STATE OF ILLINOIS

Model Programs of Study Guide

Manufacturing and Engineering

PATHWAYS

ICCB
ILLINOIS COMMUNITY COLLEGE BOARD

EdSystems
EDUCATION SYSTEMS CENTER at 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 EdSystems

Education Systems Center (EdSystems) is a mission-driven policy development and program implementation center based within Northern Illinois University. We work at the state level to create ecosystem and policy change while simultaneously working at the local level to create organizational change. This bi-directional approach allows us to align local efforts to state policy while elevating local experiences and learnings to state tables. Learn more at edsystemsniu.org.

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I. About the Model Programs of Study Guide

The Illinois Community College Board (ICCB) sponsored the development of the State of Illinois 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 pathway programs to adopt or customize as they develop programs of study for approval as part of Perkins V or Illinois' College and Career Pathway Endorsements.
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 sector's program of study 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 work-based learning 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, Recommended Technical and Essential Employability Competencies, State of Illinois Workforce Development 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 Model Programs of Study Guide in Manufacturing and Engineering can be used as a reference in local planning processes. The guide presents and describes in detail each component of the sequence, including descriptions of the underlying research, analysis, and Advisory Committee input. In addition to the complete guide, a pathway map depicting the diagrams of the secondary and postsecondary sequences, as well as a table of the selected occupations, wages, and job growth, is available at the end of this document or at edsystemsniu.org/guides.

II. Development of the 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. The State of Illinois Model Programs of Study Guides are aligned with broader state policy goals to promote college and career readiness, including the state's Perkins V and ESSA plans (in particular, the College and Career Readiness Indicator), the Postsecondary and Workforce Readiness Act, the Dual Credit Quality Act, and the Illinois Career Pathways Dictionary.

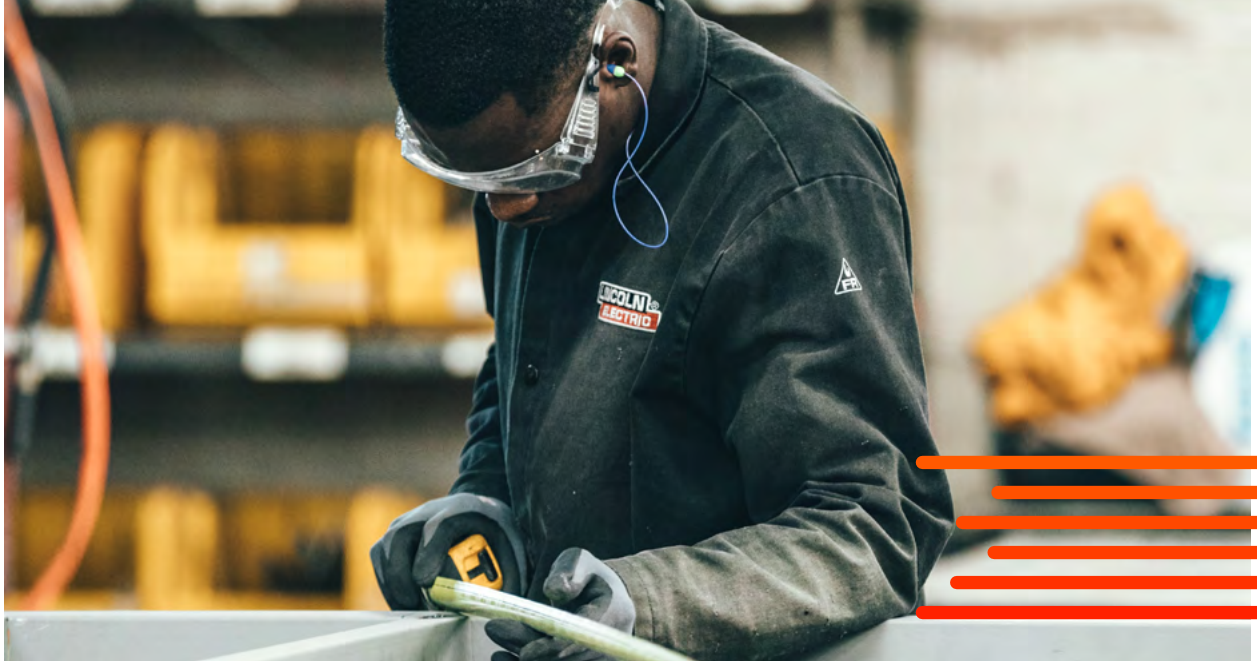
Process for Development

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 Illinois.
2. **Identifying promising postsecondary credentials** (degrees or certificates) that are broadly accessible to and 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 broadly among promising credentials, provide a solid 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 is applicable to both Illinois secondary and postsecondary Perkins V requirements.
6. **Defining related technical competencies** for the foundational program of study courses that can be utilized to guide course development and postsecondary articulation.

Using data from the Department of Labor, Illinois Department of Employment Security, and MIT's Living Wage Calculator for the State of Illinois as a reference, the project team identified "high-priority occupations" as jobs with a positive growth outlook over the next 10 years, of high relative volume within that industry sector, and with median salaries that could sustain various family sizes within Illinois.[1] Occupations with median salaries higher than the living wage for 1 adult + 1 child ($39.63/hour) are considered as having a "high" living wage potential. Occupations with median salaries only higher than the living wage of 1 adult, no children ($22.86/hour) are considered as having a "medium" living wage

[1] U.S. Department of Labor, Employment and Training Administration (n.d.). "Explore Careers." CareerOneStop. Retrieved December 2023, from careeronestop.org/explorecareers. Illinois Department of Employment Security, "Long-Term Occupational Projections 2020-2030" and "Wage Information: Occupational Employment and Wage Statistics (OEWS) Statewide." Retrieved December 2023, from ides.illinois.gov. Amy K. Glasmeier, "Living Wage Calculator," Massachusetts Institute of Technology, 2024. Retrieved December 2023, from livingwage.mit.edu.



potential, and occupations with median salaries below the living wage of 1 adult, no children (less than $22.86/hour) are considered as having a "low" living wage potential.

The team identified as a "promising credential" any degree or certification that immediately prepares an individual for entry into or is a stackable for the identified high-priority occupations, then 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.[2] EdSystems analyzed and categorized all the career-focused and general education courses across the full sampling of the promising credential programs to determine which of these courses:

- are broadly common across multiple college programs in the sample,
- are likely accessible for dual credit opportunities considering student prerequisites and teacher credentialing requirements, and
- are generally transferable through Illinois Articulation Initiative or various articulation agreements.

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 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 or IDES 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, including adjusting the course map and promising credential endpoints, selecting strategic early college credit courses, and identifying key competencies for target courses lacking broad statewide articulation. The culmination of EdSystems' analysis and the input of the Advisory Committee is reflected in this guide.

[2] For the analysis of this guide, EdSystems surveyed City Colleges of Chicago, College of Lake County, Elgin Community College, Illinois Central College, McHenry County College, Rock Valley College, and Southwestern Illinois College.

III. Priority Occupations and Promising Credentials

Manufacturing and engineering occupations are a cornerstone of the Illinois economy. According to the Illinois Manufacturers' Association, the total economic impact of manufacturing in Illinois is estimated to be between $580 billion and $611 billion every year—the largest share of the state's Gross Domestic Product by any industry. Further, the industry directly provides 9.5 percent of total employment in Illinois, and indirectly supports 29.6 of overall Illinois employment.[3] These occupations are spread across a breadth of manufacturing employer types, including metalworking, automotive production, plastic, food processing, and chemical processing. The COVID-19 public health crisis demonstrated the need to ensure the manufacturing supply chain is protected from disruption by international events. The continued availability of a qualified workforce in manufacturing and engineering is essential as this sector continues to serve as an anchor for Illinois' economic growth and recovery.

Promising 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 two credential program categories or pathways and additional subcategories:

1. **Advanced manufacturing**
    a. **Welding** credentials for careers in welding, fabrication, and structural steel industries.
    b. **Machining and production** credentials for careers utilizing manufacturing processes to transform raw material into a finished product. Subcategories include:
        - Machine tool technology, involving the set-up, operation, and testing of machines before production.
        - Precision machining and production, involving the set-up, testing, and operation of manufacturing machines and equipment involving a variety of types of production processes.
    c. **Industrial maintenance** credentials, preparing students to install, repair, adjust, and maintain industrial production and processing systems.
2. **Engineering and automation** credentials, preparing students for a range of careers to analyze, design, evaluate, and continuously improve complex manufacturing and industrial systems. Subcategories include:
    a. Computer integrated manufacturing and 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, focusing on mechanical or industrial engineering.

[3] Illinois Manufacturers' Association (2022, August). "Manufacturing Matters: Our Impact in Illinois." Retrieved April 2024, from ima-net.org/wp-content/uploads/2022/08/ManufacturingMatters2022.pdf.

Diagram: **Postsecondary Opportunities**

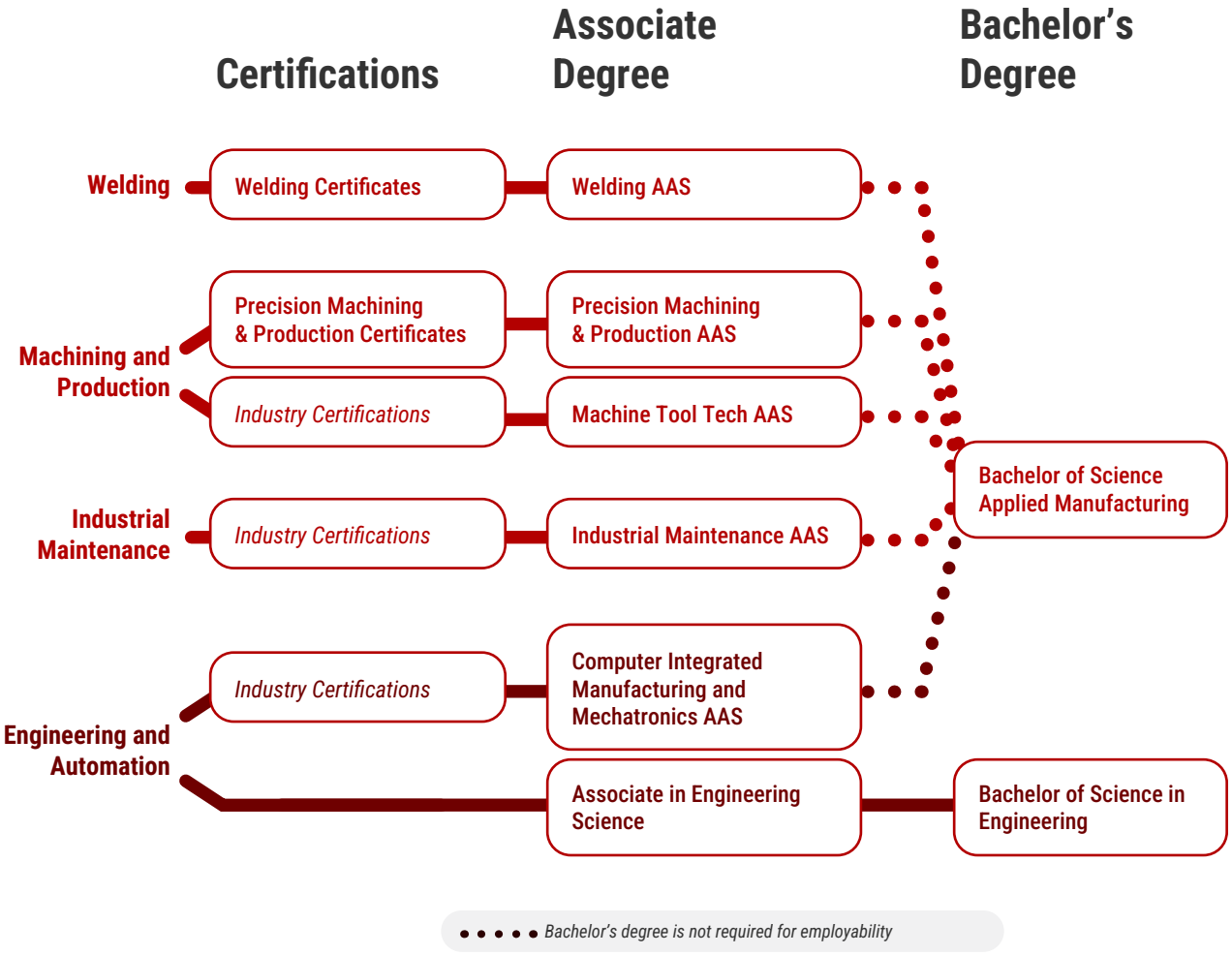


Table: **Selected Occupations, Wages, and Job Growth**

Program	Typical Job(s)	Living Wage Potential*	Median Annual Wage**	IL Growth: Change over 10 years ***	IL Annual Job Openings***	Typical Educational Requirements
Welding	Welders, Cutters, Solderers, and Brazers	Medium	$23.37	10.3%	1,765	High School Diploma
Machining and Production	Tool and Die Makers	Medium	$29.78	2.4%	456	Postsecondary Certificate
	Machinists	Medium	$24.13	9.1%	3,280	High School Diploma, Some College
	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	Medium	$22.05	9.7%	1,325	
	Computer Numerically Controlled Tool Programmers	Medium	$30.22	29.1%	175	
Industrial Maintenance	Industrial Machinery Mechanics	Medium	$29.96	27.2%	1,680	High School Diploma, Some College
Engineering and Automation	Electrical and Electronic Engineering Technologists and Technicians	Medium	$32.96	1.2%	280	Associate Degree
	Industrial Engineering Technologists and Technicians	Medium	$30.85	7.0%	195	
	Mechanical Engineering Technologists and Technicians	Medium	$33.46	7.0%	166	
	Mechanical Engineers	High	$47.34	8.7%	872	
	Industrial Engineers	High	$48.88	15.6%	1,028	Bachelor's Degree

* Living wage potential is based on MIT's Living Calculator (livingwage.mit.edu) for Illinois in 2024. Occupations with median salaries higher than the living wage for 1 adult + 1 child ($39.63/hour) are considered as having a "high" living wage potential. Occupations with median salaries only higher than the living wage of 1 adult, no children ($22.86/hour) are considered as having a "medium" living wage potential, and occupations with median salaries below the living wage of 1 adult, no children (less than $22.86/hour) are considered as having a "low" living wage potential.

** Illinois Department of Employment Security (2022). Wage Information: Occupational Employment and Wage Statistics (Statewide). Retrieved April 2, 2024, from ides.illinois.gov/resources/labor-market-information/oews.html

*** Illinois Department of Employment Security. Employment Projections (Long-Term Occupational Projections 2020-2030). Retrieved April 2, 2024, from ides.illinois.gov/resources/labor-market-information/employment-projections.html

High-Priority Occupations

The high-priority occupations associated with each of the promising credential program areas are identified in the table entitled Select Occupations, Wages, and Job Growth. The occupations associated with CNC programming, industrial maintenance, computer integrated manufacturing technologists, mechatronics, and engineering all met the job growth and living wage threshold described in this guide. In Illinois, occupations as industrial machinery mechanics, various skilled technologist or technician roles, and various types of engineers have relatively high projected growth in the number of annual openings.

Promising credentials include machine tool technology, because of its capacity to lead to jobs with a living wage and its adaptability to other careers in machining and manufacturing, and welding, due to its importance in many regions and its integration with other manufacturing credential programs.

Levels of Education Needed

The levels of education needed for advanced manufacturing and engineering and automation pathways vary greatly. Two-thirds of welders, cutters, solderers, and brazers have no postsecondary education, making this career highly accessible for students receiving industry credentials and training in high school. A majority of CNC programmers and industrial machinery mechanics have some postsecondary education, and entry-level positions are accessible upon completion of a short-term postsecondary credential. For welding and machining pathways, employers often rely on industry certifications as validation of competencies; hundreds of industry certificates are available in the sector.

The course sequence in this guide 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 earn the MSSC Certified Production Technician or NIMS Operator certificates and a stackable community college credential as entry-level career 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. Through community college programs, students should be prepared to earn additional stackable industry credentials.

Careers in 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 baccalaureate degree program at a later stage in their careers, an AAS is recommended in these pathways.

Several Illinois universities offer a Bachelor of Science in Applied Manufacturing Technology or Applied Engineering that articulate AAS degrees in advanced manufacturing or engineering.[4] Whenever possible, community colleges should ensure that AAS degrees in advanced manufacturing or engineering articulate to baccalaureate degree programs that offer articulation. Students may need targeted instructional supports to complete the math sequence requirements typical of bachelor's degrees.

Engineer positions typically require a Bachelor of Science degree, a requirement for licensure. Therefore, engineering is depicted as a guided transfer program pathway, from an Associate of Science to a Bachelor of Science in Engineering.

[4] Examples include Northern Illinois Unversity's Bachelor of Science in Engineering Technology with an emphasis in Applied Manufacturing Technology, Southern Illinois University's Bachelor of Science in Industrial Management and Applied Engineering, or Governors State University's Bachelor of Arts in Manufacturing Management.

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 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 included course sequences and competencies.

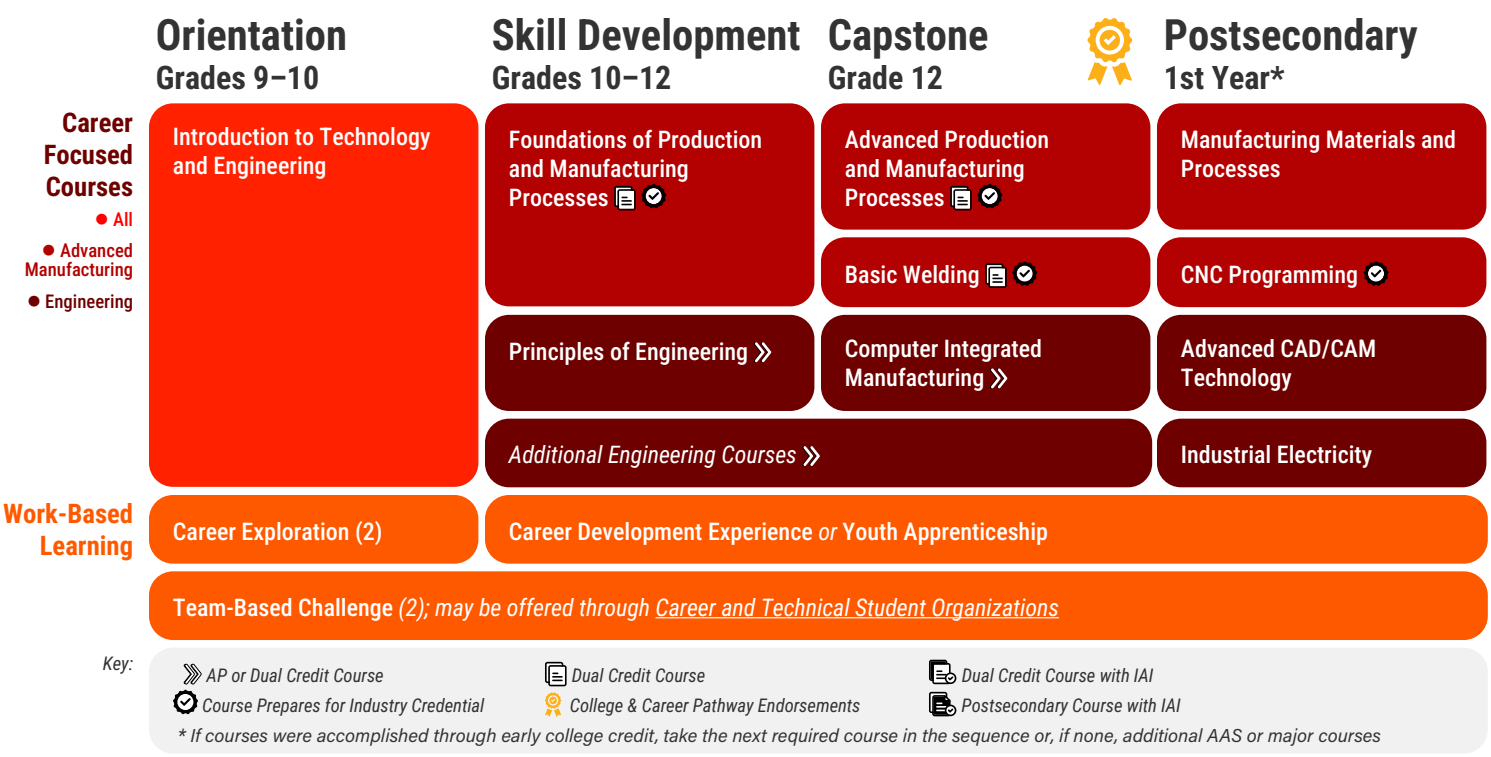
IV. Programs of Study Sequence Description

The Model Programs of Study in Manufacturing and Engineering begin in high school by introducing students to the broad range of careers in this field, and then enable students to pursue either an advanced manufacturing or engineering focus while in high school. In postsecondary, students will pursue promising credentials in one of the four areas: welding, machining and production, industrial maintenance, or engineering and automation. In all but welding, students can continue a course sequence through stackable credentials and associate degrees to a Bachelor of Science program.

Students should generally start a career-focused instructional sequence with an orientation course in 9th or 10th grade, with students engaging in career awareness and exploration in the middle school grades if possible. With this early start, students have more openings in their schedule to complete skill development and capstone options, obtain significant early college credits, earn valuable industry credentials, and potentially acquire a College and Career Pathway Endorsement before high school graduation.

As school districts and their community college partners develop a program of study sequence, they should ensure that the high school coursework enables all students in the pathways to attain Illinois' Recommended Essential Employability and Technical Competencies and the top relevant technical competencies (see Appendix A).

Diagram: **Career-Focused Instructional Sequence**



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

The career-focused instructional sequence 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. However, students should not be limited to either focus area; instead, the high school program should support integration and expanded opportunities for taking courses across both advanced manufacturing and engineering 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 curriculum options that incorporate secondary, postsecondary, and employer input.

Orientation Coursework

The orientation level commences with the broadly applicable Introduction to Technology and Engineering course, through which 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. Schools may use the Project Lead the Way Introduction to Engineering Design for this course, with enhancements to address the course expectations. The course may also provide an introduction to other related career clusters, such as architecture, construction, and energy.

To begin preparing for the College and Career Pathway Endorsements, students should also participate in multiple virtual and in-person visits to employer sites to better understand authentic industry environments and engage with professionals in the field. Students should hear from a variety of guest speakers in an array of manufacturing and engineering careers to better understand opportunities in the field. Through the orientation course, students should be prepared to document their own personalized career pathway that leads to a promising credential.

Skill Development Coursework

The skill development level includes Foundations of Production and Manufacturing Processes, an advanced manufacturing-focused course recommendation. Generally aligned to the Project Lead the Way sequence, 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 and 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. The course emphasizes application of safety, production processes, and other basic concepts under close teacher direction, and should utilize authentic projects addressing realistic customer needs. Understanding production, either machining or non-durable production processes, is critical for students planning for a career requiring postsecondary credentials. The course competencies scaffold on to those attained in the orientation-level Introduction to Technology and Engineering course, and, for machining-focused programs, address the expectations of the Beginning Machining and Machine Shop Technology I courses in ISBE's Career and Technical Education (CTE) program. 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 at the this level as well as more advanced courses in the sequence.

In addition, students should be prepared to attain the foundational certifications in MSSC (Safety; Quality Practices and Measurement) or NIMS Machining Level I (Measurement, Materials, and Safety; Job Planning, Benchwork and 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. Students should also attain the Occupational Safety and Health Administration (OSHA) ten-hour course completion card, which can be earned online through the CareerSafe program.

To be on track to earn the College and Career Pathway Endorsements, regional high school and community college partners should ensure students have earn three to six early college credit hours through the skill development courses. Additionally, students should continue progressing through the work-based learning continuum. 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 related to their program area, such as a robotics or SkillsUSA Illinois or Technology Student Association of Illinois competitions. Team-based challenges should be completed either as activities embedded within course curriculum or through a student/extracurricular organization. Students should be encouraged to engage in student or professional manufacturing and engineering organizations, including Career and Technical Student Organizations, to continue to build familiarity with the profession and pathways towards various career options.

Capstone Coursework

At the capstone level, students engage in advanced topics in advanced manufacturing, engineering, or both. The recommendations for students with an advanced manufacturing focus are to either complete the Advanced Production and Manufacturing Processes course (or two-semester sequence), or, for students interested in pursuing a welding career, the Basic Welding Course. Basic Welding 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.

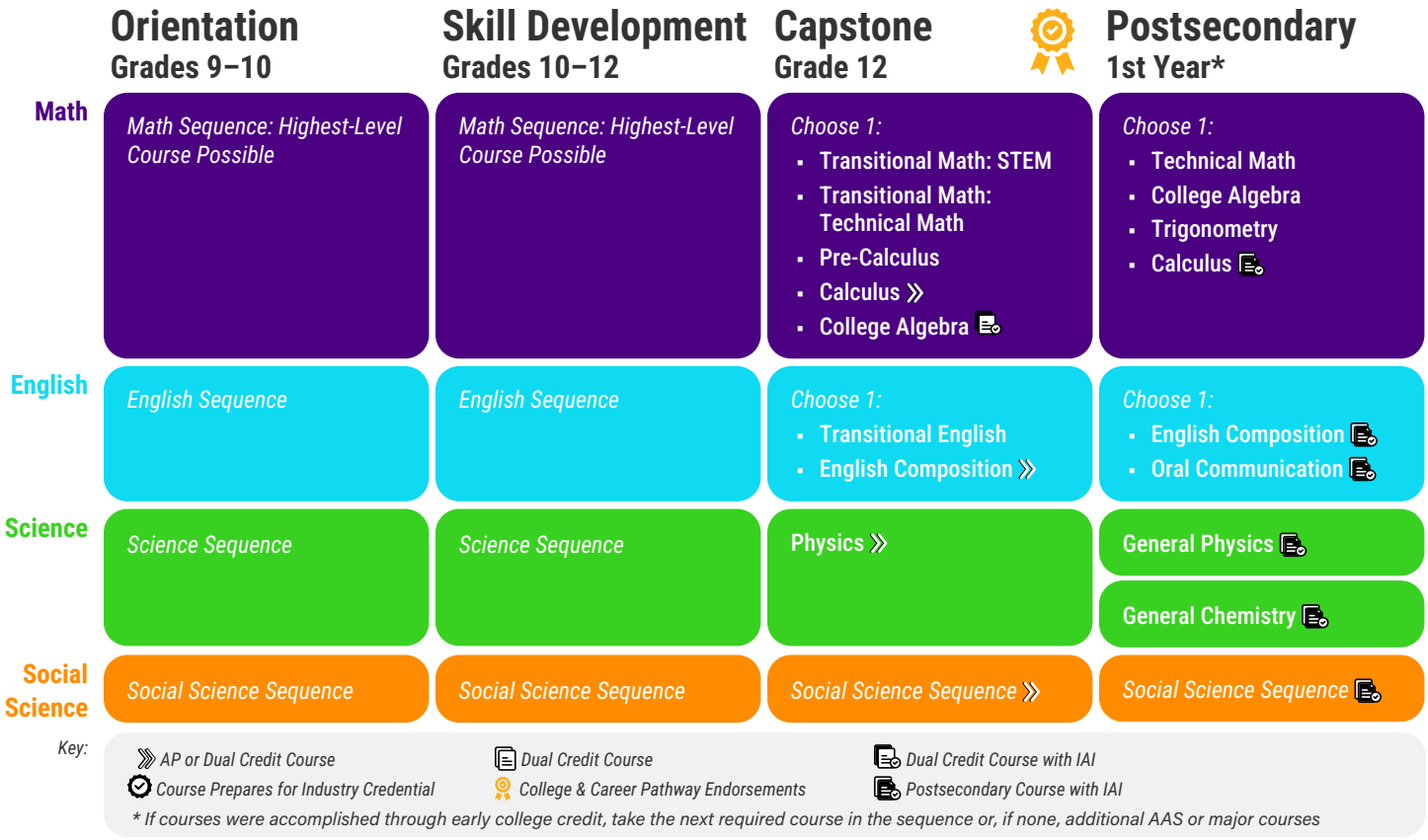
Students with an engineering focus should complete the Computer Integrated Manufacturing course (based on the Project Lead the Way sequence), and additional career-focused coursework schedules permit. Computer Integrated Manufacturing should require students to (i) engage with computer aided manufacturing (CAM) software and (ii) design, build, program, and present a manufacturing system model capable of creating a product.

The Advanced Production and 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, 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 understanding of supply chain logistics, maintenance, and robotic automation. However, students seeking entry-level careers in industrial maintenance and automation fields will require at least a postsecondary certificate, and typically an associate degree.

Students should 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.

To be eligible for the College and Career Pathway Endorsements, all students should complete a career development experience of at least 60 hours in length and earn at least six or more early college credit hours, through a mix of both career-focused and general education coursework. 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. Additionally, students should continue participation in clubs, professional organizations, or challenges related to their pathway, such as robotics.

Diagram: **General Education Instructional Sequence**



High School General Education Courses

There are several critical considerations for general education coursework before graduating high school. The courses mentioned here are frequent requirements for many postsecondary promising credentials in manufacturing and engineering and enhance students' opportunities for postsecondary success in addition to the career-focused courses already delineated.

- In **science**, students should complete physics, where possible, as either Advanced Placement (AP) or dual credit.
- In **math**, students should complete the highest course possible in a calculus-based sequence to be prepared for the full range of career options in manufacturing and engineering. Districts should consider math courses that contextualize 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 Transition to STEM, a transitional math course that guarantees placement into College Algebra at the postsecondary level. Students pursuing a postsecondary credential in welding or machining and production may instead take Technical Math, also a 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 AP English Language and Composition. If 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.

First-Year Postsecondary Courses

The recommended first-year postsecondary courses build upon the knowledge and skills recommended at the capstone level. As with high school programs, community colleges should pursue opportunities to integrate and align advanced manufacturing and engineering coursework and work-based learning opportunities.

In advanced manufacturing 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 engineering 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, engineering pathway students 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.

V. Strategic Dual Credit Courses: Competency Descriptions

EdSystems and ICCB convened a stakeholder Advisory Committee of secondary, postsecondary, and private sector representatives to vet the Model Program of Study recommendations. A smaller working group further convened to identify key competencies for the targeted early college course currently lacking current statewide articulation. In manufacturing and engineering, those courses are Introduction to Technology and Engineering, Foundations of Production and Manufacturing Processes, and Advanced Production and Manufacturing Processes.

INTRODUCTION TO TECHNOLOGY AND ENGINEERING Key Competencies	
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.
Work-Based Learning	• Students can assess and implement procedures used to recruit, train, and retain employees in order to create a sustainable pipeline of human resources for AFNR operations. • Students can identify and apply business management skills in order to conduct AFNR business operations in an efficient, legal, and ethical manner. • Students can use their understanding of verbal and written communication to effectively maintain relationships with employers, employees, and customers.
Postsecondary and Career Expectations	Students have documented a personalized career pathway leading to a promising credential in Advanced Manufacturing or Engineering.

FOUNDATIONS OF PRODUCTION AND MANUFACTURING PROCESSES Key Competencies	
Goal	Students engage in teacher-directed machining applications.
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.
Work-Based Learning	• 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.
Credential Preparation	Students are prepared to attain either: • OSHA 10-hour course completion card and MSSC Safety + Quality Practices and Measurement • NIMS ML I: Measurement, Materials, and Safety + Job Planning, Benchwork and Layout

ADVANCED PRODUCTION AND MANUFACTURING PROCESSES Key Competencies	
Goal	Students are self-directed in production applications.
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: equipment safety; manufacturing environment; personal health and safety; spatial reasoning; process, design, and 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.
Work-Based Learning	• 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.
Credential Preparation	Students are prepared to attain either: • MSSC Certified Production Technician • NIMS Level I CNC Turning (Lathe) Operations + Mill Operations

Appendices

A.1: Technical and Essential Employability Competencies for Manufacturing, Engineering, Technology, and Trades

The following technical and employability competencies for agriculture, food, and natural resources are from "Recommended Technical and Essential Employability Competencies for College and Career Pathway Endorsements," a document developed through an iterative process involving public-private steering committees established pursuant to the Postsecondary and Workforce Readiness Act in order to implement College and Career Pathway Endorsements.

Technical and Essential Employability Competencies for **MANUFACTURING, ENGINEERING, TECHNOLOGY, AND TRADES**	
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 threedimensional 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.

A.2: Cross-Sector Essential Employability and Entrepreneurial Competencies

The following cross-sector competencies are from "Recommended Technical and Essential Employability Competencies for College and Career Pathway Endorsements," a document developed through an iterative process involving public-private steering committees established pursuant to the Postsecondary and Workforce Readiness Act in order to implement College and Career Pathway Endorsements.

ESSENTIAL EMPLOYABILITY COMPETENCIES	
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.

ENTREPRENEURIAL COMPETENCIES	
Principles of Entrepreneurship	Students can apply their understanding of the process and characteristics of business development and promotion in order to apply strategies of innovation to personal and professional business pursuits.
Innovation & Invention	Students can use their understanding of idea generation, design thinking, product and business development in order to introduce and process new and effective ideas.
Growth Mindset	Students can use their understanding of learning from challenges, set-backs, and failure in order to adapt strategies and continue efforts to achieve personal goals.

B: 2020 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

Paul Carlson
Associate Dean of Business & Technology
Kankakee Community College

Angela Gerberding
Associate Director for Integrated Career Programs
Illinois Community College Board

Kathy Gilmore
President
Valley Industrial Association

Robert Gosch
Principal
River Bend School District

Susan Grzanich
Innovation and Grants Officer
Peoria Public Schools District 150

Christopher Kendall
System Director
Peoria Educational Region for Employment & Career Training

Mario Kratsch
Vice President
German American Chamber of Commerce of the Midwest

Kim Kuchenbrod
Workforce Development Consultant
Vermilion Advantage

Michael Kuhn
Principal
Woodruff Career & Technical Center

Kathy Lively
Chief Executive Officer
Man-Tra-Con Corp

Amanda Martin
Assistant General Manager, Corporate Human Resources
North American Lighting, Inc.

Tom McGee
Dean of Career and Technical Education
McHenry County College

Mollie Dowling
Executive Director
OAI, Inc.

Jim Nelson
Vice President, Education & Workforce Policy
Illinois Manufacturers' Association

David Osborne
Principal Consultant
Illinois State Board of Education

Patrick Osborne
Vice President of Training & Education
Technology & Manufacturing Association

Steve Parrott
Technology and Engineering Education Principal Consultant
Illinois State Board of Education

Analiesa Rackauskas
Division Talent Development Manager ITDD & ACM
Caterpillar Inc.

Andrew Rice
Teacher of Engineering, Manufacturing, and Welding
Manual Academy

Virginia Rounds
Director, Apprenticeship Networks Chicago
German American Chamber of Commerce of the Midwest

Blanche Schoup
President/CEO
Western Illinois Works

Brad Sparks
Dean of Technical Education
Southwestern Illinois College

Whitney Thompson
Senior Director for Career & Technical Education
Illinois Community College Board

Tom Wendorf
Co-Founder/ Manager
DuPage Impact LLC

Lead EdSystems Staff

Jon Furr
Executive Director

Juan Jose Gonzalez
Pathways Director

Sarah Clark
Development and Communications Director

C: College and Career Pathway Endorsements Framework

The College and Career Pathway Endorsements system is a voluntary system for school districts to award endorsements on high school diplomas to graduates who have demonstrated readiness for college and careers. The following framework for the endorsement system is available as a PDF download.

College and Career Pathway Endorsements Framework

INDIVIDUAL PLAN

Each student completing an endorsement must have an individualized plan, which includes college planning linked to early understanding of career goals, financial aid, resume, and personal statement.

PROFESSIONAL LEARNING

Awareness, exploration, and preparation activities that provide opportunities for students to interact with adults in their workplace and gain essential employability and technical competencies.

9th	10th	11th	12th
At least 2 career exploration activities or 1 intensive experience		60 cumulative hours of paid or for credit, supervised caree development experience(s) with a professional skills assessment r	
At least 2 team-based challenges with adult mentoring			

CAREER-FOCUSED INSTRUCTIONAL SEQUENCE

2 years of secondary coursework or equivalent that include essential employability and technical competencies, at least 6 hours of early college credit, and articulation to a postsecondary credential with labor market value.

9th	10th	11th	12th
Orientation / Introduction Courses			
	Skill Development Courses		
			Capstone / Advanced Courses

ACADEMIC READINESS

Ready for non-remedial coursework in reading and math by high school graduation through criteria defined by the school district and local community college.

D: Illinois' Work-Based Learning Continuum

Illinois has a defined continuum of work-based learning opportunities, which spans from secondary to postsecondary. Components, defined in statute and the Illinois Career Pathways Dictionary, include career awareness, career exploration, team-based challenges, career development experiences, youth or pre-apprenticeships, and apprenticeships.

Work-Based Learning & Host Engagement Continuums

Illinois' continuum represents the many forms of work-based learning that grow in intensity depending on the model. However, this continuum is not intended to convey a fixed or ideal progression. As individuals learn through their work-based learning experiences, they may return to less intensive models to develop different skills or explore additional interests. Individuals should be supported to engage in these activities iteratively as they explore the multiple entry and exit points of career pathways.

Providing high-quality work-based learning requires strong partnerships between educators and regional employers. As the intensity of students' experiences progress, so too does the role of employer partners serving as host sites.

STATE OF ILLINOIS

Model Programs of Study in Manufacturing and Engineering

Recommended Courses

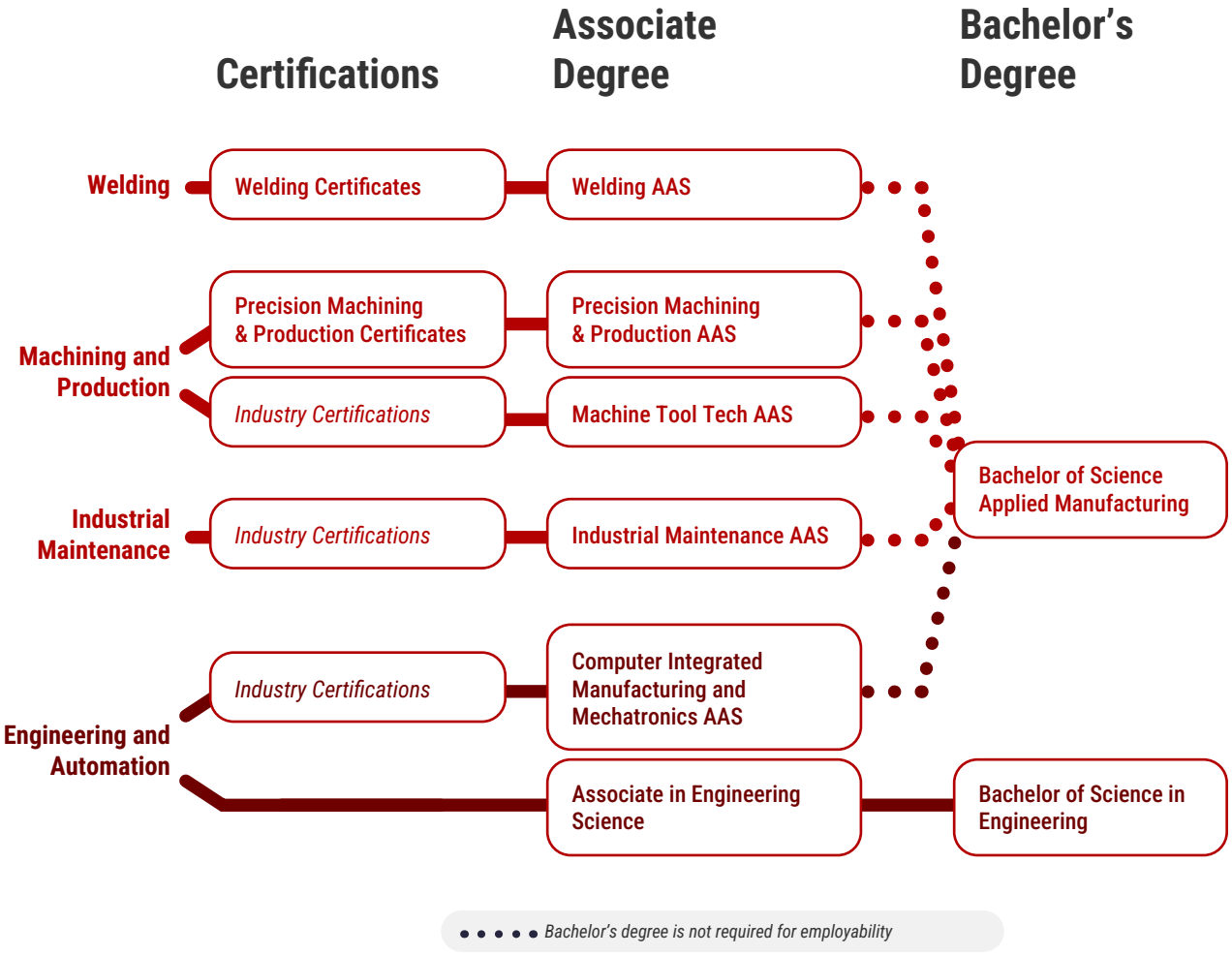
	Orientation Grades 9–10	Skill Development Grades 10–12	Capstone Grade 12	Postsecondary 1st Year*
Career Focused Courses ● All ● Advanced Manufacturing ● Engineering	Introduction to Technology and Engineering	Foundations of Production and Manufacturing Processes	Advanced Production and Manufacturing Processes	Manufacturing Materials and Processes
			Basic Welding	CNC Programming
		Principles of Engineering »	Computer Integrated Manufacturing »	Advanced CAD/CAM Technology
		Additional Engineering Courses »		Industrial Electricity
Work-Based Learning	Career Exploration (2)	Career Development Experience *or* Youth Apprenticeship		
	Team-Based Challenge *(2); may be offered through Career and Technical Student Organizations*			
Math	*Math Sequence: Highest-Level Course Possible*	*Math Sequence: Highest-Level Course Possible*	*Choose 1:* ▪ Transitional Math: STEM ▪ Transitional Math: Technical Math ▪ Pre-Calculus ▪ Calculus » ▪ College Algebra	*Choose 1:* ▪ Technical Math ▪ College Algebra ▪ Trigonometry ▪ Calculus
English	*English Sequence*	*English Sequence*	*Choose 1:* ▪ Transitional English ▪ English Composition »	*Choose 1:* ▪ English Composition ▪ Oral Communication
Science	*Science Sequence*	*Science Sequence*	Physics »	General Physics
				General Chemistry
Social Science	*Social Science Sequence*	*Social Science Sequence*	*Social Science Sequence* »	*Social Science Sequence*

Key:

» *AP or Dual Credit Course*
Dual Credit Course
Dual Credit Course with IAI
Course Prepares for Industry Credential
College & Career Pathway Endorsements
Postsecondary Course with IAI

** If courses were accomplished through early college credit, take the next required course in the sequence or, if none, additional AAS or major courses*

Postsecondary Opportunities



Selected Occupations, Wages, and Job Growth

Program	Typical Job(s)	Living Wage Potential*	Median Annual Wage**	IL Growth: Change over 10 years ***	IL Annual Job Openings***	Typical Educational Requirements
Welding	Welders, Cutters, Solderers, and Brazers	Medium	$23.37	10.3%	1,765	High School Diploma
Machining and Production	Tool and Die Makers	Medium	$29.78	2.4%	456	Postsecondary Certificate
	Machinists	Medium	$24.13	9.1%	3,280	High School Diploma, Some College
	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	Medium	$22.05	9.7%	1,325	
	Computer Numerically Controlled Tool Programmers	Medium	$30.22	29.1%	175	
Industrial Maintenance	Industrial Machinery Mechanics	Medium	$29.96	27.2%	1,680	High School Diploma, Some College
Engineering and Automation	Electrical and Electronic Engineering Technologists and Technicians	Medium	$32.96	1.2%	280	Associate Degree
	Industrial Engineering Technologists and Technicians	Medium	$30.85	7.0%	195	
	Mechanical Engineering Technologists and Technicians	Medium	$33.46	7.0%	166	
	Mechanical Engineers	High	$47.34	8.7%	872	
	Industrial Engineers	High	$48.88	15.6%	1,028	Bachelor's Degree

* Living wage potential is based on MIT's Living Calculator (livingwage.mit.edu) for Illinois in 2024. Occupations with median salaries higher than the living wage for 1 adult + 1 child ($39.63/hour) are considered as having a "high" living wage potential. Occupations with median salaries only higher than the living wage of 1 adult, no children ($22.86/hour) are considered as having a "medium" living wage potential, and occupations with median salaries below the living wage of 1 adult, no children (less than $22.86/hour) are considered as having a "low" living wage potential.

** Illinois Department of Employment Security (2022). Wage Information: Occupational Employment and Wage Statistics (Statewide). Retrieved April 2, 2024, from ides.illinois.gov/resources/labor-market-information/oews.html

*** Illinois Department of Employment Security. Employment Projections (Long-Term Occupational Projections 2020-2030). Retrieved April 2, 2024, from ides.illinois.gov/resources/labor-market-information/employment-projections.html