Board 313: Industry 4.0 Engineering Technology Skill Integration into Florida's Technical Workforce Environment

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A Statewide Strategy to Address Workforce Requirements

Abstract

Industry 4.0-based systems and subsystems are replacing current process and process control equipment in Florida's manufacturing environment. The Florida State College System Engineering Technology (ET) degree pathway for developing engineering technology professionals is responding to this reality at the ET two-year associate degree, the 4-year ET B.S. degree, and post-graduate degrees as well as a statewide recognized path to the Professional Engineers license in Engineering Technology.

The National Science Foundation Advanced Technological Education program (NSF-ATE) supports this effort. NSF-ATE assets provided to FLATE and five partner colleges are directed to the formation of a statewide advisory board for the 20 colleges that offer ET degrees as well as supporting six overarching Florida ET education system target goals:

(1) Adjust Florida Department of Education Standards and Benchmarks to include criteria that address Florida manufacturer-identified Industry 4.0 skills gap in its technical workforce.
(2) Create a statewide streamlined seamless articulation environment from the Engineering Technology A.S. to B.S. degree programs.
(3) Provide Professional Development that up-skills Engineering Technology Degree faculty as related to identified Industry 4.0 technician skill needs.
(4) Create a short-term ET College Credit Certificate to prepare current and future technicians to apply these new skills in the manufacturing workspace.
(5) Amplify the manufacturer's involvement with college engineering technology certificates and A.S.ET degree programs.
(6) Create Post-A.S. Curriculum Advanced Technology Certificate (ATC) to facilitate skilled technician professional advancement.

Statewide implementation of the curriculum changes is key to more robust programs and more work-ready technician graduates. This paper and presentation poster will share the strategies the project team is using to achieve its goals and objectives. It will also share the feedback received from the industry relative to industry 4.0 skills needed in their facilities.

Background

The Associate of Science Engineering Technology (ASET) degree is a well-coordinated degree program among 23 of the 28 Florida State Colleges. The degree program consists of a core of classes that meet a series of outcomes and include a specialization. These specializations are included in Table 1.

Table 1. Specializations are offered as part of the ASET degree.

Specialization	Number of Schools
Advanced Manufacturing (Mechatronics)	17
Advanced Technology	3
Alternative Energy	3
Biomedical Systems	1
Digital Design and Modeling	3
Digital Manufacturing	3
Electronics	10
Mechanical Design and Fabrication	3
Protection and Control Technology	1
Quality	2
Supply Chain Automation	2

The ASET program's core consists of classes in electrical circuits and electronics, computer-aided design and drafting, quality, manufacturing processes and materials, safety, and measurement and instrumentation. All the programs include classes in these areas to meet the outcomes that are part of the statewide curriculum framework. Table 2 contains the primary areas in the statewide framework that address the ASET core.

Table 2 - Major topic areas (standards) of the ASET Technical Core

1.0 Demonstrate knowledge of industrial processes and materials properties.
2.0. Generate and interpret computer-aided design/drafting.
3.0 Demonstrate a fundamental understanding of electronics and electricity.
4.0 Generate and interpret computer-aided design/drafting.
5.0. Demonstrate proficiency in use of quality assurance methods and quality control concepts.
6.0. Demonstrate proficiency in using tools, instruments, and testing devices.
7.0. Demonstrate basic troubleshooting skills.
8.0. Demonstrate appropriate communication skills.
9.0. Demonstrate appropriate math skills.
10.0. Demonstrate an understanding of modern business practices and strategies.
11.0. Demonstrate employability skills and identify career opportunities.

The full framework including all of the specialization outcomes is available in the appendix and also at https://www.fldoe.org/academics/career-adult-edu/career-tech-edu/curriculum-frameworks/2022-23-frameworks/manufacturing.stml

Adjusting Standards to Meet the Skills Gap

This project emerged from the results of an NSF Advanced Technological Education (ATE) conference project (DUE 1939173), which focused on identifying the emerging skills that recent ASET graduates of manufacturing and industrial technicians will need to support new Industry 4.0 technologies that are rapidly being adopted in many small and medium manufacturing facilities in Florida. Florida is home to over 25,000 manufacturing companies, with dense concentrations in the cities along the coast and the state's center. It employs over 420,000 Floridians. Most are small to medium size enterprises with limited resources.

The pandemic required the project team to get creative with the proposed data collection methods. The project's research method started with an online survey to collect specific data, two virtual caucuses for participants to contribute more details to the survey responses, and clarifications from industry and educators. This approach gave the project team time to work with the data, pose additional questions, and conduct ongoing analyses.

The project survey focused on four of the nine Industry 4.0 technologies that were identified by the team as technologies that graduates of 2-year manufacturing technician programs would encounter early in their new careers: Robotics, additive/subtractive manufacturing, systems integration, and industrial internet of things. Fifteen specific skill areas were defined for the four technologies. Survey results from 131 manufacturers and 24 educators were analyzed, compared, and prioritized for discussion at the online caucus events.

After and between the online Caucus events, the data was reviewed, compared to the Florida State Standards for this program, and analyzed. The following observations/ and recommendations were made:

1. 37 specific Industry 4.0 skill areas were defined and organized into six categories.
2. 32 of these 37 specific skills are already covered in the Florida curriculum frameworks for advanced manufacturing.
3. Four of the 37 specific skills were not included in the current statewide curriculum frameworks of the AS Engineering Technology. These four skills were related to working with data and can be summarized as a basic understanding of databases, cloud technology, data interpretation, and data integrity.
4. **Since** these four skills were aligned to the upper-level standards for the BS Engineering Technology (post-associate degree level skills), it was recommended to investigate further and possibly develop a new advanced technical certificate or new BSET specialization.
5. Five crosscutting skills (skills assigned to all six defined categories) emerged from this categorization: critical thinking, integrating systems, interdisciplinary skills, technician involvement with engineers, and diagnostics with understanding the connected processes. These skills need to be taught and practiced throughout the program where appropriate.

The ubiquitous topic of cybersecurity skills for manufacturing technicians was discussed separately. This project aims to address the identified skill gaps in the ASET or BSET as appropriate, including better defining the cross-cutting skills that are somewhat vague in the current ASET curriculum standards.

Adjusting Standards and Benchmarks

The conversion of topics and outcomes identified by industry into statewide curriculum follows a process of (1) recommendation, (2) review, (3) incorporation into the frameworks, and (4) adoption into curriculum. The CO-PI's of the grant set up regular meetings to review the industry survey results and develop recommendations for incorporating the topics into the ASET degree. The outcome of these meetings was that a basic understanding of data use and data analysis would be incorporated into the framework and ASET degree. At the same time, the more advanced topics would become part of the BSET degree.

The identified skills gaps were particularly relevant as the gap between operational technology and information technology was a major part of the reason for the skills gap. Reference on IT vs. OT Within the ASET degree, the focus would be on (1) what types of data are collected, (1) methods of collection of data, (3) getting data into a format to be analyzed, and (4) basic analysis of this data. In a practical sense, this meant getting the data into a spreadsheet and doing a fundamental analysis of this data consisting of plots and simple statistics (averages and trends). The first step in incorporating these into the statewide curriculum is developing new or modifying existing outcomes within the curriculum framework.

Below are the suggested additions to the curriculum framework for the core of the ASET degree. These additions are currently being reviewed for inclusion in the framework. The additional outcomes are in three of the benchmark areas: 5.0 Demonstrate proficiency in the use of quality assurance methods and quality control concepts, 7.0 Demonstrate basic troubleshooting skills, and 11.0 Demonstrate employability skills and identify career opportunities. The full set of outcomes for each benchmark is included, with the new outcomes indicated.

05.01 Apply quality methods to industrial processes.
05.02 Apply quality principles to manufactured products.
05.03 Document quality measurements and observations.
NEW 05.04 Collect data from processes for analysis.
NEW 05.05 Create plots of data given dependent and independent data values.

07.01 Apply critical thinking skills to identify problems.
07.02 Identify symptoms and changes in a system.
07.03 Apply root cause analysis techniques to identify problem causes.
07.04 Evaluate corrective action options.
07.05 Properly document all corrective actions.
NEW 07.06 Identify and troubleshoot problems using collected process data.

11.01 Describe the appropriate steps to acquire employment.
11.02 Respond appropriately to professional criticism.

11.03 Identify and practice professional work habits.
NEW 11.04 Explain the importance of security and cybersecurity in the workplace.

Professional Development Activities

As part of this grant, professional development is being offered to support preparing faculty teaching in the ASET programs at the participating State Colleges to facilitate the upcoming changes in standards and benchmarks. Faculty from every participating college have been able to participate in professional development. The professional development workshops offered are based on the identified unfamiliar emerging topics. These have included (1) a 3-day cybersecurity workshop in mechatronics at the College of Central Florida and (2) a 4-part series of lectures/webinars on cybersecurity in manufacturing that is now available on YouTube. An intensive 36-hour Programmable Logic Controller (PLC) faculty training was also offered with two 2-day in-person sessions (August and December 2023) with two 2-hour virtual sessions in between to better secure the PLC programming skills of ET college faculty. Engineering Technology and manufacturing high school teachers were also provided 2 1-day workshops for Mechatronics in which they built and wired an electronics trainer that they were allowed to take back to their institutions and use with their students.

Figure 1. High School Mechatronics Workshop at St. Petersburg College

Engineering Technology Advanced Automation Specialization

Under development is a new Engineering Technology Specialization with a working title, Advanced Automation. As part of the ASET degree, it includes the core of the ASET program standards (1-11) from Table 2 and the following additional standards to define a technician who works primarily with system automation and digital communications between equipment:

12.0 Understand, operate, troubleshoot, and maintain industrial automation systems.
13.0 Collect and process data from automated systems.
14.0 Identify, implement, and interpret data collected from automation systems.
15.0 Apply the principles of programmable logic controllers, human-machine interfaces, and robotics to automated systems.
16.0 Apply the principles of industrial networking to automated systems.
17.0 Understand the fundamental programming used in network systems.
18.0 Practice the basic concepts of cyber hygiene.

An example of proposed benchmarks (outcomes) to meet one specific standard (13.0) are:

13.0 Collect and process data from automated systems.
13.01 Identify, classify, and describe the data collected in an automated system.
13.02 Create a database for data collection in an automated system.
13.03 Identify issues that require advanced database and data collection skills.

Items 13.0, 14.0, 16.0, 17.0, and 18.0 are additions to help fill the identified skills gap. Adding benchmarks and outcomes inside a benchmark directly drives the development of courses to fulfill those requirements. In some cases, existing courses can be added to the curriculum. It may also be necessary to develop new courses to meet the requirements. The final option is to add additional curriculum to existing courses to ensure coverage of the outcomes. Once the new frameworks are approved by the Florida Department of Education, the course curriculum will be defined by the colleges that adopt the framework.

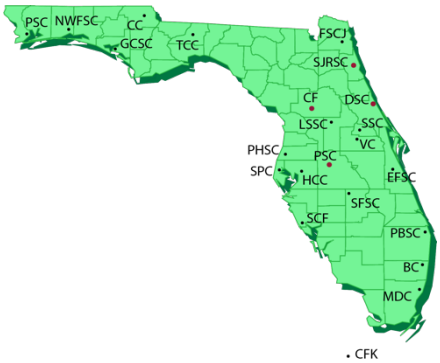

Figure 2. FLATE Engineering Technology College Network

Industry Engagement Strategies

To ensure the direct engagement of Florida's manufacturers with the engineering technology programs from across the state, a State Engineering Technology Industry Advisory Board (SETIAB) was formed. Based on the governing documents created, the board members are representatives from each college offering an ET degree program. The SETIAB officers are elected officials by and from the SETIAB voting members only. The ET program directors serve as nonvoting members of SETIAB to support their industry representatives. The objective of this statewide board is to increase collaboration between the 23 ASET programs around the state and industry and to raise awareness of the technical skill set of the ASET graduates and the program itself.

The board has met two times in person and one time through virtual meetings for a total of three times. The board is reviewing two different sets of curriculum issues. First, the competencies and skills related to the advanced technologies utilized and applied by manufacturers undergoing Sterling Business Excellence evaluations. This evaluation is used to identify and recognize high-performing manufacturers in Florida and Georgia and showcase their best business and/or technology practices. Second, the competencies associated with the new Advanced Automation specialization. A SETIAB webpage has been created to facilitate communications and the sharing of documents and to motivate brainstorming and networking among members (https://flate.site/setiab/).

Post AS-Curriculum

This research aimed to produce an Advanced Technical Certificate (ATC) to cover educational topics that could not be done at the AS level. In Florida, an ATC is a post-AS certificate typically offered by a 4-year granting institution. As the items required for the curriculum development were identified, the project team decided to make this a specialization of the existing Bachelor of Science Engineering Technology (BSET) degree. Advanced Technical Certificates have not been popular with students for several reasons, but especially because they were not eligible for financial aid, based on the number of credit hours.

The existing BSET had one specialization in Electronics Engineering Technology (EET), so the addition of a second specialization in Industrial Engineering Technology (IET) was investigated, and the decision was made to pursue this approach. The objectives of this development were to (1) cover the identified topics to increase the industrial readiness of our students and (2) seamlessly articulate from the existing ASET degree programs at all the Florida State Colleges.

Three courses are being added to the current curriculum for the new BSET specialization and are presented here.

Figure 3. Florida Colleges Offering ASET Degree

Operation Research ESI3306 (3 Credit Hours)
Operations research applies scientific methodology to analyzing the management, function, and operation of complex systems, resources, human resources, and/or information. The course is built around non-probabilistic models, mainly the linear programming methodology and its variations. Case studies involve, among others, the transportation problem, the assignment problem, and the allocation problem. Through mathematical modeling, it seeks to design, improve, and operate complex systems in the best possible way.

Manufacturing Process Engineering EIN3398 (3 Credit Hours)
This course will address the planning, development, and optimizing production system processes. It will also discuss the methods and techniques used to improve manufacturing productivity in assembly, testing, and fabrication areas, including advanced topics in networking and the protection of those systems from cybersecurity attacks.

Probability and Statistics for Engineers EGN3440 (3 hours)
This course applies mathematical and scientific principles to solve various practical problems in the engineering profession. It contains probability and statistical analysis for these problems and develops related Engineering graphs, charts, and measurements. The course will cover data collection and presentation, descriptive statistics, basic elements of probability theory, sampling techniques and theory, statistical estimation, hypothesis testing, and an introduction to regression. Some elements of the course will require the use of statistical software for data analysis. The emphasis will be on problem setup & solution interpretation and using tools in engineering applications.

The ability to seamlessly articulate from existing AS programs was achieved by creating a flexible core curriculum that allows students to meet outcomes by taking lower or upper-level classes to meet some of the outcomes. These lower-level class options are taken from the ASET core curriculum used by the state. In the BS program, students must take 48 hours of upper-level classes. The choice of classes to meet this requirement is very flexible, with students able to take many of the core courses at either the lower level as part of the ASET program or upper level as part of the BSET program.

Summary and Conclusion

To date, excellent progress toward the original goals has been made. The major advances are (1) the establishment of the SETIAB to provide a statewide voice to help steer the engineering technology programs and specifically the ASET core in the future, (2) the design and upcoming

of a BS program that articulates all of these various ASET degrees and provides more in-depth coverage of the identified topics, the design of a CCC to meet specific needs identified in the project, and provided professional development for faculty to meet these needs.

Several challenges to completing the scope of work still need to be addressed. This April at the bi-annual meeting of the engineering technology programs we will be determining exactly how and where the new outcomes will be incorporated into the ASET core framework and then we will begin the implementation phase of these outcomes. Additionally, industry members representing all colleges offering ASET for the statewide advisory board need to be recruited.

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Appendix

Major topic areas (standards and benchmarks) of the ASET Technical Core

After this program, the student will be able to:

01.0 Demonstrate knowledge of industrial processes and materials properties. The student will be able to:
- 01.01 Explain current manufacturing processes to include modern trends.
- 01.02 Determine available and needed resources for the production process.
- 01.03 Describe the factors considered for design, maintenance, procurement, and handling.
- 01.04 Analyze process changes for impact on a product.
- 01.05 Identify principles and practices of production timing.
- 01.06 **Identify the** effect of time, motion, and procedural changes on productivity.
- 01.07 Demonstrate knowledge of raw materials properties and requirements.
- 01.08 Follow engineering specifications and documentation in equipment setup.
- 01.09 Explain the importance of routine maintenance.
- 01.10 Identify customer needs. Document product and process compliance with customer requirements.

02.0 Generate and interpret computer-aided design/drafting. The student will be able to:
- 02.01 Apply current industrial computer-aided design and drafting practices.
- 02.02 Import and export various file types and formats.
- 02.03 Create and interpret technical drawings.

03.0 Demonstrate a fundamental understanding of electronics and electricity. The student will be able to:
- 03.01 Use appropriate electrical circuit grounding techniques.
- 03.02 Solve circuit problems using appropriate units and notation.
- 03.03 Operate appropriate test equipment.

04.0 Generate and interpret computer-aided design/drafting. The student will be able to:
- 04.01 Identify and select appropriate Personal Protective Equipment (PPE).
- 04.02 Follow appropriate safety procedures.
- 04.03 Follow applicable environmental laws and regulations.
- 04.04 Identify and report unsafe conditions and practices.
- 04.05 Explain when a machine or a process should be stopped to investigate an unsafe condition.
- 04.06 Demonstrate knowledge of regulatory agency requirements for corrective actions.
- 04.07 Use and evaluate information resources such as SDS (Safety Data Sheets).

05.0 Demonstrate proficiency in the use of quality assurance methods and quality control concepts. The student will be able to:
- 05.01 Apply quality methods to industrial processes.
- 05.02 Apply quality principles to manufactured products.
- 05.03 Document quality measurements and observations.

06.0 Demonstrate proficiency in using tools, instruments, and testing devices. The student will be able to:

- 06.01 Identify and operate hand tools properly.
- 06.02 Use inspection equipment appropriately.
- 06.03 Implement appropriate testing techniques and procedures.
- 06.04 Use appropriate measurement tools.
- 06.05 Use appropriate safety monitoring and testing equipment.
- 06.06 Communicate issues with visual tools.

07.0 Demonstrate basic troubleshooting skills. The student will be able to:

- 07.01 Apply critical thinking skills to identify problems.
- 07.02 Identify symptoms and changes in a system.
- 07.03 Apply root cause analysis techniques to identify problem causes.
- 07.04 Evaluate corrective action options.
- 07.05 Properly document all corrective actions.

08.0 Demonstrate appropriate communication skills. The student will be able to:

- 08.01 Write logical and understandable statements, or phrases, to accurately complete forms commonly used in business and industry.
- 08.02 Read and understand graphs, charts, diagrams, and common table formats.
- 08.03 Read and follow written instructions.
- 08.04 Demonstrate an understanding of; and ability to follow oral instructions.
- 08.05 Demonstrate knowledge of technical language and technical acronyms.
- 08.06 Explain the benefits of teamwork.

09.0 Demonstrate appropriate math skills. The student will be able to:

- 09.01 Solve problems for appropriate scalars.
- 09.02 Calculate tolerance(s).
- 09.03 Use different unit systems appropriately.
- 09.04 Convert between different units and unit systems.
- 09.05 Use appropriate notation.
- 09.06 Solve simple algebraic equations.

10.0 Demonstrate an understanding of modern business practices and strategies. The student will be able to:

- 10.01 Demonstrate knowledge of production process to meet business requirements.
- 10.02 Demonstrate knowledge of the alignment of a company’s business objectives with production goals.

11.0 Demonstrate employability skills and identify career opportunities. The student will be able to:

- 11.01 Describe the appropriate steps to acquire employment.
- 11.02 Respond appropriately to professional criticism.
- 11.03 Identify and practice professional work habits.