State of Illinois
Model Programs of Study Guide:
Manufacturing and Engineering

October 2020

ICCB
ILLINOIS COMMUNITY COLLEGE BOARD

Education Systems Center
NORTHERN ILLINOIS UNIVERSITY

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About ICCB

In 1965, the Illinois General Assembly established the Illinois Community College Board to create a system of public community colleges that would be within easy reach of every resident. Today, the Illinois Community College System covers the entire state with 48 colleges and one multi-community college center in 39 community college districts. Community colleges serve nearly one million Illinois residents each year in credit and noncredit courses and many more through their public service programs.

Illinois' community colleges meet both local and statewide needs for education and workforce development through high-quality, affordable, accessible, and cost-effective programs and services. Learn more at iccb.org.

About Education Systems Center

Education Systems Center (EdSystems) is a mission-driven policy development and program implementation center based within Northern Illinois University's Division of Outreach, Engagement, and Regional Development. EdSystems' mission is to shape and strengthen education and workforce systems that prepare more young people for productive careers and lives in a global economy. EdSystems leads and manages the Illinois P-20 Council's College and Career Readiness Committee, which recently drove the development and adoption of the Postsecondary and Workforce Readiness Act (pwract.org). Learn more about EdSystems at edsystemsniu.org.

About the Model Programs of Study Guide

The Illinois Community College Board (ICCB) sponsored the development of Model Programs of Study Guides in crucial industry areas as part of the Illinois State Plan for Strengthening Career and Technical Education for the 21st Century Act (also known as the Perkins V Plan). This Guide was developed in consultation and collaboration with the Illinois State Board of Education (ISBE) through a process led and facilitated by Education Systems Center at NIU (EdSystems). As further detailed in this Guide, the process involved extensive research into labor market information and credential programs, and dialogue across secondary, postsecondary, and employer stakeholders.

The primary purposes and goals for the Model Programs of Study are to:

1. **Provide guidance and exemplars** for local programs to adopt or customize as they develop programs of study for approval as part of the Perkins V Plan.
2. **Establish a framework** for State agencies to develop and implement program supports.
3. **Identify priority dual credit courses** that are foundational to the industry area and well-situated for statewide scaling and articulation.
4. **Define the competencies** that should be sequenced across a program of study course sequence to prepare students for the future of work in that industry area.
5. **Identify entry points** for employers to support coursework and related experiences.

Model Programs of Study supplement and complement other State of Illinois career and technical education and career pathway resources, including the ISBE Career Guide, State of Illinois Career Pathways Dictionary, Career Development Experience Toolkit, Postsecondary and Workforce Readiness Act Recommended Technical and Essential Employability Competencies, State of Illinois Workforce Development Strategic Plan, Workforce Education Strategic Plan, and related state and regional data resources. School districts, community colleges, and their partners are encouraged to use this Guide, state resources, and local program and course information to develop materials for student and family outreach.

The full Model Programs of Study for Manufacturing and Engineering, depicted graphically on pp. 4 – 5, can be used as a reference in local planning processes. The Guide then presents and describes in detail each component of the sequence, including descriptions of the underlying research, analysis, and Advisory Committee input leading to each component:

I. Background and Process for Developing Model Programs of Study (pp. 6 – 7)
II. Priority Occupations and Promising Credentials in Manufacturing and Engineering (pp. 8 – 10)
    a. Postsecondary Credential Program Categories (pp. 8 – 9)
    b. High-Priority Occupations (pp. 9 – 10)
    c. Levels of Education Needed (p. 10)
    d. Advisory Committee Considerations (p. 10)
III. Programs of Study Sequence Description (pp. 11 – 16)
    a. High School Career-Focused Instructional Sequence and Related Work-Based Learning (pp. 11– 14)
    b. Recommended High School General Education Courses (p. 14)
    c. Recommended First Year Postsecondary Courses (p. 14)
    d. Advanced Manufacturing and Engineering High School Course Sequence and Competencies (pp. 15 – 16)

Appendix A includes the PWR Act Recommended Technical Competencies for Manufacturing and Engineering, and the recommended Essential Employability Competencies. Appendix B includes the Advisory Committee membership.

Model Programs of Study Guide:
Manufacturing & Engineering

Education Systems Center, Northern Illinois University | ICCB

	ORIENTATION / INTRODUCTION Grades 9–10	SKILL DEVELOPMENT Grades 10–12	CAPSTONE / ADVANCED Grades 12	POSTSECONDARY COURSES ⊕ Recommended 1st Year
CAREER FOCUSED COURSES	Introduction to Technology & Engineering	Foundations of Production & Manufacturing Processes [1]	Advanced Production & Manufacturing Processes [2] & / or Basic Welding	CNC Programming Manufacturing Materials and Processes
		Principles of Engineering » & Additional Engineering »	Computer Integrated MFG » & Additional Engineering »	Industrial Electricity CAD / CAM Technology
WORK-BASED LEARNING	Career Exploration (2) Team-Based Challenge	Team-Based Challenge Career Development Experience or Youth Apprenticeship		Team-Based Challenge Career Development Experience or Apprenticeship
SCIENCE	Science Sequence	Science Sequence	Physics »	General Physics General Chemistry
SOCIAL SCIENCE	Social Science Sequence	Social Science Sequence	Social Science »	Social Science
MATH	Algebra Geometry	Geometry Algebra 2 Pre-Calculus	Transitional Math: Technical Transitional Math: STEM Pre-Calculus College Algebra Calculus »	Technical Math College Algebra / Trigonometry Calculus
ENGLISH	English Sequence	English Sequence	Transitional English English Composition »	English Composition Oral Communication

Advanced Manufacturing & Engineering Pathway

Advanced Manufacturing Focus

Engineering Focus

Courses and Work-Based Learning Address the PWR Act Recommended Technical and Essential Employability Competencies

» *AP or Dual Credit*

Dual Credit Course

Dual Credit Course Affiliated With IAI Code

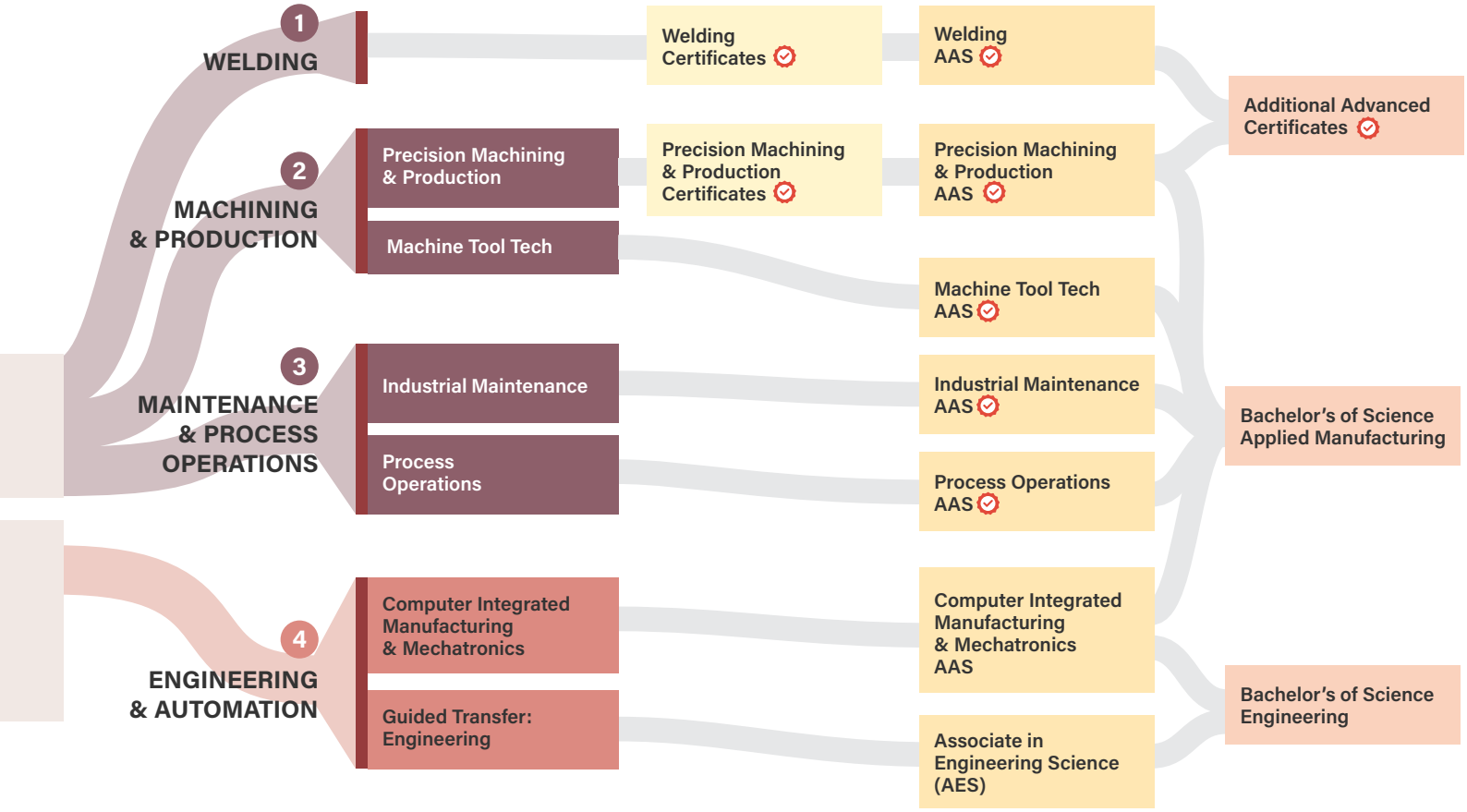
Course or Program Prepares for Industry Credential

Postsecondary Course Affiliated with IAI Code

College and Career Pathway Endorsement Earned

⊕ *If courses in this column were accomplished through early college credit, students should take the next required course in the sequence or, if none, additional AAS or Major Courses*

POSTSECONDARY OPTIONS



SELECTED OCCUPATIONS, WAGES, & JOB GROWTH

	Program	Typical Job	Near or Above Living Wage Threshold for 1 Adult + 1 Child [3]	Median Hourly Wage [4]	Growth in IL: Annual Job Openings [4]	Growth in IL: % Change Over 10 years [4]	Stackable?
1	**Welding**	Welders, Cutters, Welder Fitters	N	$19.28	1,540	5%	Not Typically Stackable
2	**Machine Tool Technology**	Tool and Die Makers	Y	$25.34	450	–5%	Typically Stacks to Related Bachelor's Program at **Select** IL Universities
2	**Precision Machining**	Machinists	N	$19.44	3,630	4%	Typically Stacks to Further Certificates or an AAS
2	**Precision Machining**	Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic	Y	$25.65	160	18%	
3	**Industrial Maintenance**	Industrial Machinery Mechanics	Y	$26.41	1,240	10%	Typically Stacks to Related Bachelor's Program at **Select** IL Universities
3	**Process Technology**	Chemical Equipment Operators and Tenders, Biofuels Processing Technician	Y	$24.95 - $33.87	200	1% - 3%	
4	**Computer Integrated Manufacturing & Mechatronics**	Manufacturing Engineering Technologists, Electromechanical Engineering Technologists, Robotics Technicians	Y	$30.26 - $30.48	460	5%	
4	**Guided Transfer: Engineering**	Engineers in Various Branches: Mechanical, Civil, Electrical, Chemical, Mechatronics, Industrial	Y	$40.65 - $44.51	3,760	4% - 12%	Typically Stacks to Related Bachelor's Program at **Most** IL Universities

1. For machining-focused programs, equivalent to ISBE CTE Courses — Beginning Machining and Machine Shop Technology 1
2. For machining-focused programs, equivalent to ISBE CTE Course — Machine Shop Technology II
3. Living wage calculations are based on MIT's Living Calculator (livingwage.mit.edu), where the "Living Wage" for 1 Adult + 1 Child is $26.27/hour for the state of Illinois. "Near" defined as 85% of the statewide living wage, which is $22.33/hour
4. U.S. Department of Labor, CareerOnestop (careeronestop.org/explorecareers)

Background and Process for Developing Model Programs of Study

Programs of study are a coordinated, non-duplicative sequence of academic and technical content at the secondary and postsecondary levels that culminate in a recognized postsecondary credential. In Illinois, Perkins V programs of study are aligned with broader State policy goals to promote college and career readiness, including the State of Illinois' ESSA plan (in particular, the College and Career Readiness Indicator), the College and Career Pathway Endorsement framework and other elements of the Postsecondary and Workforce Readiness Act, the Dual Credit Quality Act, the Illinois WIOA Unified State Plan, and the State's Career Pathways Dictionary.

Process for Development

Each Model Programs of Study was developed using a data-driven, backward-mapping approach that extended from the areas of job growth down through to the high school course sequence. The specific steps in this analysis included:

1. **Identifying high-priority occupations** in the industry sector that are high-skill, high-wage, and in-demand based on federal Department of Labor data for the State of Illinois.
2. **Identifying promising postsecondary credentials** (degrees or certificates) that are broadly accessible through the Illinois community college system and lead to high-priority occupations.
3. **Mapping the stackable degrees and certificates** that progress to promising credentials.
4. **Identifying strategic community college courses** that appear across the maximum number of promising credentials, provide a broad foundation of knowledge essential to that industry sector, and are feasible for dual credit delivery.
5. **Mapping a course sequence from secondary through the first year of postsecondary** that incorporates strategic early college credit (including at least six early college credits in the career-focused course sequence) and considers industry trends and innovations in career and technical education.
6. **Defining related technical competencies** for the foundational program of study courses that can be utilized to guide course development and postsecondary articulation.

Using Department of Labor[1] data and the MIT Living Wage Calculator[2] for the State of Illinois as a reference, the project team identified "high-priority occupations" as jobs with a positive growth outlook and median salaries near or greater than the living wage for one adult and one child[3]. Thus, a "promising credential" is a degree or college certification that immediately prepares an individual for entry into a high-priority occupation or is a stackable credential for a high-priority occupation.

After identifying the promising credentials in each industry area, the project team analyzed community college programs leading to these credentials from a sampling of six to ten colleges from across Illinois, representing a mix of urban, suburban, and rural institutions[4]. EdSystems analyzed and categorized all of the career-focused and general education courses across the full sampling of the promising credential programs to determine which of these courses:

- Are most common across all programs in the sample,
- Are broadly accessible for dual credit opportunities considering prerequisites and teacher credentialing requirements, and
- Are included within the Illinois Articulation Initiative.

This analysis and categorization process led to a recommended set of "strategic" career-focused and general education courses that provide a critical foundation for the program of study sequence.

Following this internal analysis, EdSystems and ICCB convened a stakeholder Advisory Committee of secondary, postsecondary, and private sector representatives to vet the recommendations and provide expertise and guidance on the development of the Model Programs of Study (see Advisory Committee listing in Appendix B). Over multiple webinars and feedback sessions across four months, the Advisory Committee and smaller working groups provided information about industry trends that may not be reflected in the Department of Labor data, credentials and degrees that are emerging as most promising in the field, on-the-ground implementation considerations for secondary and postsecondary programs, and future of work implications for the sector. The Advisory Committee further informed important decision-points in the Model Programs of Study process, including adjusting the Model of Programs of Study course map and promising credential endpoints, selecting strategic early college credit courses, and identifying key competencies for target courses in the Model Programs of Study currently lacking current statewide articulation. The culmination of EdSystems' analysis and the input of the Advisory Committee is reflected in the draft Model Programs of Study and course competencies included within this Guide.

[1] U.S. Department of Labor, Career Onestop: careeronestop.org/ExploreCareers/explore-careers.aspx

[2] livingwage.mit.edu

[3] "Living Wage" for 1 Adult + 1 Child is $26.27/hour for the whole state of Illinois. "Near" is defined as 85% of the statewide living wage, which is $22.33/hour

[4] For the analysis of Manufacturing and Engineering, the community colleges surveyed were City Colleges of Chicago, College of Lake County, Elgin Community College, Illinois Central College, McHenry County College, Rock Valley College, and Southwestern Illinois College

Priority Occupations and Promising Credentials in Manufacturing and Engineering

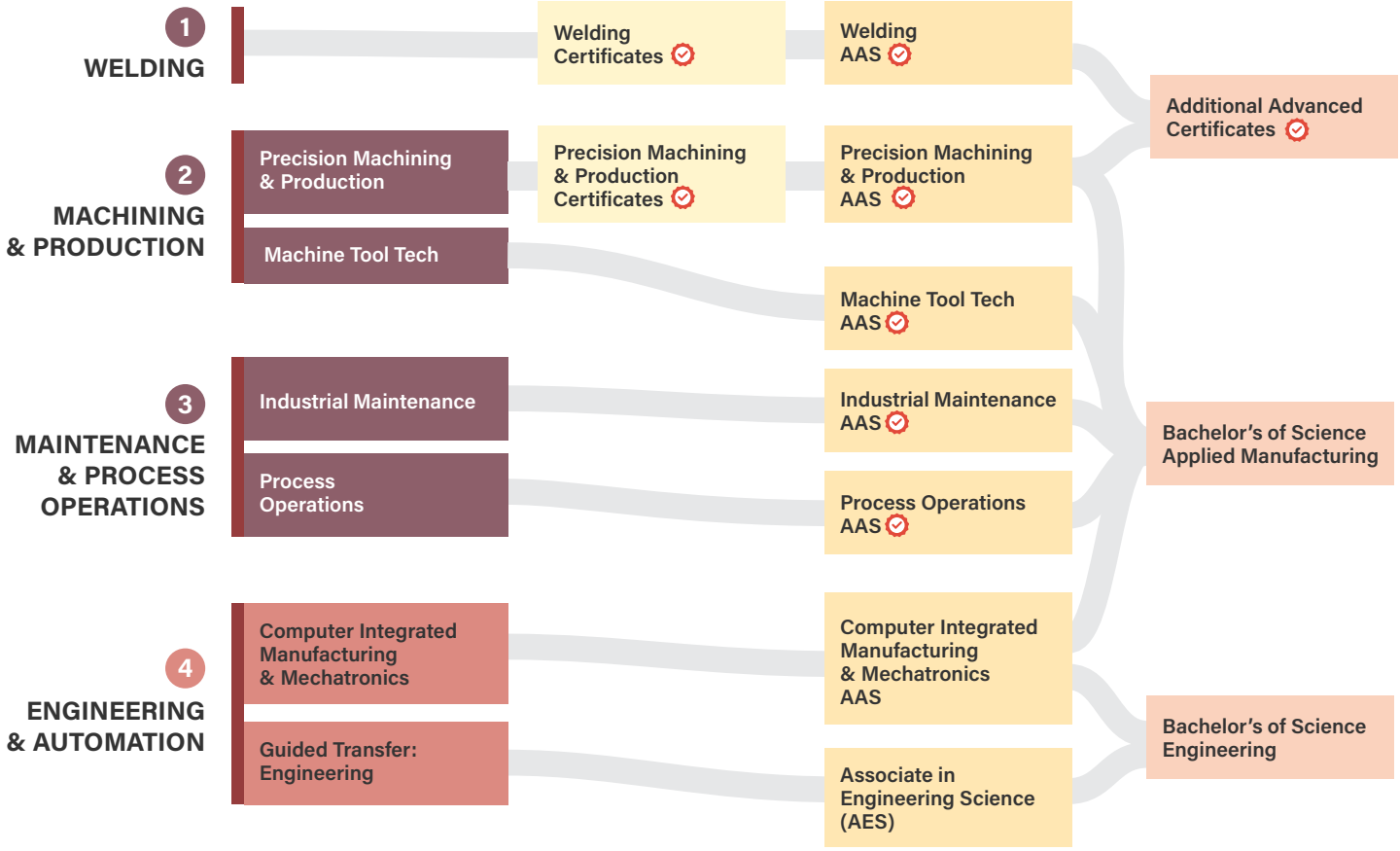
Manufacturing and engineering occupations are a cornerstone of the Illinois economy. According to the State's five-year Economic Development Plan released in 2019, Illinois manufacturers account for more than 13 percent of the State's output and employ 10 percent of the State's workforce, with manufacturing exports in Illinois growing faster than the national average[5]. These occupations are spread across a breadth of manufacturing employer types, including metalworking, automotive production, plastic, food processing, and chemical processing. The recent COVID-19 public health crisis has demonstrated the need to ensure the manufacturing supply chain is protected from disruption by international events. As Illinois rebounds from the impacts of COVID-19, the State will need to ensure the continued availability of a qualified workforce for its manufacturing and engineering employers as this sector continues to serve as an anchor for Illinois' economic growth and recovery.

Postsecondary Credential Program Categories

The project team's analysis of occupations and related postsecondary credentials in the manufacturing and engineering sectors led to an identification of four overarching categories and additional subcategories:

1. **Welding** credentials for careers in welding, fabrication, and structural steel industries.
2. **Machining & Production** credentials for careers utilizing manufacturing processes to transform raw material into a finished product. Subcategories of machining and production credentials include:
   a. Machine Tool Technology, involving the set-up, operation, and testing of machines before production.
   b. Precision Machining & Production, involving the set-up, testing, and operation of manufacturing

POSTSECONDARY OPTIONS



machines and equipment involving a variety of types of production processes.

3. **Maintenance & Process Operations** credentials, preparing students to install, repair, adjust, and maintain industrial production and processing systems. Subcategories include:
   a. Industrial Maintenance, involving the machinery involved in manufacturing production operations.
   b. Process Operations involving petroleum, chemical, food, or other non-durable processing equipment and systems.
4. **Engineering & Automation** credentials, preparing students for a range of careers to analyze, design, evaluate, and continuously improve complex manufacturing and industrial systems. Subcategories of engineering and automation include:
   a. Computer Integrated Manufacturing & Mechatronics, involving the design, utilization, and maintenance of complex design and production processes involving mechanical, computerized, and electronic components.
   b. Guided Transfer programs leading to a Bachelor of Science in Engineering in one of the branches of Mechanical, Industrial, Chemical, Civil, or Electrical.

High-Priority Occupations

The high-priority occupations associated with each of these areas are identified in the table entitled Select Occupations, Wages, and Job Growth. As shown in this table, the occupations associated with CNC Machining, Industrial Maintenance, Process Operations, Computer Integrated Manufacturing, Mechatronics, and Engineering all met both the positive growth outlook and living wage criteria described in Section I. In Illinois, the manufacturing and engineering occupations with relatively high projected growth in terms of the number of annual openings through 2026 are Industrial Machinery Mechanics, various skilled Technologist or Technician roles, and various types of Engineers.

While Machine Tool Technology did not meet the positive growth outlook criterion, it is still included as a promising credential in the analysis because of its capacity to lead to jobs with a living wage and its adaptability to other careers in machining and manufacturing. Welding does

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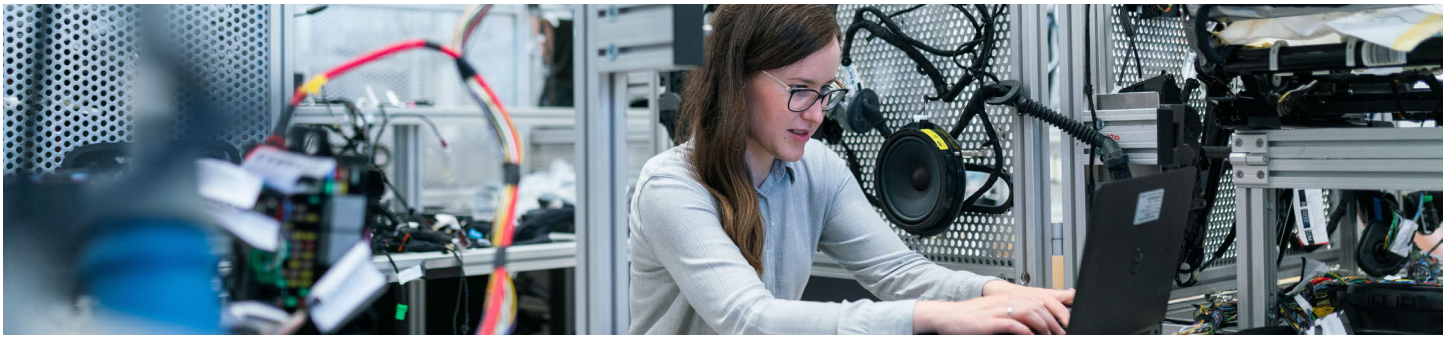


not meet the living wage criteria. However, utilizing the input of the Advisory Committee, welding is identified as a promising credential due to its importance for many regional employers and economic development plans, and because various other manufacturing credential programs integrate welding skills.

Levels of Education Needed

The levels of education needed for the various pathways in the Model Programs of Study vary greatly. Two-thirds of welders, cutters, and welder fitters have no postsecondary education, making this pathway highly accessible for students receiving industry credentials and training in high school. A slight majority of CNC Machinists have some postsecondary education, and entry-level positions are accessible upon completion of a short-term postsecondary credential. For the welding and machining pathways, employers often rely on industry certifications as validation of competencies within the field with hundreds of industry certificates available in the sector. As described in Section III, the Model Programs of Study course sequence aligns to the certifications of two predominant providers of manufacturing industry certifications: the Manufacturing Skill Standards Council (MSSC) and the National Institute of Metalworking Skills (NIMS). Students pursuing machining or production technician careers should aim for at least the MSSC Certified Production Technician or NIMS Operator certificates, along with a stackable community college credential, as entry-point preparation. Students pursuing welding careers should be supported to attain stackable credentials provided by the American Welding Society (AWS), the primary industry association establishing standards in the United States for welding. As students continue to progress through community college and AAS programs in these areas, students should be prepared to earn additional stackable industry credentials.

Careers in Machine Tool Technology, Industrial Maintenance, Process Operations, Computer Integrated Manufacturing, and Mechatronics typically require at least a long-term certification (e.g., 40 or more credits) or an Associate of Applied Sciences (AAS) degree. As completion of the AAS better positions manufacturing workers to enroll in a Bachelor of Science (BS) degree program at a later stage in their careers, the Model recommends an AAS in all of these paths.

Several Illinois universities offer a BS degree in Applied Manufacturing Technology (or Applied Engineering) that articulates AAS degrees in Advanced Manufacturing or Engineering[6]. Whenever possible, community colleges should ensure that AAS degrees in Advanced Manufacturing or Engineering articulate to these BS options. Students with AAS degrees in Machining or Industrial Maintenance or Processing may need targeted instructional supports in mathematics to complete the math sequence requirements typical of BS degrees.

Engineer positions typically require a Bachelor of Science degree, and a bachelor's degree is required for licensure. Engineering is therefore depicted in the Model as a Guided Transfer pathway from an AS to BS in Engineering.

Advisory Committee Considerations

Across the occupational areas, the Advisory Committee emphasized the need for the future workforce to be prepared for highly automated manufacturing environments involving integrated robotics and human-operated systems, and to understand additive manufacturing processes creating three-dimensional objects through layering. The Advisory Committee emphasized the importance of ensuring programs prepare students for manufacturing environments involving both durable products (e.g., metalworking) and non-durable goods (e.g., food, chemicals). The committee also emphasized the need for a broader approach to welding that includes not only metal fabrication but also experience with adhesives and other emerging joining technologies. These considerations are reflected in the course sequences and competencies included in the Model Programs of Study, as detailed in the following section.

[5] State of Illinois Department of Commerce and Economic Opportunity. A Plan to Revitalize the Illinois Economy and Build the Workforce of the Future. October 2019. P. 50. Retrieved May 22, 2020, from illinois.gov/dceo/Pages/EconPlan2019.aspx.

[6] Examples include NIU's BS in Technology with an emphasis in Applied Manufacturing Technology, SIU's Industrial Management and Applied Engineering Degree, or GSU's BA in Manufacturing Management.

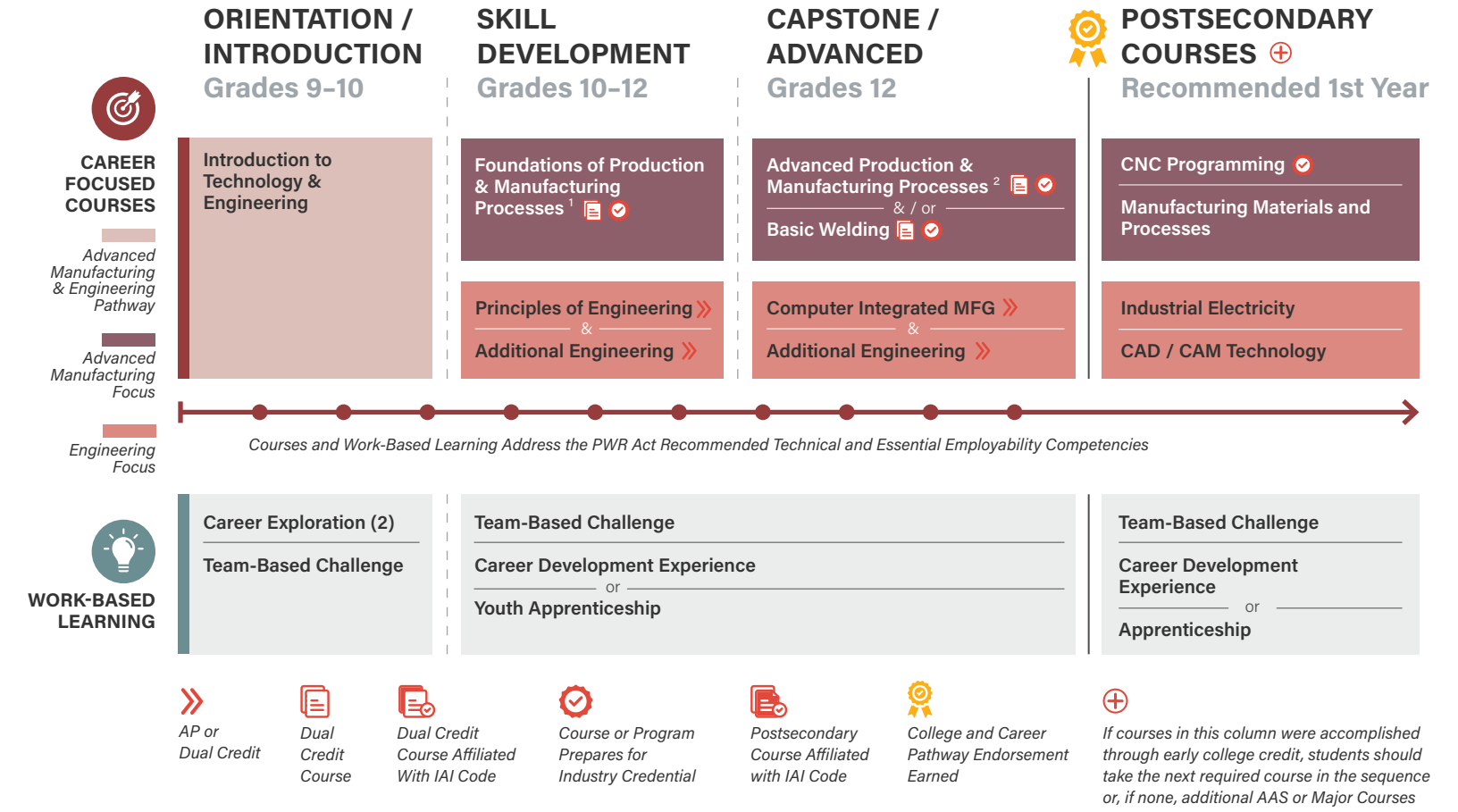
Model Programs of Study Description

The Model Programs of Study for Manufacturing and Engineering begin in high school by introducing students to the broad range of careers in this field, and then enables students to pursue either an Advanced Manufacturing or Engineering focus while in high school. Within postsecondary, students are prepared to pursue promising credentials in one of the four areas of Welding, Machining, Maintenance & Process Technology, or Engineering & Automation. In the latter three areas, students can continue the Model Programs of Study sequence through stackable credentials and degrees to a Bachelor of Science program.

High School Career-Focused Instructional Sequence and Related Work-Based Learning

Overview

The career-focused instructional sequence in the Model Programs of Study for Manufacturing and Engineering provides high school students with an orientation in both Advanced Manufacturing and Engineering, followed by the opportunity to focus on either area as students move into skill development and capstone courses. Students should not be "tracked" into either an Advanced Manufacturing or Engineering focus — instead, the high school program should support integration and expanded opportunities for course-taking across both focus areas to the extent possible. The Advanced Manufacturing course sequence provides options for schools to align with one of two commonly utilized industry credential sequences in the manufacturing sector: Manufacturing Skill Standards Council (MSSC), or National Institute of Metalworking Skills (NIMS). The high school's selection of either MSSC or NIMS should be made in collaboration with a community college partner and with input from regional employers or an employer collaborative, and other industry credentials may be incorporated depending on regional employer needs. The Engineering-focused courses generally align to the Project Lead the Way sequence but can also be fulfilled through other curriculum options that incorporate secondary, postsecondary, and employer input. Ideally, students would begin career awareness and exploration



1. For machining-focused programs, equivalent to ISBE CTE Courses — Beginning Machining and Machine Shop Technology 1
2. For machining-focused programs, equivalent to ISBE CTE Course — Machine Shop Technology II

in the middle school grades then start the career-focused instructional sequence with an orientation course in 9th grade. With an early start, students will have more openings in their schedule to complete skill development and capstone options across Advanced Manufacturing and Engineering, to obtain significant early college credits, and to earn valuable industry credentials before high school graduation. As school districts and their community college partners develop the career-focused instructional sequence, they should ensure the high school coursework enables all students in the Advanced Manufacturing and Engineering pathway to attain the State's recommended Technical Competencies for Advanced Manufacturing & Engineering and the State's Cross-Sector Essential Employability and Entrepreneurial Competencies (see Appendix A).

Orientation (Grades 9–10)

The Model Programs of Study for Manufacturing and Engineering commences at the orientation level with an Introduction to Technology & Engineering course that is broadly applicable to all pathways in the Manufacturing, Engineering, Technology, and Trades sector grouping. As reflected in the competency table (p. 15), through this course, students will (i) demonstrate awareness of career pathways and manufacturing processes, (ii) develop a safety mindset that will be critical to further coursework and work experience, and (iii) gain understanding of basic, introductory concepts in the field. Students should also participate in multiple virtual and in-person site visits to employer locations to better understand authentic manufacturing environments and have the opportunity to engage with professionals in the field. Schools may use the Project Lead the Way Introduction to Engineering Design for this coursework, with enhancements to address the course expectations. This course may also provide an introduction to other related career clusters, such as architecture, construction, and energy. Through the orientation course, students should be prepared to document their own personalized career pathway that leads to a promising credential defined in the Model.

Skill Development (Grades 10–12)

The Skill Development course recommendations in the Model Programs of Study include one Advanced Manufacturing-focused course recommendation: Foundations of Production & Manufacturing Processes, and Engineering-focused course recommendations generally aligned to the PLTW sequence. The engineering-focused courses should include Principles of Engineering and another engineering course that emphasizes the development of software skills, such as SOLIDWORKS, that are valuable for employer internships. As students' schedules permit, students are highly encouraged to take Skill Development courses across both focus areas.

The Foundations of Production & Manufacturing Processes course (or two-semester course sequence) provides all students in an Advanced Manufacturing pathway with a strong foundation in production, safety, and other foundational concepts for promising credentials in the field. A strong foundation in production (either machining or non-durable production processes) is critical for students planning for a career in any of the three manufacturing postsecondary credential areas included in the Model Programs of Study. This course's competencies scaffold on to those attained in the orientation-level Introduction to Technology & Engineering course, and, for machining-focused programs, address the expectations of Beginning Machining and Machine Shop Technology I in the ISBE CTE course titles. For programs emphasizing production processes other than machining, the high school will need to consult with its Education for Employment director and ISBE on the appropriate CTE course titles for this course and more advanced courses in the sequence. It emphasizes *application* of safety, production processes, and other basic concepts under close teacher direction, and should utilize authentic projects addressing realistic customer needs. Classroom instruction should be coupled with continued employer site visits, an opportunity for students to participate in a job shadow experience at an employer site, and clubs or challenges such as a robotics or SkillsUSA Illinois or Technology Student Association of Illinois competitions. The high school and community college partner should ensure that upon concluding this course and Introduction to Technology & Engineering, students will have earned at least three to six dual credit hours[7] from the community college within its Manufacturing CTE postsecondary course sequence. In addition, students will be prepared to attain the foundational certifications in MSSC (Safety; Quality Practices & Measurement) or NIMS Machining Level I (Measurement, Materials, and Safety; Job Planning, Benchwork & Layout). Students can prepare to earn these certifications using tools and equipment found in a typical high school shop without investment in CNC milling and lathe machines. In addition, students should attain the Occupational Safety and Health Administration (OSHA) ten-hour course completion card, which can be earned online through the CareerSafe program[8].

Capstone (Grade 12)

At the Capstone level, students engage in advanced topics in Advanced Manufacturing, Engineering, or both.

The Capstone recommendations for students with an Advanced Manufacturing focus are to either complete an Advanced Production & Manufacturing Processes course (or two-semester sequence), or, for students interested in pursuing a welding career, a Basic Welding Course. The Basic Welding course should emphasize foundational skills in the welding field, as well as introduce non-metallurgic fabrication approaches involving adhesives and plastics. The course should also prepare students to attain one or more foundational AWS certificates. Students with an Engineering Focus should complete a Computer Integrated Manufacturing Course (based on the PLTW sequence), and additional engineering-focused coursework as the student's schedule permits. The Computer Integrated Manufacturing Course should require students to (i) engage with Computer Aided Manufacturing (CAM) software and (ii) design, build, program, and present a manufacturing system model capable of creating a product.

At the Capstone level, all students should continue participation in clubs or challenges such as robotics and complete a Career Development Experience (CDE) of at least 60 hours in length. As their schedules permit, students can participate in a for-credit cooperative class to obtain work experience in addition to the career-focused courses shown in the pathway model.

The Advanced Production & Manufacturing Processes course (or two-semester course sequence) develops students' advanced production skills, either for entry-level employment, to continue into a postsecondary machining or other production program, or as a foundation for other related programs such as Machine Tool Technology or Industrial Maintenance. As a capstone project in this course, students should plan, calculate, and safely machine a part (for courses aligned to NIMS) or produce a good (for courses aligned to MSSC) meeting customer requirements. This course should also provide students with a basic

	ORIENTATION / INTRODUCTION Grades 9–10	SKILL DEVELOPMENT Grades 10–12	CAPSTONE / ADVANCED Grades 12	POSTSECONDARY COURSES ⊕ Recommended 1st Year
SCIENCE	Science Sequence	Science Sequence	Physics »	General Physics General Chemistry
SOCIAL SCIENCE	Social Science Sequence	Social Science Sequence	Social Science »	Social Science
MATH	Algebra Geometry	Geometry Algebra 2 Pre-Calculus	Transitional Math: Technical Transitional Math: STEM Pre-Calculus College Algebra Calculus »	Technical Math College Algebra / Trigonometry Calculus
ENGLISH	English Sequence	English Sequence	Transitional English English Composition »	English Composition Oral Communication

» *AP or Dual Credit*

Dual Credit Course

Dual Credit Course Affiliated With IAI Code

Course or Program Prepares for Industry Credential

Postsecondary Course Affiliated with IAI Code

College and Career Pathway Endorsement Earned

⊕ *If courses in this column were accomplished through early college credit, students should take the next required course in the sequence or, if none, additional AAS or Major Courses*

understanding of supply chain logistics, maintenance, and robotic automation. However, students seeking to pursue entry-level careers in industrial maintenance and automation fields will require at least a postsecondary certificate, and typically an AAS.

The high school and community college partner should ensure that upon concluding the capstone course and the other recommended secondary courses in the Advanced Manufacturing course sequence, students will have earned at least 9 - 12 dual credit hours from the community college applicable to aligned Manufacturing CTE programs. In addition, students will be prepared to attain industry certifications in MSSC or NIMS expected for entry-level employment: the MSSC Certified Production Technician Certificate, or the NIMS Level I CNC Turning (Lathe) Operations and CNC Mill Operations certificates. This coursework will require the high school to either invest in CNC machines, or arrange for their use at the community college, a regional vocational school, or an employer site.

Recommended High School General Education Courses

The Model Programs of Study for Manufacturing and Engineering identifies several key considerations for general education coursework:

- In **science**, students should complete physics, where possible, as either Advanced Placement or dual credit.
- In **math**, students should complete the highest math course possible in a calculus-based course sequence to be prepared for the full range of career options in Manufacturing and Engineering. Districts should consider math courses that contextualize math application in career fields, such as Geometry In Construction and that expose students to data analytics occurring in the context of manufacturing businesses. Students that do not demonstrate readiness for an early college math course during their senior year of high school should enroll in a Transition to STEM Transitional Math Course that guarantees placement into College Algebra at the postsecondary level. Students pursuing a Welding or Machining & Production postsecondary credential may instead consider a Technical Transitional Math Course if it guarantees placement into the required math for that credential at the partner community college.
- In **English**, students prepared for college-level coursework in their senior year should enroll in a dual credit English Composition course (if available) or Advanced Placement English Language and Composition. If students are not prepared for college-level coursework, students should enroll in a Transitional English course that guarantees placement into the partner community college's English Composition course.

Recommended First Year Postsecondary Courses

The recommended first-year postsecondary courses in the Model Programs of Study for Manufacturing and Engineering build upon the knowledge and skills recommended at the capstone level. As with other high school programs, community colleges should pursue opportunities to integrate and align Advanced Manufacturing and Engineering coursework and work-based learning opportunities. In the Advanced Manufacturing-focused pathways, students in machining-related programs will take more advanced CNC programming courses as well as a course such as "Manufacturing Materials and Processes" that focuses on the properties of materials and their transformation into fabricated components and finished goods. In the Engineering-focused pathways and some Advanced Manufacturing pathways, students will take coursework in areas such as Industrial Electricity addressing electrical theory, electrical circuits and components, and basic electrical maintenance. In addition, students in Engineering-focused pathways will take advanced coursework in computer-aided drafting (CAD) and computer-aided manufacturing (CAM) technology. In the general education course areas, students will take the required 100-level courses. In science, this will be typically be Physics 101, although Process Operations credentials will also require a foundation in Chemistry. If the 100-level courses have been accomplished through early college credit, students will take the next required course in the subject or, if none, additional AAS or courses in their major.

[7] As six early college credit hours are needed for the College and Career Pathway Endorsement, the high school and college should seek to meet this threshold in the Skill Development course sequence.

[8] careersafeonline.com

Advanced Manufacturing and Engineering High School Course Sequence and Competencies

ORIENTATION

Introduction to Technology & Engineering

Goal: Students build pathway awareness, excitement, and foundational knowledge.

Competencies:

- Students can demonstrate awareness of the career pathways in advanced manufacturing and engineering in order to plan a personalized pathway leading to a promising credential.
- Students can demonstrate awareness of and have exposure to the range of manufacturing processes including fabrication, machining, non-durable good production, additive manufacturing, and robotic automation in order to contextualize their instruction in the field.
- Students can use their understanding of safety practices and PPE in order to demonstrate a safety mindset when navigating a manufacturing environment.
- Students can use their understanding of simple hand and power tools in order to identify, correctly set-up, and safely operate them.
- Students can use their understanding of simple machines to describe how levers, gears, pulleys, and other simple machine components work.
- Students can use their understanding of basic concepts in layout, print reading, measurement, and quality practices in order to describe the steps in the design and development process.

Students have engaged in career exploration activities that include virtual and in-person site visits to engineering firms, manufacturers of both durable and non-durable goods, and engagement with guest speakers.

Students have documented a personalized career pathway leading to a promising credential in Advanced Manufacturing or Engineering.

SKILL DEVELOPMENT

Foundations of Production & Manufacturing Processes (Minimum 3–6 Dual Credit Hours)

Goal: Students engage in teacher-directed machining applications.

Competencies (scaffolding upon Orientation competencies):

- Students can use their understanding of safety principles in equipment usage, practices, and procedures in order to maintain a secure work environment and safely engage in manufacturing processes.
- Students can use their understanding of personal safety and environmental regulations to comply with local, federal, and company health and safety demands.
- Students can use their understanding of basic machining or other automated production methods to conduct authentic projects under close adult direction and supervision.
- Students can apply basic concepts in layout, print reading, measurement, and quality assurance practices in authentic situations.
- Students can apply their understanding of supply chain logistics in an authentic situation involving the movement and storage of materials and products.

Students have engaged in:

- Additional virtual and in-person site visits to manufacturing and engineering employers;
- A job shadow with a professional in the field; and
- At least one team-based challenge, such as a robotics team or SkillsUSA competition.

Students are prepared to attain:

- OSHA 10-hour course completion card
  and
- MSSC Safety + Quality Practices & Measurement
  or
- NIMS ML I: Measurement, Materials, and Safety + Job Planning, Benchwork & Layout

CAPSTONE

Advanced Production & Manufacturing Processes (Minimum 3–6 Dual Credit Hours)

Goal: Students are self-directed in production applications.

Competencies (scaffolding upon Skill Development competencies):

- Students can use their understanding of production applications and production process to, with minimal supervision, plan, calculate, and safely (i) machine a part meeting customer requirements (for courses aligned to NIMS) or (ii) make a product within a production system (for courses aligned to MSSC) meeting customer requirements.
  - This competency addresses the following sub-competencies included within the PWR Advanced Manufacturing and Engineering Technical Competencies: Equipment Safety; Manufacturing Environment; Personal Health & Safety; Spatial Reasoning; Process, Design, & Development; Installation; and Customer Focus.
- Students can apply their understanding of supply chain logistics in authentic scenarios involving materials for the part or product and its distribution to the customer.
- Students can apply their understanding of digital manufacturing tools and robotic automation in an authentic situation involving their application within production applications.
- Students can apply their understanding of quality control practices and continuous improvement in an authentic situation involving quality system requirements as defined by customer specifications.
- Students can use their understanding of maintenance principles and requirements to recognize potential maintenance issues and perform preventative maintenance and routine repairs.

Students have engaged in:

- At least one additional team-based challenge, and
- A career development experience of a minimum of 60 hours with a manufacturer or engineering employer sponsor.

Students are prepared to attain:

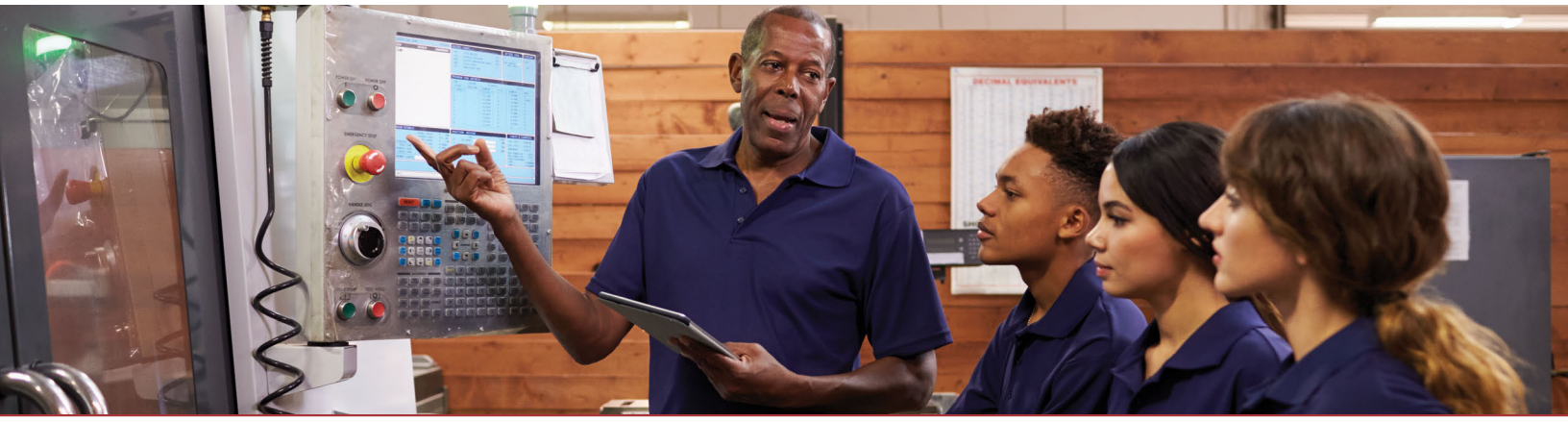
- MSSC Certified Production Technician ***or***
- NIMS Level I CNC Turning (Lathe) Operations + Mill Operations

APPENDIX A.1: PWR Act Recommended Technical Competencies for Manufacturing and Engineering

MANUFACTURING, ENGINEERING, TECHNOLOGY & TRADES

TOP 10 TECHNICAL COMPETENCY STATEMENTS FOR **ADVANCED MANUFACTURING & ENGINEERING**

Equipment Safety	Students can use their understanding of equipment usage, practices, and procedures to maintain a healthy, safe, and secure work environment.
Manufacturing Environment	Students can use their understanding of workstations, tools, and equipment operations to safely navigate a manufacturing environment.
Personal Health & Safety	Students can use their understanding of personal safety and environmental regulations to comply with local, federal, and company health/safety demands.
Spatial Reasoning	Students can use their understanding of objects in relation to one another to understand three-dimensional imaging.
Process, Design, & Development	Students can use their understanding of technical drawings and schematics to complete the design and development process.
Installation	Students can use their understanding of tools to assemble and disassemble simple tools.
Customer Focus	Students can use their understanding of communication and project management to understand client needs and complete project accordingly.
Quality Assurance & Continuous Improvement	Students can use their understanding of product and process to meet quality systems requirements as defined by customer specifications.
Digital Manufacturing	Students can use their understanding of digital manufacturing tools and computer-based programs to complete the design and develop implementation process.
Supply Chain Logistics	Students can use their understanding of materials, suppliers, and internal systems to plan and monitor movement and storage of materials and products.



APPENDIX A.2: PWR Act Essential Employability Competencies

TOP 10 CROSS-SECTOR **ESSENTIAL EMPLOYABILITY COMPETENCY STATEMENTS**	
Teamwork & Conflict Resolution	Students can use their understanding of working cooperatively with others to complete work assignments and achieve mutual goals.
Communication	**Verbal:** Students can use their understanding of English grammar and public speaking, listening, and responding, convey an idea, express information, and be understood by others. **Written:** Students can use their understanding of standard business English to ensure that written work is clear, direct, courteous, and grammatically correct. **Digital:** Students can use their understanding of email, keyboarding, word processing, and digital media to convey work that is clear, direct, courteous, and grammatically correct.
Problem Solving	Students can use their critical thinking skills to generate and evaluate solutions as they relate to the needs of the team, customer, and company.
Decision Making	Students can use their understanding of problem solving to implement and communicate solutions.
Critical Thinking	Students can use their understanding of logic and reasoning to analyze and address problems.
Adaptability & Flexibility	Students can use their understanding of workplace change and variety to be open to new ideas and handle ambiguity.
Initiative & Self-Drive	Students can use their understanding of goal setting and personal impact to achieve professional goals and understand personal impact.
Reliability & Accountability	Students can use their understanding of commitment, time management, and follow through to ensure that a professional team functions properly and meets collective goals.
Cultural Competence	Students can use their understanding of diversity and inclusion to communicate and work effectively across a multitude of abilities, cultures, and backgrounds.
Planning & Organizing	Students can use their understanding of time management to plan effectively and accomplish assigned tasks.

APPENDIX B: Advisory Committee Membership

Natasha Allen
Director for Career & Technical Education
Illinois Community College Board

Jon Althaus
Vice President for Academic Services
Lake Land College

Nancy Awdziejczyk
Executive Director
Northwest Educational Council for Student Success

Joseph Bachman
Central Illinois Vocational Education Coop System Director
Metamora Township High School

Brent Baker
Director of Workforce Solutions
Greater Peoria Economic Development Council

Kathy Burley
Executive Director
Golden Corridor Advanced Manufacturing Partnership

Jon Furr
Executive Director
Education Systems Center at Northern Illinois University

Angela Gerberding
Associate Director for Integrated Career Programs
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Kathy Gilmore
President
Valley Industrial Association

Juan Jose Gonzalez
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Robert Gosch
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Susan Grzanich
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Mario Kratsch
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German American Chamber of Commerce of the Midwest

Kim Kuchenbrod
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Kathy Lively
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Amanda Martin
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Tom McGee
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Mollie Dowling
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Jim Nelson
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David Osborne
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Patrick Osborne
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