

# **AC 2010-2043: CREATION OF A MULTI-SKILL MANUFACTURING APPRENTICESHIP PROGRAM WITH ARTICULATED PATHWAYS INTO ENGINEERING TECHNOLOGY**

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## **Creation of a Multi-Skill Manufacturing Apprenticeship Program with Articulated Pathways into Engineering Technology**

### **Abstract**

In alignment with the creation of a unified educational pathway for Florida's manufacturing workforce, Polk State College (PSC), the Employ Florida Banner Center for Manufacturing, The Mosaic Company (Mosaic), Rockwell Automation, and RWD Technologies have created an apprenticeship program that aligns with national certifications, corporate training of the incumbent workforce, and articulated credit into an Associate in Science (A.S.) degree in Engineering Technology with an Advanced Manufacturing specialization. This reform has resulted in a program that prepares the skilled craft workforce while providing academic credit and pathways into the statewide A.S. degree in Engineering Technology.

To address the current skills shortage, an immediate need for new *multi-skill* maintenance personnel, concerns about the impending retirements, and small pool of talent in the pipeline experienced by the local manufacturing community - PSC Corporate College has partnered with the Banner Center for Manufacturing, training partners and Mosaic to create and offer structured competency-based apprenticeship training. This program includes apprenticeship training for both Electrical Instrumentation & Automation Technicians (EIA) and Mechanical/Millwright Craft. The program was created to align with the Department of Education's Journeyman requirements and consists of 1152 hours classroom instruction combined with on the job training (OJT). Specifically the program consists of the following instruction:

- The Banner Center's "Manufacturing Essentials" curriculum aligned with the MSSC CPT national certification – 5 Weeks;
- Industrial skills fundamentals curriculum – 18 Weeks;
- Trade-specific skills curriculum – 12 to 18 Months;
- Advanced standing for current incumbents to meet program requirements;
- Employer provided hands-on OJT.

Upon completion of the apprenticeship program the participants are elevated to full journeyman status at Mosaic and obtain a pathway into PSC's Engineering Technology degree program. Due to the inclusion of the MSSC CPT certification into the program, participants who successfully earn their CPT are offered 15 credit hours towards the technical core of the degree based on a statewide articulation pathway already established in Florida. Then, based on the rigor of the technical training in the apprenticeship program, an additional 16 credit hours are articulated through internal articulation agreements between the corporate college and the academic department. These 31 credit hours build a strong pathway to a degree designed to meet Florida's need for a highly skilled, well-trained, and technically competent workforce in manufacturing helping to meet the challenges of ever changing and increasingly complex manufacturing processes. The degree program provides the fundamentals of production processes, the maintenance of those processes, quality assurance, and safety; followed by more in-depth study of automation and instrumentation, metrology, process improvements, total predictive maintenance, technical management competencies, as well as quality work practices utilizing Lean and Six Sigma principles.

Presented herein is the curricula map of the apprenticeship program, alignment with national certifications, articulation for the engineering technology core courses and specialization technical

electives, and institutionalization within the Department of Education. The process for conducting this reform could be applied to any technical career cluster to facilitate relevant training programs, formal manufacturing apprenticeship models, engineering technology degree programs, and articulation pathways.

## **Demand Driven Reform**

In Florida, Nancy Stephens, the Executive Director of the Manufacturers Association of Florida, presented the following statement to the state's legislature, "Addressing the needs for skilled workers is a required, competitive and survival strategy for most manufacturers." If these needs are not met we will see the:

- Eventual erosion of our manufacturing base,
- Loss of billions in business to other countries,
- Decline of the middle class,
- Loss of economic diversification.

Like other Florida manufacturers, Mosaic has surveyed their workforce and determined that they face a skills competency shortage due to pending retirements and a lack of industrial trained maintenance craftspeople in the pipeline. Mosaic is the world's leading producer of phosphate-based chemical fertilizers, supplying 75 percent of the US demand for fertilizer. A Mosaic study determined that 60 percent of its critically-skilled maintenance technicians planned to retire in seven years.

In Florida, the workforce education community has responded by undertaking the reform of: high school career and technical education programs and career academies, Associate in Science (A.S.) and Associate of Applied Science (A.A.S.) degrees associated with manufacturing and related technologies, and workforce training programs. These reforms were undertaken when an analysis of the programs that should be providing the advanced manufacturing workforce revealed that<sup>1</sup>:

- Some of the curricular frameworks that, in principle, inform the outcomes of manufacturing related A.S. and A.A.S. degrees, which may potentially address many of the high skills required by manufacturers, are outdated, some by 15-20 years.
- Manufacturers are concerned about the lack of a qualified labor force in the State of Florida. They have voiced their concerns to the State. This is also a national crisis. "Eighty-one percent of the respondents to the 2005 Skills Gap Survey of the American Manufacturing Workforce (Deloitte and the Manufacturing Institute, 2005<sup>2</sup>) said they couldn't find qualified employees to fill their open positions."
- Community Colleges are not currently addressing all of the needs of manufacturers for qualified personnel (due to a lack of communication, inadequate offerings or inadequate timing and limited graduates).
- There is limited or, at best, inefficient communication between the manufacturing sector and the community college sector at a state-wide level on workforce education and training issues.
- It seems difficult for manufacturers to know what competencies community college graduates bring to the workplace, given the nine different manufacturing related degree options and varying course names and descriptions.

- There do not appear to be clearly defined positions for A.S. and A.A.S. graduates to fill in industry; therefore the level of compensation and career pathways for such graduates are unclear and/or unknown.
- New guidelines from both the Federal (Perkins IV) and the State (Florida Department of Education and Workforce Florida) levels are moving technical programs in alignment with nationally recognized industry certification.
- Registered apprenticeship programs contained far too many clock hours and many are no longer aligned with modern manufacturing's talent requirements.

With secondary and post-secondary programs in alignment with national skills standards, a strong need for focused workforce development, and recent revisions in national apprenticeship program guidelines - Mosaic and PSC looked to create an apprenticeship program that complemented the unified educational system while providing pathways into Engineering Technology degree programs for participants.

### **The Development Process**

As stated by the U.S. Department of Labor (US DOL), "Registered Apprenticeship programs meet the skilled workforce needs of American industry, training millions of qualified individuals for lifelong careers since 1937. Registered Apprenticeship helps mobilize America's workforce with structured, on-the-job learning in traditional industries such as construction and manufacturing, as well as new emerging industries such as health care, information technology, energy, telecommunications and more. Registered Apprenticeship connects job seekers looking to learn new skills with employers looking for qualified workers, resulting in a workforce with industry-driven training and employers with a competitive edge."<sup>3</sup>

In October of 2008, to ensure that apprenticeship remains a highly successful talent development strategy, the US DOL published revised regulations governing the National Apprenticeship System. These revised regulations update Title 29 CFR, part 29 and provide a framework that supports an enhanced, modernized apprenticeship system. Important to the apprenticeship program at Mosaic, the revised regulations, specifically §29.5(b)(2), present a new competency-based pathway for progress through a registered apprenticeship program, "competency-based approach, involving successful demonstration of acquired skills and knowledge by an apprentice, as verified by the program sponsor, with an OTJ learning component and related technical instruction (RTI)."

Competency/performance-based apprenticeship programs are premised on attainment of demonstrated, observable and measurable competencies in lieu of meeting time-based work experience and on-the-job learning. However, these programs still have to comply with the requirement for the allocation of the approximate time to be spent in each major process. Therefore, work experience process schedules and related instruction outlines must specify approximate time of completion or attainment of each competency, which can be applied toward the 2,000-hour requirement (competencies demonstrated notwithstanding and assuming no credit for previous experience). In competency/performance based programs apprentices may accelerate the rate of competency achievement or take additional time beyond the approximate time of completion or attainment due to the open entry and exit design. Competency is defined as, "An observable, measurable pattern of skills, knowledge, abilities, behaviors and other characteristics that an individual needs to perform work roles or occupational functions successfully."

With this competency-based option in place, Mosaic, PSC, and the partners set out to determine the competencies needed to meet the formal demands of the US DOL and Florida Department of Education. The proposed program was discussed with the appropriate union officials and a joint apprenticeship committee (JATC) was established to administer the program. The committee sought stakeholder input to determine desired program competencies. Next, the relevant industry certifications that aligned with the program competencies were determined. The most relevant industry certification was determined from this mapping process and future program definition was aligned with this certification. Selecting an industry certification to inform and anchor the program curricula allowed for currency, precision, relevance, required competencies, and possible articulation pathways. In this specific development process, the Manufacturers Skill Standards Council (MSSC) Certified Production Technician (CPT) certification was chosen. This certification assesses a student/worker's foundational skill and knowledge in four broad areas common to all manufacturing sectors: Manufacturing Processes and Production; Quality Assurance; Maintenance Awareness; and Safety. It was determined to be the certification in greatest alignment with the core needs identified by the industry stakeholders. Next, having identified the core certification, the committee then carefully mapped the rest of the curricula into vendor specific certifications to serve as assessments through the program and agreed on a set of standards for training, including occupations, length of training, selection procedures, affirmative action plan, wages, and number of apprentices to be trained.

### **The Solution – A Competency Based Combined Crafts Apprenticeship Program**

Modern manufacturing demands a workforce with postsecondary education credentials, and the adaptability to respond immediately to changing economic and business needs. The Mosaic/PSC combination crafts apprenticeship program is meeting these demands through competency based learning and lifelong learning strategies that enable workers to advance their skills and remain competitive in the global economy. The final program outlined in Figure 1 and Table 1, creates a five unit program that provides the skills and knowledge needed for Mechanics / Millwrights and Electrical, Instrumentation & Automation Technicians. These five “program completion points” (PCPs) break the competencies into manageable blocks of education aligned with the industry defined competencies. As visualized in Figure 1, all of the program participants start with fundamental manufacturing competencies (PCP's 1 and 2) and then split off into a path relevant to their specific discipline (PCP's 3MM, 3EIA, 4MM, 4EIA, 5MM, and 5EIA).

Figure 1 – Apprenticeship Program Map

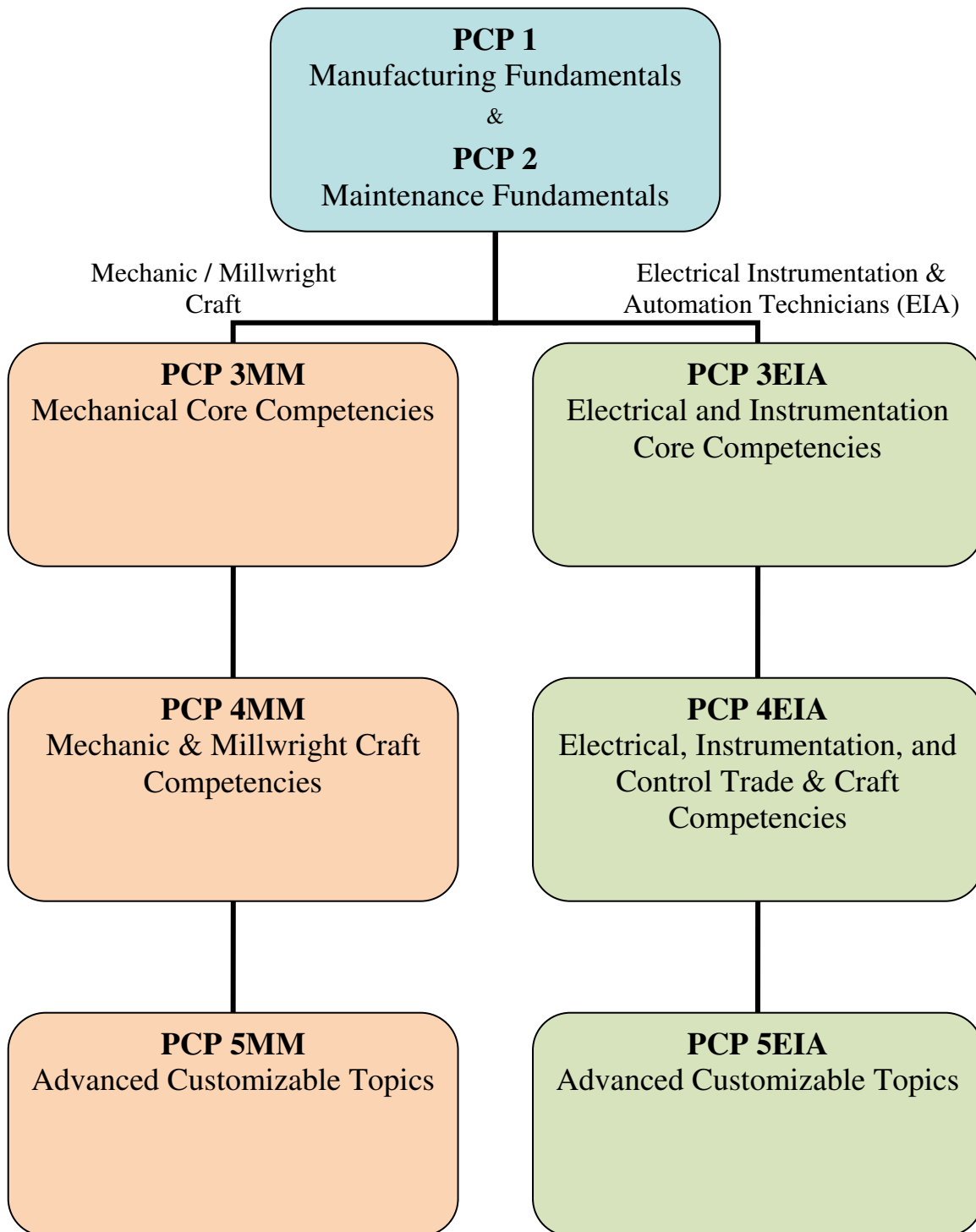


Table 1 – Apprenticeship Program Completion Points, Topics, and Certifications

<b>PCP 1 – Manufacturing Fundamentals</b> (Banner Center Curricula) <ul style="list-style-type: none"> <li>• Workplace Skills</li> <li>• Production and Processes</li> <li>• Maintenance Awareness</li> <li>• Quality Assurance</li> <li>• Safety Awareness</li> </ul> <b>Certifications: MSSC CPT and OSHA 10</b>	
<b>PCP 2 – Maintenance Fundamentals</b> <ul style="list-style-type: none"> <li>• Introduction to Hand Tools</li> <li>• Introduction to Power Tools</li> <li>• Maintenance Work Order Software</li> <li>• Craft-Related Mathematics</li> <li>• Introduction to Blueprints</li> <li>• Basic Computer Skills (Windows, Word, Excel and internet browser)</li> <li>• Computer Numeric Control (CNC)</li> <li>• Precision Measuring Tools</li> <li>• Introduction to Bearings</li> <li>• Fasteners and Anchors</li> <li>• Basic Rigging 1</li> <li>• Introduction to Valves</li> <li>• Introduction to Test Instruments</li> <li>• Introduction to PLC's (Logix Pro)</li> </ul> <b>Certifications: -</b>	
<b>PCP 3MM – Mechanical Core Competencies</b> <ul style="list-style-type: none"> <li>• Mechanical Systems</li> <li>• Vibration Analysis</li> <li>• Material Handling and Hand Rigging</li> <li>• Pumps and Drives</li> <li>• Lubrication</li> <li>• Hydraulic Systems</li> <li>• Low-pressure Steam Systems</li> <li>• High-pressure Steam Systems and Auxiliaries</li> <li>• Heaters, Furnaces, Heat Exchangers, Cooling Towers and Fin Fans</li> <li>• Welding I (arc/mig for mild steel)</li> </ul> <b>Certifications: RA Motors &amp; Drives, RA Vibration Analysis</b>	<b>PCP 3EIA – Electrical and Instrumentation Core Competencies</b> <ul style="list-style-type: none"> <li>• Electrical Theory I and II</li> <li>• AC/DC Motors</li> <li>• E&amp;I Test Equipment</li> <li>• Flow, Pressure, Level and Temperature</li> <li>• Grounding</li> <li>• Basic Ladder Logic Interpretation</li> </ul> <b>Certifications: AC/DC Motors</b>
<b>PCP 4MM – Mechanic and Millwright Craft Competencies</b> <ul style="list-style-type: none"> <li>• Identify, Install and Maintain Valves</li> <li>• Installing Mechanical Seals</li> <li>• Troubleshooting and Repairing Pumps</li> <li>• Hydrostatic and Pneumatic Testing</li> </ul>	<b>PCP 4EIA – Electrical, Instrumentation, and Control Trade &amp; Craft Competencies</b> <ul style="list-style-type: none"> <li>• Introduction to the NEC</li> <li>• Conductor Terminations and Splices (up to 15kV)</li> <li>• Motor Controls &amp; Troubleshooting</li> </ul>

<ul style="list-style-type: none"> <li>• Distillation Towers and Vessels</li> <li>• Boiler Components</li> <li>• Precision Measuring Tools</li> </ul> <b>Certifications: RA Motors &amp; Drives, RA Vibration Analysis</b>	<ul style="list-style-type: none"> <li>• Distribution Equipment – power up to 69kV</li> <li>• Transformer Applications</li> <li>• Control Logix Fundamentals – Rockwell</li> <li>• High Voltage Splicing</li> <li>• Standby and Emergency Systems</li> </ul> <b>Certifications: RA Motors &amp; Drives; RA Vibration Analysis</b>
<b>PCP 5MM – Advanced Customizable Topics</b> <ul style="list-style-type: none"> <li>• Millwright/Mechanic Curriculum</li> <li>• Advanced Trade Math</li> <li>• Tribology (Oil Analysis)</li> <li>• Welding 2 (arc/mig overhead/vertical)</li> <li>• Welding 3 (arc/mig stainless steel)</li> <li>• Laser Alignment</li> </ul> <b>Certifications: Centrifugal Pumps, Displacement Pumps, Mechanical Seals, Basic Welding (MIG/TIG), Overhead &amp; Vertical Welding, Stainless Steel</b>	<b>PCP 5 EIA – Advanced Customizable Topics</b> <ul style="list-style-type: none"> <li>• Instrument Calibration and Configuration</li> <li>• Distributed Control Systems (DCS)</li> <li>• Fiber Optics</li> <li>• Power Flex 700 Drives – Rockwell (Operation &amp; Maintenance)</li> <li>• NFPA 70E – Arc Flash</li> </ul> <b>Certifications: PLC Fundamentals, Ladder Logic, PowerFlex Drives, Control Logix, DeviceNet, Ethernet, Control Net, Automation – Pgm, Drive Troubleshooting, ArcFlash Safety</b>
<b>Total Related Instructional Hours: 1232</b> <b>Up to 13 certifications*</b>	<b>Total Related Instruction Hours: 1232</b> <b>Up to 15 certifications*</b>

\* If employer chooses to include all individual certifications

Upon completion of the apprenticeship program the participants are afforded a pathway into PSC's Engineering Technology degree program. Due to the inclusion of the MSSC CPT certification into the program, participants who successfully earn their CPT are offered 15 credit hours towards the technical core of the degree based on a statewide articulation pathway already established in Florida (Table 2). Then, based on the rigor of the technical training, an additional 16 credit hours are articulated through internal articulation agreements between the corporate college and the academic department (Table 3). The 31 credit hours builds a strong pathway to an AS degree. This AS degree in Engineering Technology is designed to meet Florida's need for a highly skilled, well-trained, and technically competent workforce in manufacturing to meet the challenges of ever changing and increasingly complex manufacturing processes. The AS in Engineering Technology degree can serve as either a terminal degree or the first step of a 2 + 2 program leading to a bachelor's degree, either in a technical area or in management. The degree program is designed to prepare students with the knowledge and skills needed for Florida's diverse manufacturing sectors by providing a technical core encompassing the fundamentals of production processes, the maintenance of those processes, quality assurance, and safety. Then the students build upon those fundamentals with more in depth study of automation and instrumentation (including PLC basics), metrology, process improvements (including total predictive maintenance, lubrication technology, vibration, and alignment), as well as quality work practices utilizing Lean and Six Sigma principles. In addition to these technical skills, students will learn the management competencies needed to advance the efficient and effective performance within our advanced manufacturing entities.



Table 2 - MSSC CPT Certification Credit Articulation to the E.T. AS Degree

Course Number	Course Name	Credits
ETM 1010C	Mechanical Measurement & Instrumentation	3
ETI 1110	Introduction to Quality	3
EET 1083C	Introduction to Electronics	3
ETI 1701	Industrial Safety	3
ETI 1420	Manufacturing Processes & Materials	3
		15

Table 3 - PSC Internal Credit Articulation to the E.T. AS Degree

Course Number	Course Name	Credits
EST 1542	Introduction to Programmable Logic Controllers	3
EST 1511	Motors and Controls	3
ETM 2315C	Hydraulics & Pneumatics	4
EST 1540	Industrial Applications using PLCs & Robotics	3
EST 1535	Automated Process Control	3
		16

## Student Feedback

The following student profile was compiled from an interview with James Brown, one of the PSC Corporate College Mosaic Apprenticeship program participants. “I’m filled with gratitude to be given this opportunity,” said James Brown, one of the 16 Mosaic apprenticeship students taking training with the PSC Corporate College at Airside. To enter the program, Brown had to take an aptitude test and a general knowledge test. Only the top three Mosaic employees at the Riverview plant would be able to enter the program. Brown finished fourth, and it looked like he wouldn’t attend. Then one of the top three men decided to retire. “This opened the opportunity for me, and I was excited to go into this EIA [electrical, instrumentation, and automation] program,” Brown said. “Out of 300 guys at the plant, I’m the one who’s here. This training makes me much more valuable. Management is investing in me; that makes me even more committed to Mosaic. That’s where my loyalty lies,” he continued. “Since they think that much of me, I’m not going to let them down. How many other companies pay you to attend school?”

For two days a week, Brown and his fellow students attend classes at PSC Airside, and the other three days they work at their plant in the Tampa Bay area. The classes started in July 2008, and they’ll complete the training in April 2010. The curriculum includes manufacturing essentials, industrial skills, and trade-specific skills. The key element in this training is to ensure that these students learn how to operate and troubleshoot the programmable logic controller—a digital computer used for automation of industrial processes, such as the control of machinery on the factory assembly line. Students who successfully complete the program receive their Journeyman status, equipment specific certifications, and a nationally recognized certification that can articulate for 15 hours of college credit for an Associate in Science (AS) Engineering Technology degree. “This is an excellent program,” said Brown. “It really is opening the door of opportunity for me.” He plans to continue his education and pursue an AS and then a BS degree. “I will take all the experience and knowledge I receive at PCC and strive to be the best I can in my job.”

## Conclusion

Registered Apprenticeship benefits employers by providing them with a pipeline of skilled workers with industry-specific training and hands-on experience. Registered Apprenticeship programs are customizable to match employers' needs, and highly flexible to meet employers' changing requirements. With careful design of the registered apprenticeship program, participants can be offered education that aligns with national industry certifications and pathways into higher education.

Through the development and implementation process, Mosaic, PSC, the Banner Center for Manufacturing, and RWD identified the following “lessons learned”:

- Participant selection is important
  - Math-math-math
  - Work experience
- Identification of national industry certifications is essential
- Focus on development of regional and statewide articulation pathways
- Pace slower than college level
  - Test taking/Study habits
- Industrial needs are specialized
- Multi-source text and materials
- DOE approval process time consuming
- Must have experienced instructors
- Flexible content with local decisions
- Client wants earlier practical skills embedded in the delivery
- Find industry standard curricula and vendor certifications that add value and can serve as completion points

## References

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