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Future of Work Issues for Florida Two Year Engineering Technology Program

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Prelude

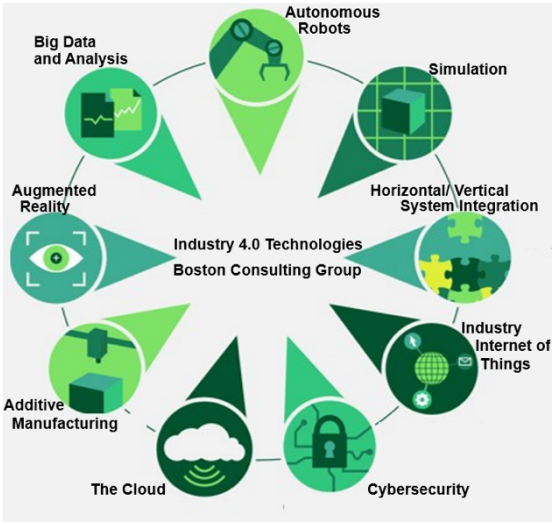
The two-year (60 semester credit hour) Engineering Technology (ET) Associate of Science (AS) degree program is available to students in 23 of the 25 Florida State Colleges that offer technician preparation degrees. As of 2020 there were over 2,000 students enrolled in this course of study. The degree has a Core set of courses completed in the first year followed by a set of specialized courses in year 2. The program has a high percentage of students working in industry during their course of study and enjoys an over 90% industry employment placement of its graduates. Graduates can also seamlessly articulate into an B.S. program offered in the Florida State College System as well as pursue a B.S. Engineering Technology degree that also leads to a Professional Engineers License. To maintain this rewarding ET career path, the Florida Advanced Technological Education Center (FLATE) with support from the Florida Department of Education, the National Science Foundation, and the National Institute of Standards and Technology, NIST, supported Manufacturing Extension Partnership (MEP) interacts directly with manufacturers, college technical faculty, and college upper administration to assure the ET degree program focus is manufacturing industry impact within each college service region.

Introduction

A recently completed National Science Advanced Technological Education support project*, (Technician Future of Work Issues Caucus for Florida Community Colleges and Manufacturers*), identified needed manufacturing education related actions in Florida. The project focused on the next 5 years and addressed two questions: (i) From industries' perspective, what new technologies really impact technicians? (ii) From the Florida Department of Education perspective, what do manufacturing programs in Florida colleges have to do to begin to address these identified Future of Work skills? The project acknowledged the operational reality that in the Florida manufacturing sector different technologies generate different impacts. The same technology may not have the equivalent impact on different company’s technician work environment.

Data required to determine the impact on technicians and the Florida Department of Education's response to Future of Work issues was acquired by creating/ conducting a Caucus that brought 130 various size Florida manufacturers across the state and all the 25 Florida State College system college technician program leaders together. This collective group, plus additional input from Florida Regional Manufacturing Associations, identified Industry 4.0 technologies that are beginning to impact Florida manufacturing productivity today. Figure 1 presents these technologies as grouped by the Boston Consulting Group.[1] The analysis of the acquired survey information lead to: (i) the identification of the most important skills and skills gaps that impact Florida's manufacturing technician performance; (ii) the determination of the two-year graduates' role in these Industry 4.0 technologies; (iii) the association of a set of thirty-seven essential manufacturing technical skills with the Florida manufacturer declared important technology categories; (iv) the categorization of these essential skills to determine sets of crosscutting skills. The overarching goal of these four analysis activity targets was to determine the instructional status of these skills.

Figure 1-Industry 4.0 Technologies

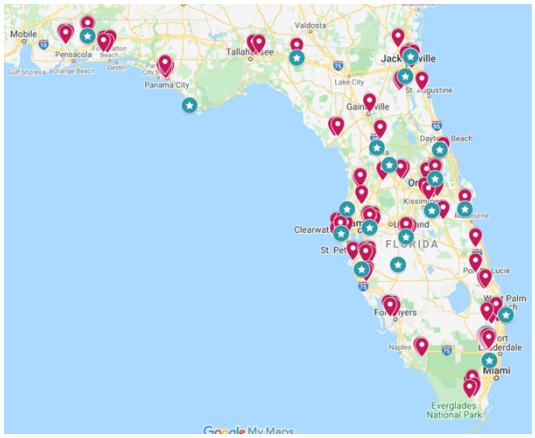


The Florida Department of Education maintains instructional Standards and Benchmarks expectations for curriculum content presented in Florida State College system two-year technical programs. It is critical to determine what, if anything, needs to be done to establish the appropriate Standards and/or Benchmarks for each crosscutting skill instructional platform. This paper and presentation will share skill gaps, the alignment of identified technician skills with the current program standards, benchmarks, and student learning outcomes.

Caucus Process

Initial information for this project's data analysis was obtained through a set of statewide caucus events that brought 130 various size Florida manufacturers and 25 community college technician program leaders together. Figure 2 illustrated the geographic distribution among caucus participants. (The figure's blue circular icons

Figure 2-Survey participation demographics



indicate the college locations while the red teardrops are the manufacturer production facility locations.) This collective group, plus additional input from Florida Regional Manufacturing Associations, identified Future of Work skills that are beginning to impact Florida manufacturing productivity today.

An open invitation for participation in this project was distributed through a variety of websites, newsletters, and blogs. In addition, the Reginal Manufacturing Associates identified possible manufacturer participants that were contacted directly. An initial survey was distributed to those expressing interest. Completion of this survey was a prerequisite for further participation in Caucus activities. After an initial review of survey responses, a Caucus event was organized. This included a set of meetings starting with survey response review followed by a discussion forum on those responses. Additional events included further analysis of the acquired information and then a review of all findings. (These Caucus events were intended to be in person encounters however, COVID restrictions dictated that they be conducted in virtual environments.)

Data Analysis

The project initially used the nine Industry 4.0 (I4.0) Technology areas identified by the Boston Consulting Group as a resource however, the survey used a subset selection of four: Autonomous Robots, Simulation, Industrial Internet of Things and Additive Manufacturing (Table 1) that directly impact starting technicians working in Florida companies that are already implementing Industry 4.0 Technologies. Technician skills are defined as those needed to set up, operate, troubleshoot, and maintain production and process equipment. Specific skills that fall in the I4.0 technologies identified as relevant for starting technicians (recent 2-year graduates) were defined to be those that will be needed in the next 3-5 years.

Table 1 indicates the Industry 4.0 technologies in blue italics with their associated Caucus focused skill groupings. The third technology in the table, Industrial Internet of Things, deals with Ethernet communications as related to machine to machine (M2M) interactions, records, and data storage. The bottom entry in Table 1 does highlight an immediate outcome of the initial survey response Caucus skills identification discussion. The manufacturers involved in the Additive Manufacturing Industry 4.0 Technology environment indicated that their activities went well beyond common tasks associated with 3D printing and they preferred to group additive and the classical subtractive operations as part of advanced materials manipulations. This paper's authors concur with that assessment and do not attempt to isolate a specific subset of technician skills that would be considered unique to additive manufacturing. The table does not priorities the skill groupings, but it does list

identified technologies, blue italics print, with their skills, black print, clockwise as relative to the technologies presented in Figure 1.

Table 1- Boston Consulting Group Identified Technologies and Caucus Identified Technician Skills Groupings.
Autonomous Robots: Programming; System Integration; Repair
Simulation: Compare Process Alternatives; Recommend new situations & identify their effects on process response to change; Participate in developing existing/new operations
Industry Internet of Things: Ethernet Communication (M2M); Record and store data
Additive/Subtractive & Advanced Materials: 3D CAD and printing/prototyping; CNC programming; Precision Manufacturing; Fabrication; Testing (destructive/non-destructive)

Results

The primary driving force for any A.S. Engineering Technology (ET) degree curriculum alterations and subsequent adjustment to the program's Standards and Benchmarks as maintained by Florida Department of Education is their direct impact on Florida manufacturers. Table 2 indicates the technician skills most wanted list from the polled manufacturers' perspective. The table indicates that "Participate in developing existing, new products and operations" is an important manufacturer identified manufacturing technician skill missing in their workforce.

Table 2- Florida Manufacturers Ranked Manufacturing Technician Related Industry 4.0 Technologies Skills	
Simulation: Participate in developing existing & new products & operations	51%
Additive/Subtractive/Advanced Materials: Fabrication	42%
Additive/Subtractive/Advanced Materials: CNC programming	39%
Simulation; Perform Root Cause Analysis	39%
Autonomous Robots; System Integration	38%

Table 3- Crosscutting Skills Found in all Categories
Critical Thinking
Diagnostics & Understanding of Full Processes
Integrating Systems
Interdisciplinary Skills
Technician Involvement with Engineering

Table 4- Project skills Lists:

1 support mockup/test	9 material knowledge	23 ensure measurement have uncertainty stated
2 provide design data	10 material testing	24 basic understanding of databases & networks
3 testing & executing	11 destructive testing	25 spreadsheet creation & manipulation
4 quality testing	12 ask 5 whys	26 CAD for layout of production processes
5 prototyping	13 fishbones	27 math, communication, teamwork, solve problem
6 critical thinking	14 brainstorming	28 human factors and interactions
7 data interpretation	15 use the Root Cause tools	29 write technical reports and data
8 3D printing	16 write SOP	30 reverse engineering
	17 cloud	31 building /assembling prototypes
	18 integrating systems, PLC	32 use technology tools to identify root causes
	19 data integrity	33 awareness of the security requirement
	20 programming	34 identify opportunities for improved products
	21 troubleshooting	35 knowledge of product standards and regulations
	22 interdisciplinary skills	36 integration of eng tech/adv mfg / computing
		37 diagnose & understanding full process

Table 3 summarizes the crosscutting skills applicable to the technologies listed in Table 2 while Table 4 is the entire list of Caucus distilled technician skills. Table 3 entries are alphabetically listed however, the 3 sections of lists in Table 4 are arranged to facilitate their visual presentation with no priority in skill listed. The skills listed reflect the spectra of expectations for technicians involved in Industry 4.0 technology integration into manufacturing processes. Those technologies are collectively resident in technology clusters defined by the Boston Consulting Group (See Figure 1.)

An important objective of the Caucus effort was to determine if the identified skills were already incorporated in the Florida Department of Education maintained A.S. ET degree Framework Standards & Benchmark structure. Each skill in Table 4 was discussed and then aligned with appropriate FDOE Framework Standards. Table 5 presents the Standards connected to the Advanced Manufacturing Specialization within the A.S.ET degree. (There are 10 more specializations within the degree structure with each having its own set of Standards & Benchmarks.) Ties to a Standard required a match with at least one Benchmark associated with that Standard. There are many Benchmarks grouped with each Standard. To acquire a sense of these Benchmarks, Table 6 lists the first Benchmark for each of the Advanced Manufacturing Standards.

Table 5- Florida Department of Education Standards that Relate to Table 4
05.0 Demonstrate proficiency in use of quality assurance methods and quality control concepts.
12.0 Understand, operate, troubleshoot & maintain pneumatic, hydraulic, electromechanical components and/or systems.
13.0 Identify lean and six sigma concepts in manufacturing environments.
14.0 Understand, operate, and maintain industrial automation systems.
15.0 Troubleshoot industrial automation systems.
16.0 Apply the principles of robotics to automated systems.

17.0 Create and operate human machine interfaces to control automated systems.

A sample of the results of this skill match up with ET degree Standards is summarized in Table 7. The table segregates the skill Standard as an ET Degree Core (first year of study) or in this case the Advanced Manufacturing Specialization (second year of study). The Brainstorming skill is connected to the degree at both Core and Advanced Manufacturing levels by single Standards while the Integrating Systems skill has no

Table 6- Benchmark Examples for ET Advanced Manufacturing Specialization
12.01 Identify, classify, and describe the function of pneumatic, hydraulic, and electrical machines and component.
13.01 Explain product manufacturing requirements.
14.01 Understand, operate, and maintain industrial automation systems.
15.01 Demonstrate troubleshooting techniques to identify root causes, errors, and faults of a problem.
16.01 Identify and describe the essentials components and characteristics of a robotic system.
17.01 Apply appropriate industry standards in the development of HMI.

Standard connection to the Core curriculum but several alignments to the Advanced Manufacturing (Adv. Manufact.) specialization. The second entry in the table indicates that the Cloud is not currently found in any part of the ET degree Framework structure.

Table 7-FDOE Framework Assignments/ ET degree		
Sample of Caucus Distilled Skills	ET Core	Adv. Manufacting
Brainstorming	*5*	*13*
Cloud	*none*	*none*
Integrating Systems (using PLCs)	*none*	*12,14,15,16,17*

An important additional discovery from this matchup process is the absence of Standard connections to Basic Understanding of Data Bases, Data Integrity, as illustrated in Table 7 for Cloud skills. Table 7 also shows that Diagnoses and Understanding of Full Processes was represented in both the Core and Adv. Manufacturing Standards. In addition, there were several skills that had indirect and/or vague connections to the Standards Framework. These included Awareness of Security Requirements, Data Interpretation, and Interdisciplinary skills. These 3 skills were thought to be more about how various topics were taught but were not included as explicit skills and might be considered to be part of troubleshooting. This last group is under consideration for how to treat them.

The absence of Standards for the four skills (Basic Understanding of Data Bases, Cloud, Data Bases, and Data Integrity) prompts the need to answer two questions; Why and what to do about it? For Cloud skills, for example, one reason why might be the focused silo style instruction of Information Technology (IT) and Operational Technology (OT) in technician preparation programs. If the faculty in these groupings do not interact, then developing Standards on skill intersections will be difficult to accomplish. However, a more fundamental reason might be that it is unclear what IT technician skills belong in an OT technician's environment.

Caucus interactions with manufacturing participants about what IT skills are needs in their operational environment produced a broad range of responses. The skill expectations for manufacturing technicians depended on their overall technical knowledge and experience with the OT processes. This status directed the project team to interact with Dayton State College to potentially develop an Advanced Technical Certificate.

The Advanced Technical Certificate (ATC) is a tool that the two-year technician preparation programs in Florida can take advantage of. This credential is directed to A.S. degree program graduates or working technicians with experience and skill sets beyond those of recent graduates. Courses within an ATC must already have approved Standards and Benchmarks as part of a Bachelor level applied degree (Bachelor of Science or Bachelor of Applied Science) Completers of the course sequence within an ATC can use those course credits for articulation into Florida State College STEM B.S. programs. An ATC that is being created to address Cloud, Database, and Data Integration skills is shown in Table 8. The sequence of courses shown is online and provide detailed study beyond introductory topics. They generate senior technical expertise that meet advanced technician and/or starting engineer positions needs.

Table 8- *draft* Advanced Technical Credential	
Applied Database I	COP 4813
Applied Database II	COP 4834
Information Technology Project Management	CIS 4510
Web Systems I	COP 4813
Web Systems II	COP 4834

Conclusion

This Caucus approach to determine skill expectations in the A.S. Engineering Technology (ET) degree program represents a good model for community college interactions with industry and is especially useful when the course of study is offered

at different colleges and or college campuses and still must satisfy industry expectations or meet system-imposed Standard, Benchmarks and learning objectives. In Florida, the project's outcomes have specific impacts statewide. From an overview perspective, project results reinforce the Department of Education Senior Chancellor Henry Mack's intent to create and maintain a Career and Technical Education (CTE) pathway that supports the nation's best workforce education system. From an "in the trenches" view, the project generated important results. The first involves the process of adjusting Benchmarks to include project detected skill discrepancies. Alterations of Florida Framework Standard and Benchmarks is done as a cooperative and semi-formal manner that involves multiple interaction among program faculty, industry representative, and Department of Education personnel. The Caucus discussions represent the required initiation stage of these sequential interactions and accelerate the inclusion of the targeted adjustments to the Frameworks. The second is the identification and increased awareness of industry recognized skill needs. The specifics related to the skills gap issues are discussed in a 2021 ASEE conference presentation.[2] A specific skills gap discussed in that paper is the first item," Participate in developing existing & new products & operations", in Table 2. For that skill 51% of the Caucus manufacturers indicated this as a needed technician skill, however, only 12% of the college Caucus participants indicated a need to teach this skill. The third is the need to identify what level of the skills in courses listed in Table 5 are critical for the manufacturing technician. The ET degree program is two-years and 60 semester hours. The skill intensity in the table's courses far exceed the program's time and credits as well as skill proficiency needed by starting technician. Thus, something must go if a new condensed Advanced Technical Credential skills course is to be added or a distilled set of Table 5 essential skills must be blended into the current ET curriculum. Finally, the project emphasizes the importance of shifting the definition and identification of technician skills needs to the industries that are the direct recipient of that technician preparation program. Using this Caucus mechanism might represent an efficient and effective way to get those manufacturers' input.