HIGHER EDUCATION COORDINATING COMMISSION

OREGON DEPARTMENT OF EDUCATION

OREGON CAREER AND TECHNICAL EDUCATION STATEWIDE FRAMEWORKS

Manufacturing Career Cluster

Resource Guide

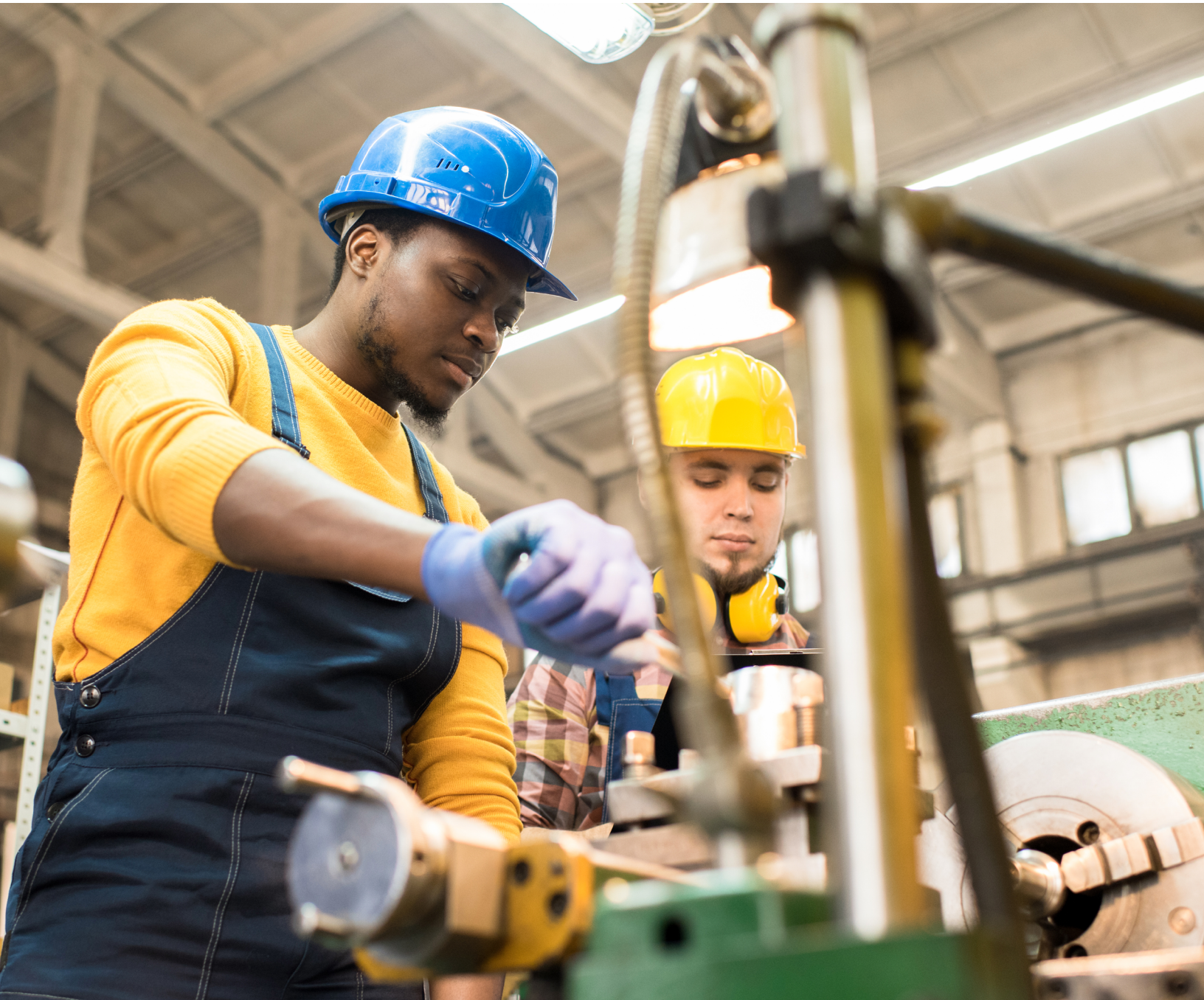

Table of Contents

Tables

Figures

Statewide Program of Study Framework.
Manufacturing

Well-designed career and technical education (CTE) programs help high school and college students make successful educational transitions and find employment in high-wage, high-skill, in-demand careers. **Oregon's State Plan for CTE: 2020-2024** lays out a comprehensive strategy for ensuring all Oregonians have equitable access to high-quality CTE programming. This entails designing instructional coursework that is sequenced within and across educational levels, grounded in rigorous academic knowledge and technical skills, and aligned with industry needs. It also requires creating quality relationships, experiences, and interactions among learners, educators, business partners, and community members.

OREGON'S VISION FOR CTE

Reimagine and transform learner experiences to enhance their future prospects, empower communities, and ensure equitable access to an inclusive, sustainable, innovation-based economy.

This document provides information and resources related to the ***Statewide CTE Framework in Manufacturing,*** which falls within the Industrial and Engineering Systems learning area. Manufacturing is one of 17 Career Clusters around which CTE is organized and delivered in Oregon. The Manufacturing field involves the producing work and parts through techniques like machining and welding. The industry has had a revolutionary impact on the global economy and society, transforming the way businesses operate and people live.

Oregon's new CTE state plan calls for the development of Statewide Frameworks to guide CTE program design. The goal is to *improve instructional quality* by aligning technical skills to the needs of employers in high-wage, high-skill, in-demand careers; promote equity by ensuring that all learners have access to consistent high-quality programming; strengthen career pathways by intentionally connecting secondary and postsecondary coursework that culminates in the award of an industry-recognized credential or certificate, or associate or baccalaureate degree; and *expand student access to dual and concurrent enrollment credit* to reduce tuition costs and the time required to earn a postsecondary credential.

While secondary and postsecondary CTE providers have considerable flexibility in designing curriculum and assessments, state approval is required to qualify programs for federal and/or state funding. This includes aligning offerings with labor market needs; meeting state-defined criteria for size, scope, and quality; addressing all of Oregon's five core elements of a Program of Study; and continuously improving CTE offerings through the use of the **Oregon CTE Program of Study Quality Rubric.**

Within Oregon, a CTE Program of Study is the primary vehicle for delivering coursework at the secondary and postsecondary levels. A CTE Program of Study is a progressive, non-duplicative sequence of courses, developed by a secondary school district and postsecondary institution partnering together, designed to prepare students to seamlessly transition across education levels and into the workforce. Coursework integrates rigorous academic knowledge with industry-validated employability and technical skills, culminating in the award of an industry-recognized credential or certificate, or an associate or baccalaureate degree. High school students may also have options to earn college credit that may be applied toward their postsecondary studies.

Within each Career Cluster, CTE Programs of Study may be offered at the Career Cluster or Focus Area level. Career Cluster Programs of Study offer students broad exposure to multiple careers in the field, along with cross-cutting skills valued by all industry employers. Focus Area Programs of Study offer students more occupationally specific training with a higher level of statewide content standardization.

The new Statewide CTE Frameworks provide updated Knowledge and Skill Statements to inform CTE program development. The updated Knowledge and Skill Statements incorporate: 1) employability skills commonly found in all jobs in all Career Clusters; 2) cross-cutting technical skills applicable to all jobs in a specific Career Cluster; and 3) Focus Area skills applicable to a specific job. Each Knowledge and Skill Statement includes an optional set of Suggested Performance Indicators, which are intended to help educators develop curriculum and assessments to teach specific skills.

Projected Labor Market Demand

Labor projections published by the State of Oregon Employment Department indicate that while the Manufacturing field will expand over the coming decade, a subset of high-wage, high-skill occupations will experience significant demand. These are defined as those paying more than the statewide median wage or having more than the statewide median number of total job openings. These occupational titles, projected demand, and wage and educational expectations of entry-level employees are provided in Table 1.

Table 1. Projections for High-Wage and High-Demand Production Occupations in Oregon, 2020-2030

Standard Occupational Classification (SOC)* code	Occupational title	Total job openings	Percent change 2020-2030	2020 median annual wage	Entry-level education
51-1011	**First-Line Supervisors of Production and Operating Workers**	7,765	14.1%	$60,840	> or = HS diploma

Standard Occupational Classification (SOC)* code	Occupational title	Total job openings	Percent change 2020-2030	2020 median annual wage	Entry-level education
51-4033	**Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic**	1,571	14.0%	$46,509	> or = HS diploma
51-4041	**Machinists**	4,167	18.0%	$53,435	> or = HS diploma
51-4121	**Welders, Cutters, Solderers, and Brazers**	6,761	21.6%	$49,192	> or = HS diploma
51-8031	**Water and Wastewater Treatment Plant and System Operators**	971	4.5%	$60,902	HS diploma
51-9162	**Computer Numerically Controlled Tool Programmers**	1,204	41.1%	$61,069	HS diploma

Note: Adapted from **State of Oregon Employment Department High-wage, High-demand occupational projections 2020-2030**

*SOC code = Standard Occupational Classification used to classify workers into job categories.

The largest growth in Oregon is projected for Computer Numerically Controlled (CNC) tool programmers, with demand expected to increase by over 40 percent between 2020 and 2030. This will lead to 1,204 projected job openings, including new and replacement workers. By total projected job openings, Machinists, Welders (including Cutters, Solderers, and Brazers), and first-line supervisors of production workers have the largest expected position openings in the next decade (adding 18,693 total jobs by 2030).

Median annual earnings in 2021 were $60,840 for first-line supervisors of production workers, the occupation projected to have the largest number of job openings. Wages in other jobs fields range from $46,509 for Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders to $61,069 for CNC Tool Programmers.

High-wage, high-demand jobs in Manufacturing have an achievable pathway to entry, with most entry level positions requiring a high school diploma. While workers may enter with a high school diploma, there are opportunities to earn professional certifications and degrees by pursuing stackable credentials.

Statewide Program of Study Framework Options

The Manufacturing Career Cluster is intended to prepare high school and college graduates for entry-level employment and/or advanced postsecondary studies. When designing programming, school district and community college CTE providers are required to collaborate to offer coursework leading to an industry-recognized credential or certificate and/or associate degree, including an Applied Associate of Science (AAS) degree. High school students also may be offered the opportunity to earn college credit that may be applied towards their certificate or degree objective. All Manufacturing-related postsecondary certificates and degrees "stack" toward a Bachelor of Science degree offered within Oregon's public four-year colleges and universities.

In fall 2021 the Oregon Department of Education launched a statewide effort to update and revalidate the Knowledge and Skill Statements used to define the Manufacturing Career Cluster. Previously, skill sets were based on the National Career Technical Core Standards published by Advance CTE in June 2012. The goal was to identify the employability and technical skills desired of entry-level workers. Work began with a review of labor market information compiled by the Oregon Employment Department to identify high-wage, high-skill, and in-demand occupations. An advisory group, comprised of Oregon employers and professional organization members, reviewed existing state skills and those of other states to create a new set of statements. A statewide survey of employers was then conducted to collect feedback on the proposed new set, with refinements made as needed.

Based on this work, two focus areas were identified as initial candidates for the statewide models in the Manufacturing Career Cluster: 1) Machining, and 2) Welding.

Knowledge and Skill Statements

Knowledge and Skill Statements describe the learning expectations of students in CTE programs. The CTE Statewide Framework for Architecture and Construction is organized around three levels of skills (see Figure 1).

Employability Knowledge and Skills – Applicable to all Career Clusters

All learners are expected to possess a basic set of knowledge and skills that will prepare them to function in the workplace. These cross-cutting abilities, found in all jobs in all industries, encompass a broad range of communication, critical thinking, interpersonal, and organizational skills considered imperative for career success.

Career Cluster Knowledge and Skills – Applicable to all Manufacturing careers

All workers in the Manufacturing field are expected to have a broad understanding of the industry. These cross-cutting, Career Cluster-specific skill statements enable workers to succeed in a range of Manufacturing jobs. High school students possessing these skills should be prepared to enter community college to pursue a range of occupationally specific training options that build on their secondary coursework.

Focus Area Knowledge and Skills – Applicable to a specific Manufacturing career

Focus area skill statements define field specific knowledge that an entry worker would be expected to possess. High school students possessing these skills would be prepared to enter employment or enroll in a community college to pursue advanced training, ideally with credit that can be applied towards their college program. Postsecondary graduates would be prepared to enter employment with a credential, certificate, or degree in a high-wage, high-skill, in-demand field.

Detailed descriptions of the Knowledge and Skill Statements for new Statewide Program of Study Frameworks in (1) Machining, and (2) Welding are contained in Appendix A. Each Knowledge and Skill Statement includes a list of Suggested Performance Indicators that illustrate how students might demonstrate their understanding or abilities relating to each statement (see Appendix A). These are examples intended to provide educators with guidance in establishing program content and assessments and designing curriculum and instructional activities. *These Suggested Performance Indicators are offered as optional, industry suggested ways to demonstrate the Knowledge and Skill Statements. They are* ***not*** *required. Educators may choose to design other means for students to show mastery of the Knowledge and Skill Statements in their Program of Study.* It is anticipated that secondary and postsecondary educators will collaborate in selecting the number, type, and specificity of Suggested Performance Indicators, as well as the educational level at which they will be taught.

Figure 1. Knowledge and Skill Statements for the Statewide Framework for Manufacturing

MANUFACTURING PROGRAM OF STUDY KNOWLEDGE AND SKILL STATEMENTS

EMPLOYABILITY

Cross-cutting, same for all Career Clusters

- Workplace practices
- Personal responsibility and accountability
- Cultural competence
- Teamwork and conflict resolution
- Communication
- Critical thinking
- Creativity and innovation
- Use of workplace technologies
- Planning, organizing, and managing work
- Career planning

CAREER CLUSTER

All Cluster and Focus Area Manufacturing Program of Study

- Industry contributions to society and economy
- Safe working practices
- Safe use of tools
- Materials knowledge
- Government policies and industry standards
- Pre-task planning for safety and efficiency
- Basic mathematics and measurement
- Manufacturing process components
- Different and evolving manufacturing process and trends

FOCUS AREAS

Machining

- Materials and technology knowledge
- Interpreting blueprints and layout
- Machining operation and control
- Machining production and processing
- Tool setup and best practices
- CNC machining
- Quality control tools and techniques
- Lifting devices
- Mathematic and measurement concepts

Welding

- Properties of metallurgy
- Material removal techniques
- Shielded Metal Arc Welding equipment hazards, protection, and operations
- Gas Arc Metal Welding setup and procedure
- Flux Cored Arc Welding setup and procedure
- Gas Tungsten Arc Welding setup and procedure
- Quality control methods
- Math and blueprints
- Welding standards and certifications

Program of Study Design Options

Educators have two options in designing a Program of Study using the Statewide Framework. They can pursue a Career Cluster Program of Study or a Focus Area Program of Study. The distinction between a Cluster and a Focus Area Program of Study relates to the Knowledge and Skill Statements covered in the Program of Study and the level of secondary to post-secondary alignment (non-duplicative sequence of courses leading to a certificate or degree).

There are two primary distinctions between the two options:

1. **Career Cluster Programs of Study** are required to cover employability skills and Cluster skills; they may draw from Focus Area skills but are not required to do so.
2. **Focus Area Programs of Study** are more occupationally specific with a higher level of content standardization. Focus Area Programs of Study are required to cover *all skill sets in the Program of Study at the Employability, Career Cluster, and Focus Area levels.*

Educators may choose to offer a Career Cluster Program of Study and/or Focus Area Program of Study. The options are not mutually exclusive. Providers with well-developed Manufacturing Programs of Study may already fulfill many of the criteria of a Statewide Framework; other districts may build toward fulfillment of the Statewide Framework over time.

Career Cluster Program of Study Option

A Career Cluster Program of Study provides high school students with a broad overview of the Manufacturing field to prepare them to specialize in an area of their choosing at the postsecondary level. With this option, educators may choose to offer a broad range of courses that address different aspects of the Manufacturing field, such as manufacturing types, machining, and welding.

While educators have flexibility in designing program coursework, it is expected that all Career Cluster Programs of Study will address all the Employability and Career Cluster Knowledge and Skill Statements desired by employers (see Figure 1). Educators will continue to have the option of selecting Knowledge and Skill Statements contained within the Manufacturing Focus Areas used in past years, or to incorporate those contained in the newly developed Machining and Welding Focus Areas.

To qualify as a concentrator at the Career Cluster level, high school students must complete at least two credits in a single Program of Study, with one of these credits earned through a course or courses identified as intermediate or advanced. High school graduates concentrating their studies in the Manufacturing Career Cluster would have the option of continuing their studies at an affiliated community college, where they could pursue training (in one or more fields) that culminate in the award of a credential, certificate, or associate degree.

Focus Area Program of Study Option

Focus Area Programs of Study are intended to align with specific certificate and AAS degrees offered at the postsecondary level. Where appropriate, districts and colleges can negotiate dual credit agreements so that high school students can earn college credit that may be applied toward a postsecondary certificate or degree, expediting the time it takes to complete.

The new Statewide Program of Study Framework option requires:

- Offering a minimum of three credits at the secondary level and 36 credits at the postsecondary level.
- Covering all the appropriate Knowledge and Skill Statements.
- Requiring concentrators to complete two credits in the Program of Study, including at least one intermediate- or advanced-level course.
- Providing a sequenced, progressive set of courses, including intro/survey, intermediate, and advanced.
- Exhibiting secondary-postsecondary alignment that is clearly defined and communicated to all stakeholders.
- Offering or potentially offering dual credit opportunities.
- Integrating career-related learning experiences, career connected learning, and work-based learning in meaningful ways

High school graduates concentrating their studies in a Manufacturing statewide program would have the option of continuing their studies at an affiliated community college, where they could seek advanced training in the Focus Area or pursue training in another Manufacturing field that culminates in the award of a credential, certificate, or associate degree.

Statewide Framework Programs of Study align course content to industry-validated skills so that students throughout the state have access to consistent, high-quality CTE with opportunities to gain college credit and skills in high-wage, high-skill, and in demand occupations.

Course Scope and Sequence

Regardless of whether a district seeks approval for a Career Cluster or Focus Area Program of Study, it is anticipated that CTE students will begin their course sequence with an introductory/survey course that opens a range of intermediate and advanced course options. An example of how a Manufacturing Program of Study might be configured is provided in Table 2. Note that course sequences and titles are provided for illustrative purposes only—*it is up to secondary and postsecondary partners to determine course titles and sequences; course content, curriculum, and assessments, including when and how Knowledge and Skill Statements are addressed; and whether dual credit or industry certifications may be awarded.*

Table 2. Proposed Scope and Sequence in Manufacturing

Level 1: Introductory (grades 9–10)	Level 2: Intermediate (grades 10–12)	Level 3: Advanced (grades 11–12)	Level 4: Advanced (grades 11–12)
Introduction to Manufacturing (survey course)	Machining I	Machining II	Machining Practicum or Dual Credit Enrollment
	Welding I	Welding II	Welding Practicum or Dual Credit Enrollment

Note: Course sequence highlighted in gray indicates Focus Area Program of Study.

Additionally, all Programs of Study are expected to integrate a full range of **Career Connected Learning Experiences** that advance progressively, as indicated in Table 3.

Table 3. Career Connected Learning Experiences

Career Awareness: Learning about work	Career Exploration: Learning for work	Career Preparation: Learning through work	Career Training: Learning at work
Build awareness of the variety of careers available and the role of postsecondary education • Workplace tour • Guest speaker • Career fair • Visiting adults at work	*Explore career options to motivate students and inform their decision making* • Informational interview • Job shadow • Virtual interactions • Service learning (one-time)	*Apply learning through practical experience that develops knowledge and skills necessary for success in careers and postsecondary education* • Student-run enterprise • Virtual and simulated work experience • Internships • Work experience	*Train for employment and/or postsecondary education in a specific range of occupations* • Internships • Registered apprenticeship • Clinical and work experience • On-the-job training

Developing a CTE Program of Study for State Approval

To meet Oregon's definition of a High-Quality Program of Study, a CTE Program of Study must be built around five core elements. These elements and supporting components, which align to the Association for Career and Technical Education's (ACTE's) High-Quality CTE Program of Study Framework, are detailed in Table 4.

Table 4. Elements and Supporting Components of a High-Quality CTE Program of Study

Element	Components
Content	***Rigorous Integrated Content:*** Appropriately licensed secondary teachers and postsecondary instructors integrate rigorous technical and academic content.
	Engaged Learning: Students are engaged through instructional strategies that are relevant and authentic, and meet the needs and interests of all students.
	Coherent Curriculum: Aligned to industry-identified content and sequenced to prepare students for their next steps.
Alignment and Articulation	***Partnerships:*** Actively engages employer and educator partners to develop, enhance and support the CTE program in a manner that is sustainable.
	Credentials: Links instruction to meaningful college credit or industry credentials that can lead to high-wage, high-skill, and in-demand occupations.
	Facilities and Equipment: Provides students with safe access to facilities and equipment appropriate to the type of instruction and reflective of workforce needs.
Accountability and Evaluation	***Continuous Improvement:*** Revisions to the Program of Study are based on student performance, economic demand, and employer requirements.
Student Support Services	***Equity and Access:*** Provides all students and their families with appropriate knowledge and experiences to help make informed education and career decisions.
	Career Connected Learning: Provides quality, accurate and timely information and support that will help students identify, pursue, transition to, and complete pathways to future careers. Career Connected Learning should include activities and opportunities within the four domains of Awareness, Exploration, Preparation and Training.
Professional Development	***Professional Development:*** Promotes instructional long-term growth that aligns with long-term program goals.

Educators are encouraged to consult the **Oregon CTE Program of Study Quality Rubric** and accompanying **Quick Guide for Using the High Quality CTE Program of Study (HQ POS) Rubric** to assess their existing CTE Programs of Study and create goals for continuous improvement.

CTE Licensure Requirements.
Manufacturing Program of Study

Educators seeking to teach in the Manufacturing Program of Study must possess a valid Oregon CTE endorsement in Industrial and Engineering Systems. See **CTE Licensure in Oregon** for an overview of licensing requirements and the steps to be taken to receive an endorsement. Contact **Muhammad Rahman** (Muhammad.Rahman@ode.oregon.gov) for more information.

Career and Technical Student Organizations

Learning is enhanced when students can apply academic, technical, and employability skills in an authentic setting. Career and Technical Student Organizations (CTSOs) are extracurricular groups that offer youth the ability to practice and enhance their classroom learning, while developing personal skills and leadership abilities, through participation in activities, events, and competitions.

In the Manufacturing field there is one active CTSO in Oregon:

Skills USA (https://www.skillsusa.org/) is an industrial and engineering CTSO preparing student learners for careers in trade, technical and skilled service occupations. Students participating in Manufacturing learn about entry-level, technical, and professional careers in a range of fields, including additive manufacturing, CNC machining, mechatronics, and robotics.

Appendix A. Knowledge and Skill Statements – Manufacturing Program of Study Framework

Overview

The Industrial and Engineering Systems career learning area is comprised of five Career Clusters, which include: (1) Architecture and Construction, (2) Manufacturing, (3) Engineering Technology, (4) Transportation, Distribution and Logistics, and (5) Automotive and Heavy Equipment.

This document details the knowledge and skill statements comprising the Program of Study for the Manufacturing Career Cluster. These statements, developed with input by business and industry practitioner groups, define the career readiness expectations of entry-level workers.

Each Knowledge and Skill Statement (indicated in bold) includes a list of Suggested Performance Indicators that illustrate how students might demonstrate their understanding or abilities relating to each statement. These indicators are intended to provide educators with guidance in establishing program content and assessments and designing curriculum and instructional activities. *These Suggested Performance Indicators are offered as options—not requirements—for addressing the Knowledge and Skill Statements comprising a Program of Study.* It is anticipated that secondary and postsecondary educators will collaborate in selecting the number, type, and specificity of Suggested Performance Indicators, as well as the educational level at which they will be taught.

The Program of Study for the Manufacturing Career Cluster is intended to prepare students to successfully transition into postsecondary education or secure gainful employment in a related career field. Labor market projections for Oregon indicate that there is strong demand for a subset of high-wage, high-skill, in-demand occupations that fall within the Career Cluster area. Accordingly, the Program of Study for the Manufacturing Career Cluster includes knowledge and skill statements (and associated Suggested Performance Indicators) for two focus areas: 1) Machining, and 2) Welding.

While each focus area is occupationally specific, the statements provided are primarily intended to address process issues, rather than the materials themselves. For example, educators offering a focus area in machining might teach skills using metal, plastic, or wood. The intent is that students learn fundamental principles of the trade, with the understanding that the curricular resources used to teach concepts will vary based on state, regional, or local economic conditions; instructor training or licensing; and/or district and college instructional resources.

Manufacturing Knowledge and Skill Statements

Employability Knowledge and Skill Statements

Applicable to all Career Clusters in the Statewide Program of Study Framework.

E-01	Adhere to workplace practices
E-02	Exhibit personal responsibility and accountability
E-03	Practice cultural competence
E-04	Demonstrate teamwork and conflict resolution
E-05	Communicate clearly and effectively
E-06	Employ critical thinking to solve problems
E-07	Demonstrate creativity and innovative thinking
E-08	Demonstrate fluency in workplace technologies
E-09	Plan, organize, and manage work
E-10	Make informed career decisions

Cluster Level Knowledge and Skill Statements

Applicable to all Programs of Study in the Manufacturing Statewide Program of Study Framework.

CC-MN01	Describe the manufacturing industry and its contributions to society and the economy
CC-MN02	Demonstrate an understanding of and adherence to safe working practices
CC-MN03	Demonstrate the safe use of tools
CC-MN04	Demonstrate knowledge about materials used in the manufacturing industry
CC-MN05	Describe government policies and industry standards that apply to manufacturing
CC-MN06	Demonstrate pre-task planning to ensure a safe and efficient jobsite
CC-MN07	Demonstrate basic principles of mathematics and measurement used in manufacturing
CC-MN08	Describe the major components in the manufacturing process
CC-MN09	Describe different manufacturing processes and evolving trends

Focus Area Level Knowledge and Skills

Knowledge and Skill Statements for the updated Statewide Program of Study Framework in:

1) Machining, and 2) Welding.

Machining

FA-MNMF01	Demonstrate knowledge of technology and materials
FA-MNMF02	Demonstrate ability to interpret blueprints and layout
FA-MNMF03	Demonstrate knowledge of machining operation and control
FA-MNMF04	Demonstrate knowledge of machining production and processing
FA-MNMF05	Demonstrate knowledge of tool setup and required best-practices
FA-MNMF06	Demonstrate ability to use CNC machines to manufacture parts
FA-MNMF07	Apply quality control tools and techniques to manufacturing processes, systems, and products
FA-MNMF08	Describe knowledge of lifting devices
FA-MNMF09	Apply mathematical and measurement concepts to the machining process

Welding

FA-MNWL01	Demonstrate an understanding of the Properties of Metallurgy
FA-MNWL02	Demonstrate an understanding of material removal techniques
FA-MNWL03	Demonstrate an understanding of safety hazards, protective devices used, and operations of Shielded Metal Arc Welding (SMAW) equipment
FA-MNWL04	Demonstrate understanding of set-up and procedure for Gas Metal Arc Welding (GMAW)
FA-MNWL05	Demonstrate proper set-up and procedure for Flux Cored Arc Welding (FCAW)
FA-MNWL06	Demonstrate proper set-up and procedure for Gas Tungsten Arc Welding (GTAW)
FA-MNWL07	Successfully apply various quality control methods to the welding process
FA-MNWL08	Demonstrate knowledge of math and blueprints that apply to welding design and layout
FA-MNWL09	Demonstrate knowledge of welding standards and certifications

Employability Knowledge and Skill Statements with Suggested Performance Indicators

E-01	**Adhere to workplace practices**
Suggested Performance Indicators	A. Explain and follow workplace standards, rules, and regulations B. Show up on time and prepared to work C. Demonstrate the ability to take direction, be proactive, and work independently
E-02	**Exhibit personal responsibility and accountability**
Suggested Performance Indicators	A. Apply professional and ethical standards of the industry to personal conduct B. Maintain integrity and promote personal and professional integrity in co-workers C. Take responsibility and carry out work assignments
E-03	**Practice cultural competence**
Suggested Performance Indicators	A. Demonstrate awareness of issues related to diversity, equity, and inclusion B. Work effectively with colleagues of differing abilities, cultures, and backgrounds C. Describe issues relating to workplace harassment D. Model behaviors that are respectful and sensitive of others
E-04	**Demonstrate teamwork and conflict resolution**
Suggested Performance Indicators	A. Demonstrate the ability to collaborate and contribute to the work of a diverse team B. Explain when it is appropriate to lead and when to follow another's lead C. Demonstrate strategies for resolving issues with coworkers
E-05	**Communicate clearly and effectively**
Suggested Performance Indicators	A. Listen attentively, and speak and write clearly to convey information correctly B. Interpret information and instructions presented in verbal and written form C. Demonstrate effective communication with colleagues, supervisors, customers, and suppliers D. Demonstrate the ability to communicate verbally, in writing, and using electronic communication tools
E-06	**Employ critical thinking to solve problems**
Suggested Performance Indicators	A. Recognize problems in the workplace and diagnose their root causes B. Develop well-reasoned plans to solve identified challenges C. Apply and follow through on plans to ensure that problems are resolved

E-07	**Demonstrate creativity and innovative thinking**
Suggested Performance Indicators	A. Develop ideas to solve problems in new and different ways B. Investigate one's own and others' ideas to find those with greatest applicability C. Develop and deploy plans to implement new ideas in the workplace
E-08	**Demonstrate fluency in workplace technologies**
Suggested Performance Indicators	A. Demonstrate knowledge and application of general technology skills, including hardware and software commonly used in the industry B. Use online communication, networking tools and social networks to access, manage, evaluate, and create information to successfully function in a knowledge economy C. Describe and demonstrate a fundamental understanding of the ethical, legal, and security issues surrounding access to and use of information technologies
E-09	**Plan, organize, and manage work**
Suggested Performance Indicators	A. Identify an intended project outcome including available inputs, materials, labor, timeline for producing work, and job-site obligations B. Effectively plan, monitor, and complete projects on time and within budget using available resources and materials C. Demonstrate ability to write coherent reports and project summaries to communicate the progress of project work and its adherence to schedule
E-10	**Make informed career decisions**
Suggested Performance Indicators	A. Identify job and entrepreneurial opportunities in the industry and the required education and credentials to obtain employment B. Set short- and long-term career goals based on personal interests and aptitudes C. Maintain a project portfolio D. Develop a professional resume E. Explain and demonstrate how to cultivate and maintain a professional presence in an online environment, including the appropriate use of social media and networking platforms

Manufacturing Career Cluster Knowledge and Skill Statements with Suggested Performance Indicators

CC-MN01	**Describe the manufacturing industry and its contributions to society and the economy**
Suggested Performance Indicators	A. Identify the role and major functions of manufacturing businesses B. Describe how manufacturing businesses and the products they produce contribute to improving people's lives and strengthening the economy C. Describe how the manufacturing sector functions in the domestic and global marketplaces and the relationship and competitive challenges between the two D. Explain how products are designed and the various professions involved (e.g., engineers, designers, fabricators, suppliers) E. Identify the customers, suppliers, and stakeholders of manufacturing businesses, their roles, and how they relate to one another
CC-MN02	**Demonstrate an understanding of and adherence to safe working practices**
Suggested Performance Indicators	A. Describe the importance of a safety culture in the manufacturing trades B. Demonstrate safe working practices that promote personal and group health C. Demonstrate awareness of common manufacturing hazards and the steps needed to correct them D. Demonstrate the use of and care for personal protective equipment
CC-MN03	**Demonstrate the safe use of tools**
Suggested Performance Indicators	E. Demonstrate the ability to use measuring, marking, and layout tools F. Identify the hand and power tools commonly used in the field and describe their uses G. Use hand and power tools in a safe manner H. Demonstrate how to maintain, clean, and store hand and power tools commonly used in the field
CC-MN04	**Demonstrate knowledge about building materials used in the manufacturing industry**
Suggested Performance Indicators	A. Identify various types of materials used in production and their uses B. Identify the different types and grades of materials used in the industry C. Demonstrate proper techniques for ordering, handling, using, and storing materials

CC-MN05	Describe government policies and industry standards that apply to manufacturing
Suggested Performance Indicators	A. State the purpose of regulations and certification requirements B. Explain the types of governmental regulations and federal, state, and local regulations that apply in the industry and how the professions engage with them C. Describe how government agencies ensure compliance with environmental regulations and the consequences that manufacturing organizations suffer when they fail to comply D. Describe how the Americans with Disabilities Act applies in the workplace E. Describe requirements related to handling and disposal of environmentally hazardous materials in accordance with the material safety data sheet (MSDS), the Occupational Safety and Health Administration (OSHA), and the Environmental Protection Agency (EPA) regulations F. Describe how to apply quality control and assurance procedures within the industry and why they are important
CC-MN06	**Demonstrate pre-task planning to ensure a safe and efficient jobsite**
Suggested Performance Indicators	A. Describe the daily scope of work and sequence of activities to perform it B. Identify and safely assemble the equipment required to conduct the daily scope of work C. Estimate the time and materials needed to perform the daily scope of work D. Identify jobsite hazards related to the daily scope of work and take steps to mitigate them
CC-MN07	**Demonstrate basic principles of mathematics and measurement used in manufacturing**
Suggested Performance Indicators	A. Add, subtract, multiply, and divide whole numbers, fractions, and decimals with and without a calculator B. Demonstrate how to determine area, volume, and length measurements using square feet, cubic feet, and yards C. Recognized and apply basic measuring instruments (e.g., rules, protractors, go-no-go gages, gage blocks, and checking fixtures) D. Recognize and apply precision measuring instruments such as micrometers, vernier, dial, and electronic calipers, dial indicators, telescoping gages, gage blocks, adjustable parallels and optical comparators

CC-MN08	Describe the major components in the manufacturing process
Suggested Performance Indicators	A. Describe how planning and budgeting are used to accomplish organizational goals. B. Demonstrate accepted planning and layout procedures (e.g., print reading) C. Summarize how materials can be processed using tools and machines (e.g., additive, subtractive, injection modeling) D. Describe various types of assembling processes (e.g., mechanical fastening, mechanical force, joining, fusion boding, adhesive bonding) E. Explain finishing processes (e.g., types of finishing materials, surface preparation, methods of application) F. Explain inspection and quality control processes
CC-MN09	**Describe different manufacturing processes and evolving trends**
Suggested Performance Indicators	A. Describe how different processes make use of specific manufacturing processes (e.g., casting and molding, forging, separating, assembling, digital and additive manufacturing, finishing, stamping) B. Analyze recent trends in the manufacturing sector and evolving technologies and processes shaping the field (e.g., additive and digital manufacturing, industrial robots, bio- and nano-manufacturing, sustainable manufacturing) C. Explain advanced manufacturing and how it applies information, automation, computation, software, sensing, and networking to make traditional processes more efficient

Machining Focus Area Knowledge and Skill Statements with Suggested Performance Indicators

FA-MNMF01	Demonstrate knowledge of technology and materials
Suggested Performance Indicators	A. Describe key material properties as they relate to machining efficiency B. Explain material properties and tooling processes to created finished products C. Describe the different types and uses of metal (e.g., ferrous metals, non-ferrous metals, high temperature metals and rare metals) and woods (e.g., hardwood, softwood) D. Determine the hardness values of different materials E. Explain types of tool wear and their consequences F. Discuss which parameters to change to improve unfavorable tool failures and/or poor surface finish of parts
FA-MNMF02	**Demonstrate ability to interpret blueprints and layout**
Suggested Performance Indicators	A. Examine and interpret engineering drawings to manufacture an object B. Apply knowledge of engineering drawing to machining process C. Use modern-day electronic systems to look up most current version of engineering drawings need for manufacturing D. Define the information necessary to complete a machining task such as materials to be used, required surface finish, tolerances, quantity of units etc. E. Distinguish between detail and assembly drawings F. Use precision measuring and layout instruments and inspection processes to ensure quality of a finished product
FA-MNMF03	**Demonstrate knowledge of machining operation and control**
Suggested Performance Indicators	A. Manage and coordinate the operation of the cutting pieces, feeds, and mounts associated with both manual and computer-numerical controlled (CNC) machining tools to complete advanced projects involving mills, lathes, and grinders B. Correctly, safely, and efficiently schedule, configure, administer, and verify heat-treatments to machined parts according to blueprint specifications C. Demonstrate the following higher functions: cutter diameter compensation; comfort with built-in risk management systems D. Demonstrate how to inspect and assess the condition of tools and maintain them so that they are safe and operational

FA-MNMF04	Demonstrate knowledge of machining production and processing
Suggested Performance Indicators	A. Describe and demonstrate various machining techniques including procedures on drill press, lathe, saw grinders, and milling machines B. Solve manufacturing-related problems by analyzing and weighing the constraining factors including schedule, cost, materials, and equipment, as well as productivity, regulations, maintenance, and quality C. Employ statistical quality control test methods and techniques, especially on large volume processes, to minimize defects and waste due to poor quality
FA-MNMF05	**Demonstrate knowledge of tool setup and required best-practices**
Suggested Performance Indicators	A. Demonstrate tool and holder assembly with use height gage and pre-setter B. Demonstrate tool and holder balancing to required standards C. Follow best practices for assembly of tools using: Shrink Fit system, Collet systems, Weldon-Flats, and bold on systems D. Rotate inserts on indexable cutting tools
FA-MNMF06	**Demonstrate ability to use CNC machines to manufacture parts**
Suggested Performance Indicators	A. Produce parts to specifications or drawings provided on a computer numerical controlled mill or lathe B. Employ basic G and M Programming focusing on the use of the Cartesian coordinate system and machine axis C. Demonstrate methods by which programs can be entered into a controller D. Demonstrate the setup and safe operation of a CNC turning or milling center E. Demonstrate a tool change and tool selection to complete a multistep process on a CNC milling or turning center F. Demonstrate operation and preventive daily maintenance of a CNC Lathe machine G. Demonstrate operation and preventive daily maintenance of a CNC Mill machine

FA-MNMF07	**Apply quality control tools and techniques to manufacturing processes, systems, and products**
Suggested Performance Indicators	A. Analyze production controls and manufactured parts specifications using quality control techniques and precision measuring tools B. Measure, weigh, and visually inspect machine parts, surface finish measurements C. Use the appropriate instrumentation to measure tolerances as required in the engineering drawings D. Apply data collection for part buyoff and related documentation E. Validate that a provided part meets specifications from its engineered drawing by comparing specifications F. Record and compare data to given project specifications; interpret results G. Demonstrate ability to prove out a program using single block, lowered rapid rates, and using Distance to Go screen on control
FA-MNMF08	**Describe knowledge of lifting devices**
Suggested Performance Indicators	A. Demonstrate safe use of lifting devices and rigging equipment (e.g., cranes, jibs, slings, magnets, specialized lifting devices) B. Demonstrate ability to use lift trucks, stackers, pallet jacks for moving material
FA-MNMF09	**Apply mathematical and measurement concepts to the machining process**
Suggested Performance Indicators	A. Select appropriate tools and accurately measure solid shapes and parts B. Perform basic mathematical calculations and/or calibrations using tools such as micrometers, verniers, and gages C. Calculate the speeds, feeds, and depth of cut for various machines and materials D. Determine the appropriate units and record accurate and repeatable measures of length, diameter, and thickness to complete projects using appropriate tools E. Apply principles of trigonometry, Cartesian geometry, and/or polar geometry, distinguishing which principles apply to a given machining tool and when F. Use angle gages, a plate contractor, a universal bevel protractor with vernier scale, square and/or a sine bar and gage clocks or adjustable parallel G. Determine the appropriate units and record accurate and repeatable measurement of material properties such as hardness, pH, and load elongation test curves of stress, strain, modulus and yield H. Interpret test values and curves and use calculated results to make informed decisions

Welding Focus Area Knowledge and Skill Statements with Suggested Performance Indicators

FA-MNWL001	**Demonstrate an understanding of the Properties of Metallurgy**
Suggested Performance Indicators	A. Describe the mechanical properties of metals and their importance in the welding process including tensile, strength, hardness, elasticity, ductility, toughness, and brittleness B. Demonstrate techniques to mitigate the effects of thermal expansion and contraction that occur during the welding process C. Explain the effect that thermal conductivity and specific heat have on various metals such as steel and aluminum
FA-MNWL02	**Demonstrate an understanding of material removal techniques**
Suggested Performance Indicators	A. Demonstrate knowledge of angle grinder, die grinders and abrasives B. Demonstrate knowledge of Oxy-fuel Cutting (OFC-A) C. Demonstrate knowledge of Plasma Arc Cutting (PAC) D. Demonstrate knowledge of Air Carbon Arc Cutting (CAC-A)
FA-MNWL03	**Demonstrate an understanding of safety hazards, protective devices used, and operations of Shielded Metal Arc Welding (SMAW) equipment**
Suggested Performance Indicators	A. Recognize the AWS filler metal specification system and various electrode characteristics B. Describe characteristics of the four main electrode groups C. Explain how to select electrodes and describe their proper care and handling D. Select the proper electrodes for any given welding task E. Perform multi-pass groove welds in all positions according to industry standards F. Demonstrate the proper handling and storage of electrodes
FA-MNWL04	**Demonstrate understanding of set-up and procedure for Gas Metal Arc Welding (GMAW)**
Suggested Performance Indicators	A. Safely set up equipment for Gas Metal Arc Welding (GMAW) B. Explain the advantages of GMAW over conventional electro-type arc (stick) welding C. Explain factors that affect electrode selection for Gas Metal Arc Welding (GMAW) D. Use the gas metal arc welding method and various metal transfer methods to demonstrate how to pad beads and make fillet welds on plain carbon steel in all feasible positions E. Set-up and perform SMAW-S (short-circuit) multiple-pass V-groove welds on carbon steel plate coupons in multiple positions using solid or composite wire and shielding gas F. Perform fillet and groove welds in all positions

FA-MNWL05	Demonstrate proper set-up and procedure for Flux Cored Arc Welding (FCAW)
Suggested Performance Indicators	A. Safely set up equipment for Flux Cored Arc Welding B. Explain multiple factors that affect electrode and shielded gas selection for Flux Cored Arc Welding C. Use various electrodes and the flux cored arc welding process to demonstrate how to pad beads and make filled welds on plain carbon steel in all feasible positions D. Explain the distinctive features of Flux Cored Arc Welding E. Demonstrate how metal transfer is affected by arc-control, self-shielded, and gas-shielded FCAW
FA-MNWL06	**Demonstrate proper set-up and procedure for Gas Tungsten Arc Welding (GTAW)**
Suggested Performance Indicators	A. Safely set up equipment for Gas Tungsten Arc Welding B. Explain multiple factors that affect electrode selection for Gas Tungsten Arc Welding C. Use various electrodes and the gas tungsten arc welding process to demonstrate hot to pad beads and make fillet welds on plain carbon steel, stainless steel, and aluminum in all feasible positions D. Explain the distinctive features of Gas Tungsten Arc Welding
FA-MNWL07	**Successfully apply various quality control methods to the welding process**
Suggested Performance Indicators	A. Describe various defects found in welded products B. Discuss the value of having clean material before starting a weld and the importance of doing it right the first time C. Differentiate between destructive and nondestructive tests used as quality control techniques to prevent defects D. (Measure and visually inspect welded products for acceptability to American Welding Society QC-10 standards E. Record discontinuities and defects and compare data to given project specifications; recommend changes to reduce defects in the manufacturing process F. Distinguish between the guided-bend test and the free-bend test; explain when it is most appropriate to apply each test; demonstrate the use of each test and properly document results conforming to AWS requirements
FA-MNWL08	**Demonstrate knowledge of math and blueprints that apply to welding design and layout**
Suggested Performance Indicators	A. Demonstrate good math skills including basic geometry, fractions, decimals, multiplication, and circle math (e.g., establish radius) B. Interpret and demonstrate the planning and layout operations used in the welding process (e.g., interpret scaled welding blueprints, perform calculations, analyze welding symbols, drawings, and specifications) C. Identify, sketch, and explain the five basic weld joint designs (i.e., butt, lap, tee, outside corner, and edge)

FA-MNWL09	Demonstrate knowledge of welding standards and certifications
Suggested Performance Indicators	A. Demonstrate an understanding of Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) Development as specified by the American Welding Society B. Demonstrate the ability to review a welding procedure specification and conduct a welding procedure test C. Demonstrate knowledge of preferred Industry Certifications for welding and the requirements for successful examination D. Describe what is required to achieve certification in the following American Welding Society modules: Describe what is required to achieve certification in the following American Welding Society modules: Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), Flux Cored Arc Welding (FCAW), and Gas Tungsten Arc Welding (GTAW)