of flexibility so their employees can engage in the BSET coursework will require additional outreach.
- Align the program with the state's current initiatives to improve interest in manufacturing careers. A bias still exists related to manufacturing jobs and skills, including a societal stigma against working with your hands pervading the higher education system. A statewide marketing campaign that began less than two years ago is beginning to counter the stereotypes.
- Increase the relevance of research universities in manufacturing workforce development. This will allow policymakers to gain understanding of the larger spectrum of on- and off-ramps and the resulting industry-university collaborations required to build a fully skilled workforce in the US.

Expected Outcomes & Future Research

We continue to assess other university BSET programs to determine the best metrics to use in determining the success of this program. Traditional university metrics will be applied to this degree program, including: number of students enrolled, faculty hired, courses developed and graduation figures. As an example, in order to fulfill enrollment numbers to sustain the program, each campus is projecting a full-time enrollment of 42 students the first year, 63 the second year, 80 the third year and 95 the fourth year. In addition, the types of employment students pursue will also be tracked. The BSET goals, outcomes and proficiencies, developed in alignment with the ABET guidelines, will also be used to track students' mastery of the subject matter.

Additional metrics can track the applicability of the BSET program outside of the classroom and workforce development. As Paul Nutter et al states, "Academic programs can benefit by assessing their effectiveness to fulfill the needs and expectations of manufacturing industries, gaining insights for appropriate curriculum revisions to enhance the job-readiness of students to serve these 'customers' of our academic services." [4] Metrics may include:

- # of companies engaged in the program through guest lectures, co-ops and internships
- # of funding requests for researching teaching methods to improve BSET program
- # of sponsored manufacturing research projects with an application component not only in engineering technology but with the College of Engineering

As part of the metrics gathering, we intend to develop a questionnaire that addresses the above bullet points to hand out and collect during our paper session. The authors will then interview other ASEE engineering technology members to gather information for an upcoming ASEE conference panel or paper proposal; this information will also inform our degree program. In order to determine the metrics by which others are measuring their programs, we list the questionnaire and interviews focal areas below:

- Keys to students' success
- Biggest barriers for new faculty
- Response and input from manufacturers
- ABET considerations in program development
- Institutional approaches to supporting diverse students, especially women and minority students
- Distance education factors
- Programs for incumbent workers programs and the format those take (eg, certificate programs)
- Developing consistency across multiple campuses
- Working with community colleges to develop on and off ramps that make sense
- Co-op program – are they required? If not, what percentage of students are engaged?

At this stage, the tasks to be undertaken to prepare for a successful BSET program are formidable; however, the opportunities of this program to provide great educational opportunities for students and meet the needs of manufacturers in the region to positively impact its economic development are bright.

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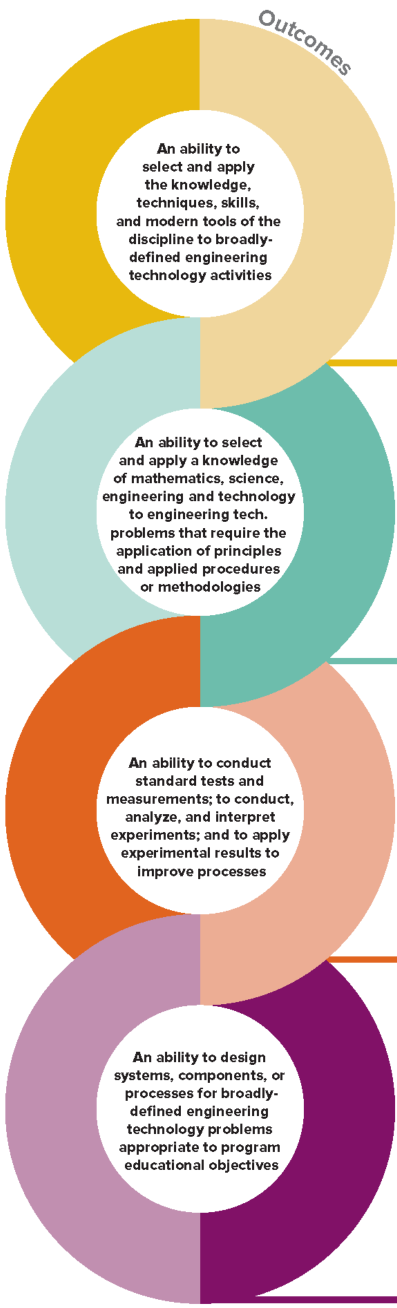
Appendix A: Student Goals, Outcomes and Proficiencies

Goal #1

Systems Thinking & Problem Solving:
The successful student will be able to effectively solve problems by applying the appropriate engineering technologies, tools and techniques within systems of equipment, controls and people.



Proficiencies

Students can:
- identify and use modern tools of engineering technology
- conceptualize the appropriate tools that can be used to solve engineering technology problems
- identify, select, apply, and properly use tools and techniques required for engineering technology problems from conceptualization to completion
- demonstrate the safety and industrial hygiene practices associated with the use of these tools and the application of their designs

Students can:
- can select the appropriate engineering & technology tools to solve a specific, given problem
- describe using proper nomenclature and application of the common tools of engineering & technology
- demonstrate the range of engineering technology tools to solve multi-faceted problems, supported by math and science principles
- understand and justify a range of problem-solving approaches and the underlying rationale for each type of problem solving approach
- evaluate and use proper scientific concepts and methods to determine what science is needed to evaluate an engineering technology application based problem
- conceptualize the types of scientific methods needed to evaluate a new problem and properly investigate it
- solve mathematical calculus-based problems required for application-based engineering tech.
- create mathematical formulations and solve them for an applied engineering tech. problem
- conceptualize the mathematical methods used to solve engineering problems, set up the approaches, and solve

Students can:
- describe and identify what standard tests or measurements they would take for a particular problem that requires analysis
- evaluate data collection plan to determine if it matches the need for and accuracy required for data
- properly execute steps required to conduct standard test / measurement with guidance / support
- conduct standard test / measurement properly without guidance / support
- interpret results of tests and provide recommendations on process improvement based on results.

Students can:
- identify the stakeholders based on a broad perspective of those who might impact or be impacted by a new or re-designed process
- solicit the needs of these stakeholders and synthesize their input into cohesive communications
- evaluate their design against the needs of their stakeholders evaluating the pros and cons
- identify possible compromises from the stakeholders and find a balanced solution that meets the organization's needs
- map out the process for achieving alignment on stakeholder needs
- implement the proposed solution or develop the proposed system or process, utilizing the proper math, science, engineering and technology.

Goal #2

Professional Skills/Communication:
A successful student will be able to demonstrate, appreciate, and master interpersonal communications skills in the modern workplace.

Outcomes

A student can conduct themselves professionally as a member or leader on a technical team, using good conflict resolution and relationship management skills

Proficiencies

Students can:
- identify and explain different styles of conflict management and schools of thought on relationship management and supervisory skills
- describe different internal and external leadership models
- determine different types of conflict, the effects of conflict and adopt practices to manage conflicts
- recognize and evaluate use of service leadership models in a given situation
- practice conflict resolution and relationship management techniques in real-life instances (through role play or internships)
- engage in service leadership model practices

An ability to apply written, oral, and graphical communication to reach both technical and non-technical audiences while identifying and using appropriate technical literature

Students can:
- discern different communication types and select message types based on the situation and mechanisms by which messages are transferred
- assess the audience(s) based on the communication type and content and craft messages based on the audience
- develop technical messaging to reach intended audiences using common mechanisms of technical writing (reports, instructions and descriptions, bids and solicitations) and oral communication (presentations)

A student can engage in self-directed continuing professional development

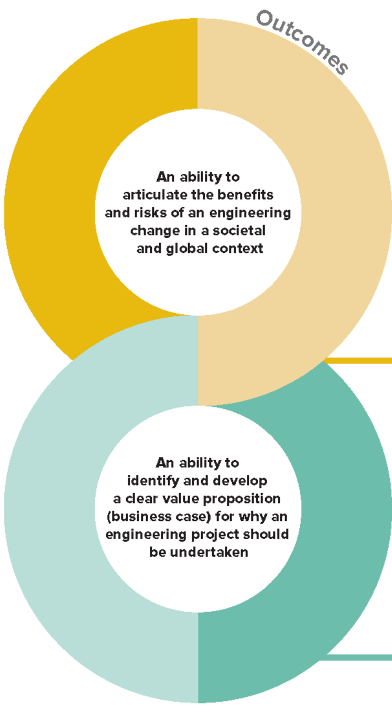
Students can:
- articulate the importance of continuing professional development (CPD) and the role of proactive self-assessment
- engage in self-assessment of professional knowledge, using objective measures and outcomes
- develop a five-year plan on status in professional development, strengths and sources for self-improvement

A commitment to address professional and ethical responsibilities including a respect for diversity

Students can:
- can determine diversity's benefits in the workplace culture and improved performance outcomes
- comprehend ethnic, gender and cultural diversity within the workplace and related laws and regulations
- recognize biases and stereotypes in the workplace
- identify basic principles of professional ethics and determine professional and ethical practices that benefit the workplace
- determine proactive approaches and potential remedies to counter unethical and unprofessional behavior in the workplace

Goal #3

Business: A successful student will be able to understand business terminology, analyze value of alternatives, and communicate the business, societal and global impacts effectively.



Proficiencies

Students can:

- describe and define the types of social and global impacts an engineering project could have
- describe connections between societal and global impacts of an engineering change on an ecosphere for a specific given problem
- craft a clear presentation for a problem solution outlining options and trade offs from a financial, societal, and global perspective

Students can:

- identify the value proposition in a business case
- communicate using appropriate business acumen
- gather data, evaluate, and describe trade-offs in recommendations for business problems
- quantify the financial value of problem solution alternatives
- present problem statements, alternatives, and recommendations in clear financial terms

Goal #4

Continuous Improvement:
The successful student will be able to optimize processes and systems with respect to quality, timeliness, and continuous improvement.

Outcomes

Proficiencies

An ability to develop / construct standard operational processes to achieve a target, which is the foundation of high quality, timely, and continuous output

Students can:
- propose appropriate targets to be achieved by a given process
- develop a high-level process to ensure an organization maintains a focus on the targets
- provide justification / rationale for including the chosen elements

Collect and understand the data associated with a standard operation

Students can:
- from the process targets identify the key data points to be monitored while the process is running

An ability to recognize deviations from standard operations

Students can:
- In a case study detail the development of a standard process including the targets to be achieved. Also include the results from the running process so the student can understand the operating data
- compare the running results to the targets
- based on the deviations in the process brainstorm the potential causes of the deviations

An ability to select and apply a knowledge of math, science, engineering, and technology to engineering tech. problems that require the application of principles and applied procedures or methodologies

Students can:
- identify and describe the purpose of lean tools
- identify a specific approach to analyzing a situation and justify their selected method for identifying the root cause of a problem
- can develop and implement the selected approach and methods
- collect relevant data and analyze results to evaluate the success of the selected approach and methods

An ability to apply a data collection method(s) that minimize human, material, and machine input while producing a complete set of data for analysis from validated source(s)

Students can:
- explain the importance and tradeoffs of evaluating data and the resultant costs
- propose modifications and improvements to the approach and methods for future application and provide a high-level decision analysis of the analysis tools that could be applied to the data set(s)