Remote learning in Washington's manufacturing sector

Washington State Department of Commerce

The value of hands-on, skills-based learning in manufacturing, reported per Chapter 64, Laws of 2021

OFFICE OF ECONOMIC DEVELOPMENT & COMPETITIVENESS

Dec. 1, 2022

Report to the Legislature

Director Lisa Brown

V3.1

Acknowledgments

The feedback and expert advice from individuals and organizations helped shape this report and are much appreciated. Contributors are fully listed in Appendix A. Their survey responses, expertise and candor were vital in shaping the conclusions presented here.

Staff:

Washington State Department of Commerce
Carolyn Busch, program coordinator
Workforce Innovation Director & Industry Sector
(206) 256-6140
carolyn.busch@commerce.wa.gov

Office of Economic Development & Competitiveness
1011 Plum St. SE
P.O. Box 42525
Olympia, WA 98504-2525

www.commerce.wa.gov

For people with disabilities, this report is available on request in other formats. To submit a request, please call 360-725-4000 (TTY 360-586-0772)

Table of Contents

Executive summary

Overview

The State of Washington has set an ambitious goal of doubling the state's manufacturing employment base, the number of small businesses, and the number of women and minority-owned manufacturing businesses in the next 10 years. The state Department of Commerce, with advising from and in consultation with the newly established Manufacturing Council, has been charged with preparing biennial reports on the state of the manufacturing and research and development industry and workforce.

In this first report, the Department of Commerce has assessed the inadequacies or gaps in delivering hands-on, skills-based remote learning (HOSBRL) to all Washingtonians seeking to enter the manufacturing workforce or to be retained for a transition within the manufacturing workforce. The report is narrowly focused on training that is delivered using all three components in combination. It does not focus on remote learning exclusively.

Key findings or highlights

Based on research that included stakeholder interviews with employers and trainees, and a survey of over 40 training providers and employers, the following key findings emerged:

- HOSBRL is a promising innovation in manufacturing training that has the potential in the future to grow awareness of manufacturing careers, diversify the manufacturing workforce, and create new methods of training workers for manufacturing careers.
- However, our research does not suggest that there is a case today from employers, trainees, or training providers to adopt HOSBRL as the dominant method of manufacturing training and make the scale of investments needed in equipment and staff retraining to support that shift.
- HOSBRL is an effective tool in promoting early career exploration in manufacturing because of its ability to bring large number of students, at scale, onto otherwise sensitive worksites.
- As a tool for more intensive job training, HOSBRL has potential to expand access for trainees who cannot attend or do not thrive in traditional on-site training, especially rural students, English language learners, and medically restricted trainees.
- More generally, trainees do not want to see HOSBRL replace traditional manufacturing training, as many gravitate to manufacturing training for the hands-on, in-person, applied aspects. HOSBRL could be effective in hybrid settings to make "lecture-style" or more passive "demonstrations" self-paced and convenient.
- Employers demonstrated an openness to HOSBRL in certain cases, especially if it could consolidate common training and reduce costs for small and medium sized employers. But there is some skepticism about how much training can truly be universalized in a sector that is increasingly focused on custom products.
- Many training providers were forced to adopt some aspects of HOSBRL during the COVID-19 pandemic and see some value in and demand for HOSBRL but are concerned about the cost and return on investment for teaching these skills remotely.
- As extended reality technologies develop, hands-on, skills-based remote learning could become a more effective tool for training of all types. Policymakers should continue to monitor these advances on an ongoing basis and assess employer, educator, and trainee demand.

Introduction

Background

Today, Washington's manufacturing sector employs nearly 270,000 individuals across 7,600 firms, representing an 8.3% share of the state's employment.[1] As the sixth-largest contributor to the state's GDP,[2] manufacturing continues to be a major economic driver and the Legislature intends to build upon the state's success and position as a nationwide leader in the manufacturing and research and development (R&D) sectors. It is the Legislature's view that when these sectors thrive across all regions, the state will experience a "strong, resilient tax base for good schools, safe streets, and community optimism," as provided in Substitute House Bill 1170.

To that end, the Washington State Legislature passed Chapter 64, Laws of 2021 (SHB 1170) in 2021, which sets the vision for manufacturing and R&D. The bill lays out a 10-year goal of doubling:

- The state's manufacturing employment base
- The number of small businesses
- The number of women- and minority-owned manufacturing businesses

To achieve this, the Legislature identified the Department of Commerce to lead the effort and produce a biennial report on the state of the manufacturing and R&D sectors and workforce, with specific attention to the progress or challenges the state has encountered in achieving its ambitious 10-year goal.

A key component of the legislation includes convening a Manufacturing Council (full list of participants is available in Appendix A) to advise and consult on the development of the report and recommendations. The council is facilitated by Commerce and includes representatives from small- to mid-sized private sector manufacturing businesses, labor, apprenticeship programs, statewide business associations, higher education institutions, and workforce partners, with equal representation from business and labor.

One path toward the goal of doubling the manufacturing employment base is a strong training ecosystem that adequately prepares a competitive manufacturing workforce. The COVID-19 pandemic underscored the need for training that is flexible and delivered in a variety of formats to remain resilient and accessible to all Washingtonians seeking opportunities in manufacturing.

In this first biennial report, through SHB 1170, the Legislature charged Commerce with working in coordination with the Office of the Superintendent of Public Instruction (OSPI) and the State Board for Community and Technical Colleges (SBCTC) to "assess any inadequacy or gaps in delivering hands-on, skills-based learning remotely to all Washingtonians seeking to enter the manufacturing workforce or to be retrained for a transition within the manufacturing workforce." This report, based on employer and trainee interviews, and a survey of 41 employers, presents gaps and recommendations related to the remote delivery of hands-on, skills-based learning to both new and incumbent workers in Washington.

Legislative mandate

In sections 3 and its subsections, SHB 1170 states:

---

[1] Employment Security Department, 2021 Labor Market and Economic Report (Feb 2022)
[2] Ibid.

(1) The department is responsible for identifying and developing strategies to help achieve the goals established in section 2 of this act. In support of pursuing the goal, the department must prepare and update each fiscal biennium a report on the state of the manufacturing and research and development industry and workforce. The report must identify progress or challenges the state has encountered in achieving the goals established in section 2 of this act and identify recommendations to the legislature.

(2) The report may include, but not be limited to: (a) Recommendations for specific actions to develop a manufacturing workforce pipeline and specific manufacturing subsectors that present workforce opportunities or challenges; (b) Identification of dislocated workers; (c) Career-connected learning opportunities; (d) A survey of financial aid that can be leveraged to fund training for the manufacturing workforce pipeline, such as Washington college grant opportunities, passport to careers, and prison to postsecondary funding; (e) Recommendations on improving the state's competitiveness for manufacturing and research and development job retention and creation; (f) Identification of high-demand advanced manufacturing industries and subsectors globally; (g) Identification of site selection criteria of advanced manufacturing and research and development projects; and (h) Recommendations of best practices to streamline environmental permit approval and appeal processes for the purpose of getting manufacturing businesses who want to site or expand in Washington more certainty, faster.

(3) The department must convene a manufacturing council to advise and consult on the development of the report and recommendations. (a) The director or the director's designee must appoint to the council such persons from the private, nonprofit, and public sectors as may best inform the state's ability to innovate, diversify supply chains, and expand living wage jobs in the manufacturing sector. (b) Representatives must include small to mid-sized private sector manufacturing businesses, labor and apprenticeship programs, statewide business associations, higher education institutions, and workforce partners. The department must work to ensure: (i) Equal representation of business and labor on the council; (ii) That appointees represent every region of the state such that economic diversification across all regions is supported; and (iii) That the council includes a strong array of voices from women and minority executives and labor in manufacturing.

(4) All state agencies with expertise in workforce development and economic development are encouraged to provide such information and resources as may be requested to inform and facilitate identification and analysis of public policy challenges and potential recommendations for the report in subsections (1) and (2) of this section.

(5) In its first biennial report, the department shall coordinate with the office of the superintendent of public instruction and the state board for community and technical colleges to assess any inadequacy or gaps in delivering hands-on, skills-based learning remotely to all Washingtonians seeking to enter the manufacturing workforce or to be retrained for a transition within the manufacturing workforce

Washington's manufacturing sector

The manufacturing sector comprises “establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products.”[3] Over time, the manufacturing industry has expanded beyond the traditional understanding of manufacturing plants, factories, or mills that

[3] North American Industry Classification System

use power-driven machines and materials-handling equipment, and now includes establishments such as custom tailors, breweries, bakeries and more, where products are manufactured and sold from the same site.

This report utilizes the North American Industry Classification System (NAICS) definition to describe the manufacturing sector as inclusive of establishments that process their own materials or contract with other establishments to process materials for them.

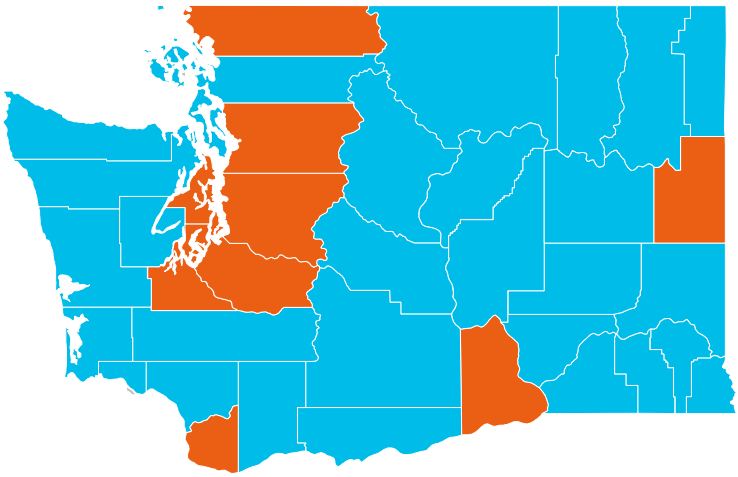
In Washington, the most common manufacturing subsectors[4] include:

- Aerospace product and parts manufacturing (NAICS 3364)
- Food (NAICS 311) and Beverage manufacturing (NAICS 312)
- Fabricated metal product manufacturing (NAICS 332)
- Computer and electronic product manufacturing (NAICS 334)
- Machinery manufacturing (NAICS 333)
- Wood product manufacturing (NAICS 321)
- Other transportation equipment manufacturing (NAICS 336)
- Nonmetallic mineral product manufacturing (NAICS 327)
- Paper manufacturing (NAICS 322)
- Printing and related support activities (NAICS 323)
- Primary metal manufacturing (NAICS 331)
- Electrical equipment and appliance manufacturing (NAICS 335)

Outside of Washington's most represented subsectors, less represented manufactured goods are aggregated into two subsectors: Other Durable Manufacturing and Other Non-Durable Manufacturing.

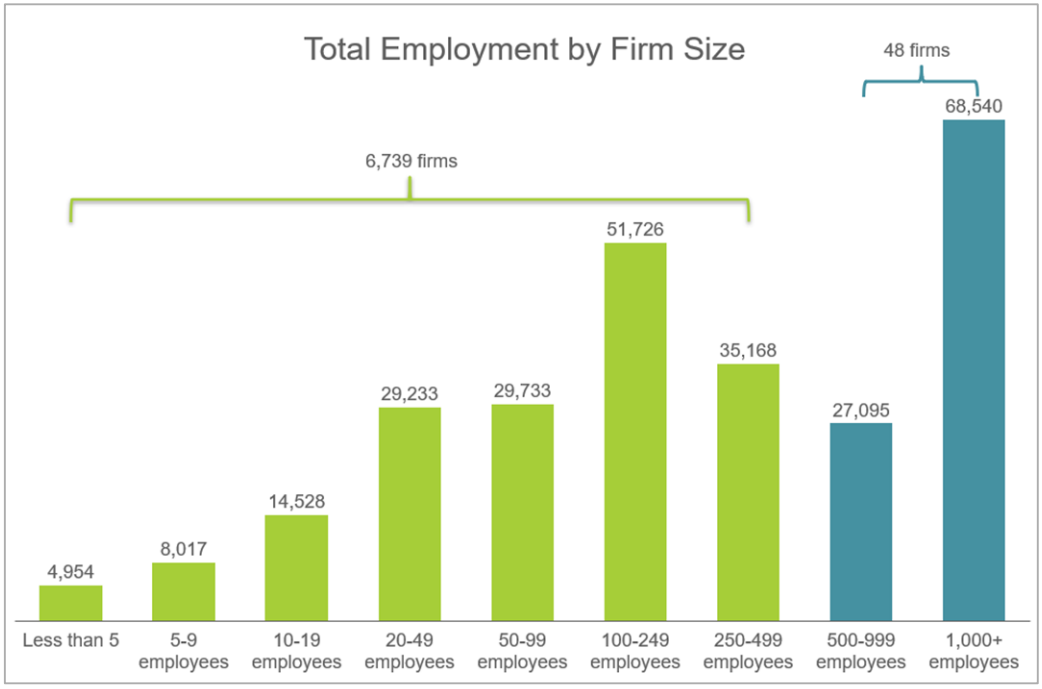
[4] Subsectors are grouped in alignment with the Washington State Employment Security Department's analysis of the manufacturing sector.

Across Washington, nearly 80% of the state's manufacturing companies are located in just nine urban counties. The remaining 20% of manufacturers are spread across 30 rural counties and tend to pay, on average, an annual wage that is $16,000 less than that of manufacturing workers in urban counties.



	Urban counties	Rural counties	Difference
Total 2020 wages paid	$18.8 B	$3.0 B	$15.8 B
Annual wage	$70,000	$54,000	$16,000
Total firms	5,916	1,753	4,163
Total employment	215,527	49,811	165,716

Numbers are reported as approximate annual averages
*Whitman and Ferry County employment and wages not included to avoid disclosure of data for individual employer
Source: Employment Security Department/LMEA Covered employment classified by industry Washington State 2020 annual averages[5]



Source: U.S. Census Bureau, County Business Patterns[6]

Also of note is the disbursement of firms across the manufacturing sector. Approximately 35% of manufacturing jobs are associated with just 48 firms, large companies that each employ upwards of 500 employees.[7] These companies tend to have the resources and infrastructure to run their own workforce

[5] Employment Security Department/LMEA – Covered employment classified by industry 2020 averages
[6] U.S. Census Bureau, County Business Patterns (2020)
[7] Ibid.

training programs internally. At the other end, another third, or 32%, of Washington's manufacturing workforce is employed by companies made up of less than 100 employees. Together, these 6,300 firms represent 92% of the manufacturing companies in the state.[8] These companies are more limited in the resources they can spend on creating their own internal training system.

Manufacturing remains a vital sector in Washington's economy and a sector from which Washingtonians can earn a living wage, particularly for workers with less than a college education.[9] However, a deeper look reveals that some demographic groups are under-represented within the manufacturing sector compared to Washington's overall labor force, most notably women, younger and rural workers.

	Washington Civilian Labor Force (2020)	Washington Manufacturing Sector Labor Force (2020)	Percentage point difference
Race/ethnicity			
White alone	78.7%	77.7%	- 1.0
Black or African American alone	4.2%	3.9%	- 0.3
American Indian or Alaskan Native alone	1.5%	1.3%	- 0.2
Asian alone	9.6%	13.1%	+ 3.5
Native Hawaiian or Pacific Islander	0.7%	0.9%	+ 0.2
Hispanic or Latino	13.5%	13.2%	- 0.3
Two or more races	3.9%	3.2%	- 0.7
Gender			
Male	53.3%	72.2%	+ 18.9
Female	46.7%	27.8%	- 18.9
Age			
14-21	6.1%	2.7%	- 3.4
22-34	29.8%	24.4%	- 5.4
35-54	42.4%	45.2%	- 2.8
55+	21.8%	27.7%	+ 5.9
Geography			
Urban	81%	91.7%	+ 10.7
Rural	19%	8.3%	- 10.7

Sources: Local Area Unemployment Statistics[10] and U.S. Census Bureau Quarterly Workforce Indicators[11]

These regional and demographic discrepancies in the manufacturing sector highlight an opportunity for targeted and innovative training strategies that can prepare a diverse manufacturing workforce, primed to meet some of the emerging trends in the sector.

Notable manufacturing trends with implications for training

According to the Washington Employment Security Department (ESD) 2022 industry employment projections,[12] total nonfarm employment for the state is expected to grow by 1.83% between 2020 and 2030. With the exception of manufacturing, every sector is projected to see a net gain in employment over this period. Overall employment in the manufacturing sector is projected to decrease from an estimated 292,000 jobs in 2020 to

[8] U.S. Census Bureau, County Business Patterns (2020)
[9] AWB, Manufacturing and Technology Study (PDF) (March 2021)
[10] Employment Security Department, Washington state unemployment statistics by county (Excel) (June 2022)
[11] U.S. Census Bureau, QWI Explorer (June 2022)
[12] Employment Security Department, 2022 Industry Employment Projections (June 2022)

274,000 jobs in 2030,[13] a net loss of 18,000 jobs. Significant losses are projected to occur between 2020-2025 in the aerospace product and parts manufacturing subsector, where the projected average annual growth rate is -7.13%.[14]

The ESD's latest 2021 Labor Market and Economic Report[15] suggests that supply chain issues may be a driver of this contraction. Wages for domestic suppliers are being driven down by some larger retailers forcing their finished good suppliers to lower their costs, leading to more offshoring and greater reliance on a resilient and durable supply chain. There has also been a pattern of manufacturers using a single supplier, spurring the consolidation of smaller suppliers into larger businesses that can offer more competitive pricing. However, emerging data suggests that a growing number of businesses are considering or actively reshoring jobs in order to be more resilient in the face of supply chain issues, citing labor costs and availability, logistics costs, delivery time, and a desire to reduce their carbon footprint as some of the major drivers of that consideration.[16]

Additionally, automation is often cited as a leading culprit when it comes to the erosion of manufacturing jobs.[17] However, according to a 2021 automation impact study by the Association of Washington Business, manufacturer decisions to move toward automation were not driven by a desire to replace workers, but rather, they were driven by challenges finding high-skilled workers (such as welders), supply chain requirements, task complexity and worker safety.[18] The shift toward automation has created new types of jobs that complement automation, but still requires human capabilities.

The outlook for the manufacturing sector may appear challenging, but there are bright spots worth noting. While some manufacturing subsectors may see a loss in employment, there are projected employment gains for other subsectors including electrical equipment and appliance manufacturing, as well as food and beverages manufacturing. It is also important to note that Washington's manufacturing sector is increasingly intersecting with information and communication technology,[19] a growth area for the state. The information sector alone is projected to grow by more than 66,000 jobs from 2020-2030,[20] the biggest increase among all nonfarm employment sectors. As the distinction between manufacturing and information sectors becomes less precise, there is an opportunity to train the workforce in anticipation of these changes to meet the projected demand. Furthermore, recent federal legislation such as the Bipartisan Infrastructure Law (Infrastructure Investment and Jobs Act)[21] and the Inflation Reduction Act[22] have created new opportunities to grow manufacturing in Washington.

Advancements in technology have had ongoing impacts in the manufacturing sector, particularly regarding automation. Additionally, technological advancements have led to important developments in worker safety, particularly for subsectors that are highly regulated. The development of extended reality technologies, including virtual, augmented, and assisted reality technologies, has allowed for virtual collaboration in complex scenarios or when workers are more likely to face safety hazards. For example, assisted reality technology was used in the design of safety systems inside the aft section of the Boeing 777. Technology allowed more than 10 stakeholders to simultaneously review within a confined space. It is also worth noting, in this example,

---

[13] Employment Security Department, All-term aggregated industry employment projections (Excel) (July 2022)
[14] Ibid.
[15] Employment Security Department, 2019 Employment Projections Report (PDF) (September 2019)
[16] Kearny 2021 Reshoring Index (September 2022)
[17] Acemoglu, D. & Restrepo, P., Tasks, automation, and the rise in US wage inequality (June 2021)
[18] AWB, Automation and manufacturing employment in Washington state (September 2021)
[19] AWB, Manufacturing and technology study (PDF) (March 2021)
[20] Employment Security Department, All-term aggregated industry employment projections (Excel) (July 2022)
[21] The White House, President Biden's Bipartisan Infrastructure Law (2022)
[22] Internal Revenue Service, Inflation Reduction Act of 2022 (2022)

that FAA regulations may have prohibited any number of those 10 individuals to be on site if they arrived physically on site. Utilizing assisted reality allowed experts to view a narrow problem, without exposing other elements of the project that might require layers of security clearance.

Taken together, these sector employment trends and advancements in technology have important implications for the future of the manufacturing workforce, particularly as the Legislature tasks the state's Manufacturing Council with doubling the manufacturing employment base, the number of small businesses, and the number of women- and minority-owned manufacturing business. There are considerable opportunities for Washington to be a leader in manufacturing workforce development and training.

Current state of manufacturing training

Today, manufacturing training in Washington is comprised broadly of seven training types[23] along a spectrum:

- **Career exploration**: Activities in which young people explore, examine and investigate a new and/or unexpected world of work. Students gain awareness of a specific field without heavy investment in developing skills specific to that field
- **Career launch**: Programs that provide K-12 students with real-life work experience related to their classroom studies
- **Registered apprenticeship**: A formal relationship between a worker and a sponsor that consists of a combination of on-the-job training and related occupation-specific instruction in which the worker learns the practical and theoretical aspects of an occupation
- **Classroom-based learning**: Also called traditional learning, it is characterized by face-to-face interactions between trainees and instructors where all are physically present in the same classroom or training space
- **Cooperative education**: A structured method of combining classroom-based education with practical work experience. A cooperative education experience, commonly known as a "co-op," provides academic credit for structured job experience
- **Reskilling**: The process of teaching workers new skills so they can do a different job, often required due to modernization and technological advances
- **Upskilling:** Training the current workforce to learn new, more advanced skills and competencies that are required for new and/or changing jobs, helping them along their current career path

These trainings are offered by a constellation of providers that include K-12 career and technical education (CTE), skill centers, community and technical colleges (CTCs), registered apprenticeship programs, labor unions, employers, private providers, and four-year colleges and universities.

While there are a number of different manufacturing training providers, the focus of this report is on training programs delivered or funded by the state, namely K-12 CTE, skill centers, CTCs, and registered apprenticeship programs. The purpose of this narrower scope is to inform potential recommendations within the purview of the Legislature. However, it will include relevant information for other public and private training providers to consider as well. Collectively, these state-sponsored trainings capture a spectrum of potential and current members of the manufacturing workforce, including youth, new workers/new entrants, incumbent workers, and dislocated workers.

[23] Definitions for Hands-on, skills-based, remote learning (June 2022)

While these programs have significant reach, their current capacity does not meet the scale needed to meet the current manufacturing workforce gap. A 2021 study from Deloitte and The Manufacturing Institute projects that the current manufacturing skills gap in the U.S. could result in 2.1 million unfilled manufacturing jobs by 2030.[24] This trend appears consistent with what Washington manufacturers are experiencing. These state-sponsored training providers will need significant support to innovate and scale existing programs that meet current workforce needs and achieve the Legislature's ambitious 10-year goal.

Hands-On, Skills-Based Remote Learning (HOSBRL)

Chapter 64, Laws of 2021 (SHB 1170) requires that the first biennial report on the state of manufacturing and R&D "assess any inadequacy or gaps in delivering hands-on, skills-based learning remotely to all Washingtonians seeking to enter the manufacturing workforce or to be retrained for a transition within the manufacturing workforce."

The term "hands-on, skills-based learning remotely" encompasses three distinct teaching and learning concepts:

- **Hands-on learning is learning by doing.**[25] Through a process of trial and error, learners practice realistic first-hand activities that allow them to handle and manipulate the objects they are studying.[26]

- **Skills-based learning is designed to teach the learner to carry out a task with acquisition of a specific skill and industry standards in mind.** Similar to hands-on learning, skills-based instruction allows learners to actively develop and apply practical skills through activities and demonstrate competency in a safe learning environment.[27] This is different from knowledge-based learning, which refers to gaining a theoretical understanding through reading, listening and watching.

- **Remote learning occurs when the trainer and the trainee are not in physical proximity to one another.** Information is relayed through technology and can occur either synchronously with real-time interaction, or asynchronously with self-paced learning activities taking place independently of the trainer.[28]

The legislation considers these concepts together to assess Washington's manufacturing training landscape. When combined, hands-on, skills-based remote learning for manufacturing could take on a variety of forms, including, but not limited to:

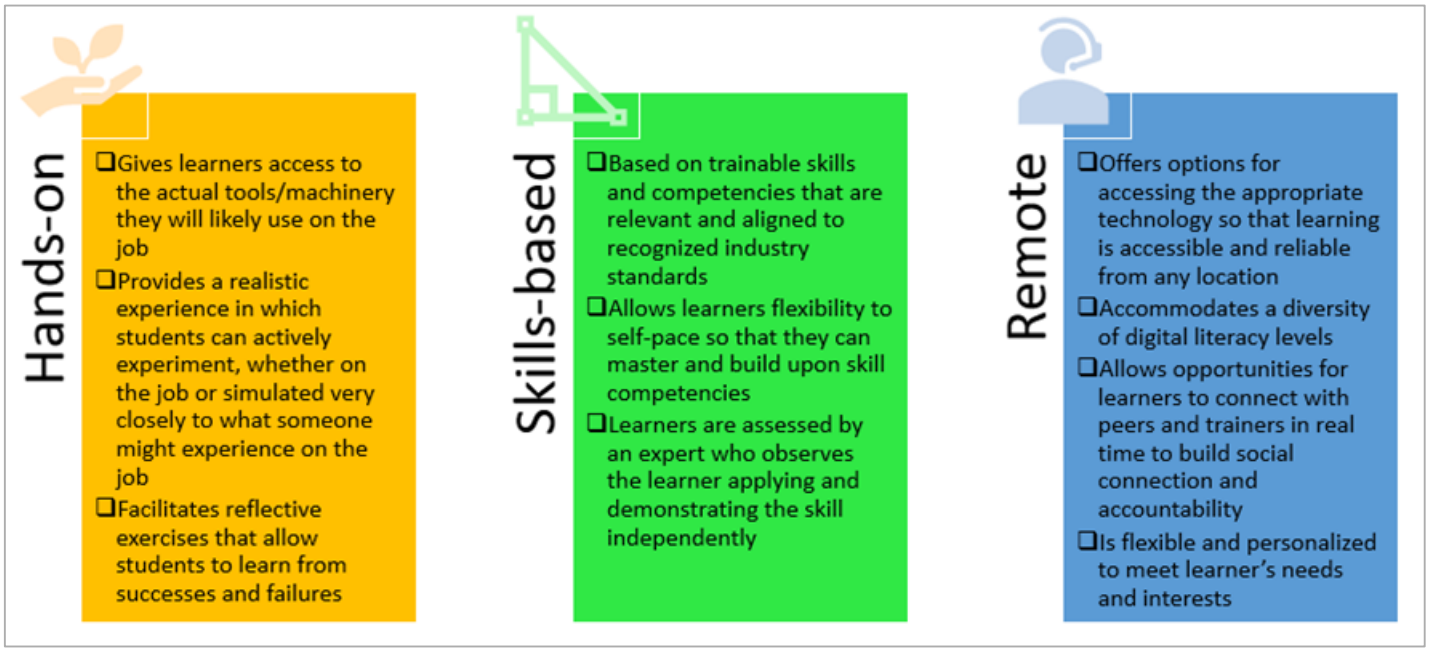
- Trainees follow along with pre-recorded lectures at their own pace and convenience. Trainees are provided kits with the materials and tools they need to practice the physical components of the skill from their home, or software/hardware that allows them to simulate the skill. Once a week, trainees have the option to participate in virtual office hours with trainers, who are available to address questions about the training material.
- Trainees participate in remote live classes twice a week with a trainer who walks them through tasks and skills. Once a week, the trainee comes to a skill center to practice and apply their learning, working

[24] Deloitte, Creating pathways for tomorrow's workforce today: Beyond reskilling in manufacturing (May 2021)
[25] Holstermann, N., Grube, D. & Bögeholz, S., Hands-on activities and their influence on students' interest (2010)
[26] Rutherford, F. J., Hands-on: a means to an end (1993)
[27] Dula, C., & Porter, A. L., Addressing Challenges in Skills-based Education Through Innovation and Collaboration (2021)
[28] Top Hat: Glossary of Higher Education (June 2022)

directly with tools and materials alongside the trainer, who can give feedback and assess skill acquisition.

- Trainees complete components online from a location of their choice, on their own time. Once a week, they practice the skills at their worksite with real materials and tools. The trainer calls in remotely via a video conferencing tool, patched through an assisted reality headset, that offers the trainer a real-time visual of what the trainee is seeing. This allows the trainer to guide and assess the trainee's capability to perform the skill.

As in these examples, how the components of hands-on, skills-based and remote learning are weighted in combination can vary across programs. However, there are important considerations in implementing each component. The following rubric provides 10 elements of effective hands-on, skills-based remote learning for manufacturing:



Source: Components were derived from existing frameworks including the Experiential Learning Cycle, Competency-Based Education Mastery Framework, and Framework for Quality K-12 Remote Learning.

It is important to note that this report will focus specifically on training delivery that combines all three components. This is distinct from programs that are delivered entirely remotely. Remote learning or distance education is a particular pedagogy with proven success and has an important role to play in the training landscape. The following offer some examples that may better illustrate the different ways of delivering effective hands-on, skills-based remote learning for manufacturing:

Clover Park Technical College (Lakewood, Washington)
School of Advanced Manufacturing
Clover Park Technical College (CPTC) has adapted courses as part of its bachelors, associate level, and introductory program in the School of Advanced Manufacturing to be offered as HOSBRL options. Advanced manufacturing programs teach everything from leading technologies such as the Internet of Things and artificial intelligence to understanding sustainable systems and smart manufacturing. As such, it facilitates access to a variety of equipment for students, and programs are designed to prepare individuals with the knowledge and tools to succeed in the digital age. Courses that typically run over a 10-week quarter are split into two phases.

Phase 1 (five to six weeks) is offered entirely remotely and asynchronously. Students pick up course-specific kits, such as programmable logic controllers (PLC) kits or Internet of Things kits, at the start of the quarter. During this phase, students are presented with information on a particular subject, review demonstration videos, and complete small assignments using the kits to build their background knowledge. On occasion, instructors might offer live workshops. Instructors use Discord to share files, start digital conferences between individuals, and instruct live. Instructors record their live demonstrations and use Twitch for live streaming and upload videos that can be accessed later by students unable to attend the live workshop. These two digital platforms, used primarily in gaming communities, were identified for use because of their ability to scale to whatever device a student may be using (such as a phone, computer or tablet) without putting stress on a student's broadband capacity.

Simultaneously during this phase, the instructor polls students about availability Monday through Sunday, from 5 a.m. to midnight, to determine designated times for the Phase 2 hands-on practical application component of the course. This approach to scheduling allows students to dictate the terms of their course schedule so it accommodates potential conflicts like child care or work.

During Phase 2, students complete in-person labs, equating to about 33 hours. Because the schedule is developed based on student availability polled in Phase 1, a student can conceivably travel in from another part of the state or a different state and complete the lab component in as little as two to three days. As an outcome of Phase 2, students develop a portfolio to showcase their work. The portfolio becomes an artifact that program graduates can use in job interviews to demonstrate their skills to potential employers.

Currently, the HOSBRL program serves 12 bachelor's level students, 24 associate level students, and 28 intro students. With their current instructional capacity, the program has the ability to serve an additional 24 associate level students and an additional 20 intro students. Overall, the program has been well received by students and the program reports a very high job placement rate. Of the 12 bachelors level students, 7 reported they would not have been able to attend the program at all if it were not offered in this HOSBRL format. In the future, the program will be able to deploy the instructor to travel and meet a cohort of students where they are. For instance, if there is a cohort of eight students in Eastern Washington, an instructor can travel with kits to teach and assess the hands-on application of skills.

Transfr

Transfr worked in partnership with an aerospace and defense original equipment manufacturer to design a pre-employment program. The program goal was to teach content and skills for precision measurement. The specialized program utilized Transfr's virtual reality (VR) technology to simulate and provide hands on experience for a cohort of 20 trainees ranging in ages from 18 to 65. Trainees were guided through a program with the goal of understanding mastery in two modules: One on fractions and one on precision measurement tools. There are a total of 10 simulations between the two modules on topics including four tutorials and individual simulations on the Fractional Inch Rule, Dial Inch Caliper, Digital Caliper, Digital Micrometer, Zeroing and Calibrating tools, and Simplifying Fractions. The program included two to three self-paced sessions over about 10 days.

During their time in the program, students used Oculus headsets preloaded with the modules only, so as not to be distracted by other content. When logging into the VR system, trainees are introduced to Simon, the avatar or coach that provides feedback to the trainee throughout their time in the simulation. Guided by Simon, students receive expert, personal instruction that teaches them how to perform essential tasks, gives feedback based on their specific actions, and assesses performance to help students improve. Within each non-tutorial simulation, trainees earn experience points for each correct answer or skill they demonstrate within the

module. Students must earn 10,000 experience points within each module to move on. These experience points help us gauge mastery within each simulation. In total, trainees spent an average of 1 hour and 37 minutes in the Transfr modules.

After the VR training, trainees were asked to perform the task using real instruments in front of a hiring manager who evaluated their performance. Nineteen trainees completed the real-word transfer test. The instructor assessed each trainee's performance and provided coaching on areas of deficiency. Nearly half scored above 90%, with four students scoring 100%. The average score for the cohort was 82.10%, and the median was 82%.

RealWear

The global excellence team of a multinational pet product manufacturer was tasked with upskilling its staff to operate and maintain its automated equipment sites. Its goal was to prepare frontline staff to keep autonomous equipment running at high capacity to ensure factories are efficient and maximize their output, while keeping workers safe. Their solution was Vancouver, Washington, based company RealWear.

RealWear produces industrial-grade headsets that offer hands-free voice-controlled capabilities to connect frontline workers to information and expertise needed for operational efficiency, productivity, and enhanced safety around machinery or in dangerous working environments. The RealWear HMT-1 allowed the manufacturer's frontline staff to display and connect to Microsoft OneDrive, while connecting to a coach or trainer via Microsoft Teams in real time, providing individualized support on the job. With this approach, employees did not need to complete training outside of their scheduled worktime. Coaches are also able to focus on their mission of training and supporting frontline staff, rather than spending time traveling between sites. As a result of using the RealWear product, work travel is expected to reduce by more than 35%.

One executive's testimony: "We had to adapt to new ways of working to do that, which is where connecting with hands-free devices on the shop floor has been extremely helpful. RealWear with Teams allows our associates to coach and allows operators to safely use their hands and do tasks while the team is working with them."

Because of its success in training up their workforce for new processes, RealWear was rolled out to all 14 of the company's U.S. factories. The adoption of RealWear came just ahead of COVID-19 pandemic, allowing the company's factories to continue to operate despite a newly socially distanced and often remote workforce. The integration of RealWear has become an essential part of how frontline and other staff can continue to collaborate remotely, while getting work done.

Attention to, and investment in, HOSBRL is one tactic to make progress on the state's 10-year goal of doubling the state's manufacturing employment base, the number of small businesses, and the number of women and minority-owned manufacturing businesses. But it is only one tactic that alone might not have significant impact on the state's ambitious goal.

As one industry advocate summarized, "HOSBRL won't solve 75% of the challenges we are trying to address in [SHB 1170] … The whole challenge is that the entire system is broken. We have to fix taxation, affordable housing, childcare, etc. – It's hard to answer but everything is so dependent on each piece. What I see is that if people get hired, but they can't afford housing, or pay for gas to get to their worksite, etc., then it doesn't matter

[what kind of training you've had]." In its current delivery across the state, HOSBRL comes with several of its own challenges that must be addressed in order to be impactful at scale.

Key findings in assessing challenges to delivering HOSBRL

To assess the current delivery, as well as inadequacies and gaps, in delivering HOSBRL, CTCs, K-12 CTEs, skill centers and registered apprenticeship programs were invited to complete a survey to capture information about their current capabilities for manufacturing training. The goal of the survey was to understand some of the current offerings, reach, demand and resources required to deliver HOSBRL with fidelity to the different pedagogical approaches and modalities presented earlier in this report. Again, the training models being assessed in this report require the delivery of all three components within a single program. It is separate and distinct from fully remote delivery alone.

In total, 41 organizations responded to the survey, 32 of which are public training providers that cover 25 of Washington's 39 counties, with a number of providers offering remote training options for the entire state. Surveys were further supplemented with over a dozen interviews with employers, trainees/apprentices and industry advocates.

From this research, eight key findings emerged:

1) HOSBRL is a promising innovation in manufacturing training that has the potential in the future to grow awareness of manufacturing careers, diversify the manufacturing workforce, and create new methods of training workers for manufacturing careers.
2) However, our research does not suggest that there is a case from employers, trainees or training providers to adopt HOSBRL as the dominant method of manufacturing training and make the scale of investments needed in equipment and staff retraining to support that shift at this time.
3) HOSBRL is an effective tool in promoting early career exploration in manufacturing because of its ability to bring large number of students, at scale, onto otherwise sensitive worksites.
4) As a tool for more intensive job training, HOSBRL has potential to expand access for trainees who cannot attend or do not thrive in traditional onsite training, especially rural students, English language learners and medically restricted trainees.
5) More generally, trainees do not want to see HOSBRL replace all traditional manufacturing training, as many gravitate to manufacturing training for the hands-on, in-person, applied aspects. HOSBRL could be effective in hybrid settings to make "lecture-style" or more passive "demonstrations" self-paced and convenient.
6) Employers demonstrated an openness to HOSBRL in certain cases, especially if it could consolidate common trainings and reduce costs for small- and medium-sized employers. But there is some skepticism about how much training can truly be universalized in a sector that is increasingly focused on custom products.
7) Many training providers were forced to adopt some aspects of HOSBRL during the pandemic. They see some value in and demand for HOSBRL but are concerned about the cost and return on investment for teaching these skills remotely.
8) As extended reality technologies develop, hands-on, skills-based remote learning could become a more effective tool for training of all types. Policymakers should continue to monitor these advances on an ongoing basis and continue to assess employer, educator, and trainee demand.

Today, HOSBRL makes training more accessible for certain students, employers and fields, and may lower the cost of training by reducing rework. In the future, there could be broader application, but as it stands today, a clear demand for HOSBRL options does not exist among trainees or employers.

HOSBRL is limited in the following ways:

- Employers do not feel HOSBRL can replace in-person training for most roles in most fields in the manufacturing sector.
- Many students and trainees are drawn to the manufacturing field because they value the hands-on, kinesthetic learning. Remote options may not provide these students with the specific learning experience they desire.
- For training providers, there is a cost to making materials accessible and training instructors on how to teach in this modality. Training providers do not see HOSBRL changing career or net wage outcomes for those HOSBRL-trained employees.

While HOSBRL had a place during the COVID-19 pandemic and illuminated certain benefits of remote options, it has certain, more limited application for manufacturing training going forward. Currently, there is not a strong case for HOSBRL to be the predominant training modality for manufacturing in the state. The following eight key findings that emerged from the assessment show the inadequacies and gaps in delivering HOSBRL, with particular emphasis on who HOSBRL works for, and where its application may be most relevant today and into the near future.

1. HOSBRL is a promising innovation in manufacturing training that has the potential in the future to grow awareness of manufacturing careers, diversify the manufacturing workforce, and create new methods of training workers for manufacturing careers.

Overall, survey respondents and interviewees saw the potential for HOSBRL in manufacturing. Broadly, they believed that HOSBRL delivery could offer a number of advantages for manufacturing training. Perhaps most obvious is that the remote delivery component allows for training to be accessed from any region of the state. With nearly 1 in 5 members of the civilian labor force residing in rural counties in the state,[29,30] remote training options mean a trainee is not as inhibited by location or limited transportation. This is especially true for workers and employers looking to access specific trainings not yet readily available in the regions where subsectors might emerge, or employers who need to skill up the local workforce to meet workforce gaps.

According to survey respondents and interviewees, remote delivery can also have cost-savings implications for training providers who cannot invest in specialized equipment, establish physical locations in every part of the state, or attract qualified instructors. Certain forms of remote delivery may also protect against costly damage or mistakes that can be expected by trainees, not to mention protect against potential safety hazards.

Other potential benefits of HOSBRL identified include flexibility with existing work schedules and the ability to upskill workers who can be adaptive and responsive to technological advances in the sector. This will allow employers to maintain a competitive advantage by skilling a workforce in anticipation of emergent manufacturing subsectors. Importantly, as we have seen in the past few years, HOSBRL also allows training to persist despite extraneous factors like public health or other emergencies that could limit in-person interaction.

While respondents and interviewees overall could see the potential for HOSBRL, there was general agreement that current HOSBRL offerings have limitations, particularly without a significant investment of time and financial resources to ensure that delivery is high quality and meets the needs of stakeholders. The wide

[29] Washington State Department of Health, Rural and urban counties (PDF) (April 2017)
[30] Employment Security Department, Unemployment statistics by county (Excel) (June 2022)

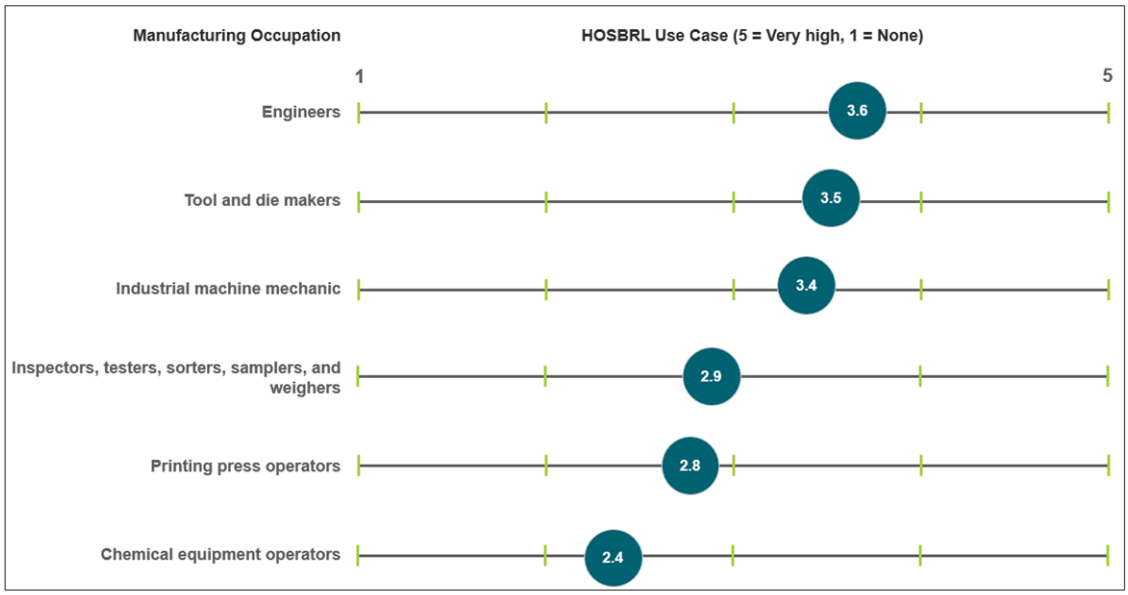
variation in delivering HOSBRL indicates inadequacy and gaps that the state of Washington may consider addressing now to ensure its viability, and therefore accessibility for all Washingtonians, in the future.

2. However, our research does not suggest that there is a case from employers, trainees, or training providers to adopt HOSBRL as the dominant method of manufacturing training and make the scale of investments needed in equipment and staff retraining to support that shift at this time.

In the case of both surveys and interviews, the general sentiment among employers, trainees, and training providers was that there was potential and a place for HOSBRL in manufacturing training, but that it cannot replace other in-person training delivery models with a heavy emphasis on hands-on, skills-based components. Both training providers and employers surveyed were given a list of the top 17 manufacturing occupations in Washington, based on number of current employee, then asked to rank the HOSBRL use case on a 1 to 5 scale for each occupation. Across the board, there was not strong agreement that any manufacturing occupation was well suited for HOSBRL options.

The strongest use case for HOSBRL came up for engineers (industrial, chemical, aerospace, mechanical, etc.), tool and die makers, and sewing machine operators. At the other end, respondents identified chemical equipment operators, printing press operators, and inspectors, testers, sorters, samplers, and weighers as occupations for which HOSBRL training might be least useful. The other 11 occupations had an average that fell between the extremes of engineers (average: 3.6) and chemical equipment operators (average: 2.4).

HOSBRL Survey: Top and bottom three averages of 17 total manufacturing occupations



The remaining 11 occupations ranked on average as follows:

- Industrial machine mechanic (3.4)
- Machinist (3.4)
- Welders, cutters, solderers, and brazers (3.4)
- Electrical/electronic/electromechanical assembler (3.3)
- Fabricator (3.2)
- Machine setters, operators and tenders (3.2)
- Food preparation (3.2)

- Carpenter (3.2)
- Packaging and filing machine operators and tenders (3.0)
- Supervisors of production and operating workers (3.0)
- Technologists and technicians (3.0)

The limited range in terms of use case for different manufacturing occupations indicates that there is not strong support for broad HOSBRL delivery, even for specific occupations. When probed further, employers and trainees interviewed agreed that for nearly all manufacturing occupations, the more advanced skills and application of manufacturing training were not ideal for HOSBRL.

However, there was consistent agreement among interviewees that an area where HOSBRL can add significant values is in exposing and introducing young people to manufacturing broadly. From one trainee's perspective, "In machining, there isn't a large role for HOSBRL, but it is definitely a useful tool for manufacturing as an umbrella. It's best as a means to introduce information."

3. HOSBRL is an effective tool in promoting early career exploration in manufacturing because of its ability to bring large number of students, at scale, onto otherwise sensitive worksites.

The emphasis on knowledge and awareness over hands-on skills development in the early awareness/exposure stage allowed people to see a broader and effective use case for HOSBRL in manufacturing, particularly as a means to draw interest from a broader group of individuals who might not otherwise consider manufacturing as a potential career path. HOSBRL could also allow young students into space or facilities they would not otherwise be able to access. It allows K-12 students to see worksites – particularly sites that are sensitive to safety issues or unable to accommodate large groups of students – at scale.

One employer interviewed by the research team envisioned the following: "When I think about what 4-H programs have done for promoting kids interests in farming and agriculture — what if we did the same for manufacturing? Give kids hands-on opportunities to become exposed to manufacturing early on and incorporate technology for remote learning opportunities."

Leveraging digital tools that allow for increased remote access to the sector's facilities and machinery would be a welcomed opportunity from the perspective of the training providers, employers and industry advocates we heard from. Many saw early career exploration as a critical intervention point for growing the manufacturing workforce because it offers an earlier introduction to modern manufacturing. Paired with opportunities like National Manufacturing Day (the first Friday of October), HOSBRL opportunities could allow the state's manufacturing sector to capture the interest of students earlier, increasing the likelihood they might pursue manufacturing career paths. It would also be an opportunity to broaden exposure to supportive adults, such as teachers, counselors, or parents, who might steer young people away from manufacturing based on an outdated conceptions of the type of work done in the sector.

4. As a tool for more intensive job training, HOSBRL has potential to expand access for trainees who cannot attend or do not thrive in traditional onsite training, especially rural students, English language learners and medically restricted trainees.

Among the five trainee interviews conducted, all affirmed demand for programs that integrate remote learning to some degree. This was confirmed by training provider respondents, among which 75% indicated seeing a demand from trainees/employees to have more hands-on, skills-based remote learning options. The demand

is particularly apparent among rural students who are challenged by the driving distance required to get to training sites.

Remote learning options give rural students the ability to access early training opportunities that might not exist where they live, though they might eventually need to move closer to employment opportunities. According to a CTC student interviewed: "[T]here is (demand for remote components), especially if you think about someone like me who has to drive 25 miles just to get on site … I see high demand – I know there are people like me who don't want to have to drive into school for a two-hour class when we can just go in for the labs for the hands-on component. In composites, you really need someone holding your hand dealing with chemicals and hazardous materials – that part definitely needs to be live and not on a screen." This conclusion was supported among training provider survey respondents, nearly 40% of whom believed that HOSBRL would allow them to recruit and retain more rural trainees.

While there is a case for HOSBRL increasing training access among rural trainees, some employers and industry advocates were skeptical, citing that barriers would persist for rural trainees after training was completed. Said one, "The impact of HOSBRL for the manufacturing sector is less [significant in rural communities] because at the end of the day, you still have to have an employer near you and if you are in a rural community, you are still limited by what is around you."

Both training providers and employers saw the potential for HOSBRL to narrow the learning gap for English language learner (ELL) trainees. Employer survey respondents named remote training being only available in English as one of the top five barriers trainees/employees face when accessing HOSBRL. Remote learning formats would allow ELL trainees to move at their own pace and broaden options for sourcing bilingual trainers, integrating in-language materials, or providing subtitle captions to translate content delivered in English.

> "We get a lot of language issues that happen. Aviation is taught in English. We would need to have presentations (be) bilingual."
>
> Former trainee

A training provider offered an illustration of this growing need: "We get a lot of language issues that happen. Aviation is taught in English. We would need to have presentations (be) bilingual. For sure, English and Spanish. Ideally, more than two languages. We are starting to have situations where we have trainings in English and have subtitles in Spanish."

Remote learning options also allow trainees to continue their training without interruption during life events, including pregnancy, which can prevent trainees from working around hazardous chemicals that may be part of a manufacturing process. Remote options are particularly important for apprentices and adult learners who are receiving on-the-job training, and for whom life events like pregnancy, elder care, or child care might be more challenging to manage with the less flexible schedule of a shop floor.

HOSBRL Survey: Top five barriers to accessing HOSBRL for trainees/employees

All Respondents (41)*	Training providers (TPs) (32)	Employers (5)
1) Lack of access to reliable broadband	1) Lack of access to reliable broadband	1) Lack of access to childcare (ranked last / 13th by TPs)
2) Limited interaction with or access to trainer / instructor	2) Lack of access to reliable hardware	2) Lack of digital literacy / computer literacy (ranked 6th by TPs)
3) Lack of digital literacy / computer literacy	3) Limited interaction with or access to trainer / instructor	3) Limited interaction with or access to trainer / instructor
4) Curriculum isn't adapted to all components of HOSBRL	4) Curriculum isn't adapted to all components of HOSBRL	4) Training requires the availability of an on-site supervisor (ranked 8th by TPs)
5) Training options and times don't work with work schedule	5) Training options and times don't work with work schedule	5) Remote training is only available in English (ranked 10th by TPs)

*includes two labor organizations and two centers of excellence considered "other"

Balancing on-the-job training with the inflexibility of work schedules may explain why employer respondents named childcare as the single biggest barrier to accessing HOSBRL for trainees/employees. This is in stark contrast to training providers, who ranked it last among the 13 barriers offered. While HOSBRL training in a CTC or CTE setting would offer greater access to trainees facing life events, on-the-job training, which employers are closer to, is less flexible and requires a trainee's ability to be at the employer site for training or on the clock during a particular time.

An important consideration in expanding access to manufacturing training via HOSBRL is access to the appropriate technology. Lack of access to reliable hardware and reliable broadband were the top two barriers named by training providers. This can be more challenging for students from low-income backgrounds or those from rural communities that have not had equitable investment in broadband. Significant resources are required to ensure an equity approach that sets all trainees up for success.

5. More generally, trainees do not want to see HOSBRL replace all traditional manufacturing training, as many gravitate to manufacturing training for the hands-on, in-person, applied aspects. HOSBRL could be effective in hybrid settings to make "lecture-style" or more passive "demonstrations" self-paced and convenient.

In addition to HOSBRL options providing accessibility benefits to specific trainee populations, trainee interviewees noted that the demand for HOSBRL options extends broadly across all manufacturing students. All interviewees asserted that they, along with their peers, liked the remote options in particular for certain types of content, such as lecture material on foundational theories and processes. Remote delivery of this content was more convenient, allowing students to review and revisit material at their own pace and on their own time.

Outside of learning very foundational skills or skills that are inherently computer-based (such as programming), hands-on learning is needed at a certain point. Trainees talked about the value of learning kinesthetic and auditory feedback – components of the industry that attracted them in the first place. Many trainees said they were drawn to manufacturing precisely because of their interest in being "makers" and being on-site, rather than being in front of a computer all day. Manufacturing trainees desire relevance and realistic opportunities to engage in the content. They also affirmed that there was no substitute for hands-on, in-person learning when it comes to developing physical muscle memory and understanding the real-world consequences of safety protocols.

One said, "The way that my mind works, the hands-on and the actual doing the thing — that brings up the questions to ask. If I don't have that loop, that's a struggle. That's why I decided to do this instead of staying in the office … And when you make mistakes, the lessons stick with you." Learning from mistakes and learning to

solve problems beyond the script or manual are critical skills in the profession. Likewise, trainees saw it as a critical component of their own learning, best learned through in-person, hands-on training.

In some specific cases, such as machine programming, HOSBRL delivery has the potential to be more effective than in-person, hands-on learning. One trainee interviewed shared an example: “I’ve done three to four Master Cam classes for a CNC program [remotely], and it was better than hands-on. We each had a workstation [at the worksite] that we were working through, and the instructor was down in south Washington. We logged into virtual machines that they had the software run on, and while we were working, [the instructor] had a second monitor where he could watch all our screens simultaneously. If we were together [in person], he’d have to walk around and look over shoulders and make sure everyone was focused. There were some IT problems, but it was really good.” Occupations that require intensive focus on computer-based skills such as programming are primed for HOSBRL because the hands-on component is already done on a computer. If structured appropriately with accessible digital tools, these programs could scale to serve more trainees across the state.

Overall, our trainee interviewees provide anecdotal evidence of trainee demand for HOSBRL options. Given they were not surveyed for this study, more research needs to be done to confirm that this is true more broadly.

6. Employers demonstrated an openness to HOSBRL in certain cases, especially if it could consolidate common trainings and reduce costs for small- and medium-sized employers. But there is some skepticism about how much training can truly be universalized in a sector that is increasingly focused on custom products.

Employers surveyed and interviewed largely believed there was potential for HOSBRL options, but had concerns about the ability to implement it effectively with current tools. For example, one employer said, “We can train with hands-on, skills-based remote learning, but there are some things where you are relaying a complex process and it can be hard to do unless you are physically there.” According to training provider respondents, only 16% had ever been asked by an employer to create a hands-on, skills-based, remote training. Forty percent of surveyed employers did not believe HOSBRL to be a valuable way of training for the trainees/employees they serve. This is consistent with the 44% of training providers who share uncertainty about the value of HOSBRL.

Among employers, capital is one of the biggest barriers to investing in training broadly, let alone HOSBRL. This is especially true for small- and medium-sized manufacturers who do not have the size to justify the establishment of their own internal training function the way larger manufacturers can. Small- to mid-sized manufacturers are often relying on training providers for imperfect (but "good enough") training for their employees. Said one, “Resource sharing among small manufacturers would help quite a bit. Thinking back to when we were smaller in size, if we could have pooled resources, that would have been really helpful … If a program could be developed for the right pool of candidates, some of that could be done remotely.”

Many of the employers interviewed spoke of the U.S. manufacturing sector being one that creates custom and unique products, far different from older models of domestic mass production of a single product. This uniqueness is an important characteristic of the American manufacturing identity today, and it creates a challenge for standardizing training in a shared-services model — that is, a single training program that can be accessed by multiple manufacturing employers. As one employer stated, "Some of the skills we look for now and that we teach are more specific than they have historically been. Specific unique skills that take time to learn and are challenging to teach [in a shared services model]." The sentiment was echoed by another employer, who said, "Manufacturing in the U.S. is very niche – we are not mass-producing things … We are producing very unique things that require niche training."

> "Resource sharing among small manufacturers would help quite a bit … If a program could be developed for the right pool of candidates, some of that could be done remotely."
>
> — Employer

Employers recognize that this presents challenges for establishing training provider partnerships that can perfectly meet all their training needs. They see the value in having a shared service model that can serve as foundational training, which then allows employers to take on the more customized training with greater ease. One employer saw it this way: "80% of what we do is similar across manufacturing, the 20% is what we do individually internally. If you could identify the 80% of the skills needed you could share that across providers." HOSBRL training can take the burden off employers by creating a shared service that focuses on the universal aspects of manufacturing, accessible to any manufacturing trainee from anywhere in the state. This would allow employers to maximize resources on specialized training that meets the niche needs of their business. Bolstering the state's existing manufacturing training systems like CTCs, registered apprenticeships, and K-12 CTEs/skills centers to do this would be of great benefit to employers, particularly in cooperative models that create a seamless transition directly from training to the employer in a short amount of time.

One caution that came up repeatedly was designing an appropriate cost-sharing model for shared training services. This is perhaps best illustrated from the words of employers and industry advocates themselves:

An employer noted, "One of the challenges is the funding. Whoever pays the bill decides what they're going to learn. Smaller businesses who contribute, may not contribute enough to buy influence."

An industry advocate added, "What I hear from a lot of smaller manufacturers is that they spent their own capital to upskill and train their workforce only to have them stolen by larger employers who [can offer better wages and benefits]. If everyone is contributing to the program, it benefits everyone. [Smaller manufacturers] will likely still lose those people, but there will be a smaller deficit. You won't get smaller manufacturers [in a shared-services program] without an equal commitment from larger manufacturers."

Together, these quotes show the potential complexity in developing a shared services model. It will require further exploration and intentional design.

7. Many training providers were forced to adopt some aspects of HOSBRL during the pandemic. They see some value in and demand for HOSBRL, but are concerned about the cost and return on investment for teaching these skills remotely.

The COVID-19 pandemic forced training providers to pivot to remote delivery models to operate safely within the parameters of public health guidance. Federal relief programs, such as the Governor's Emergency

Education Relief Fund,[31] gave Washington community and trade colleges like Big Bend Community College and Clark College access to valuable resources that allowed them to reopen manufacturing programs that were closed or suspended due to COVID-19.

Through pivots like this, training providers identified several benefits of HOSBRL for trainees, including the ability to increase the amount of training received, increase accessibility to all types of learners, and help meet students and employers where they are with greater potential for cross-curricular reinforcement. As one training provider respondent put it, "Students are better prepared to actually enter the workforce when they have had access to and experience with manufacturing equipment but who have also had to navigate online learning."

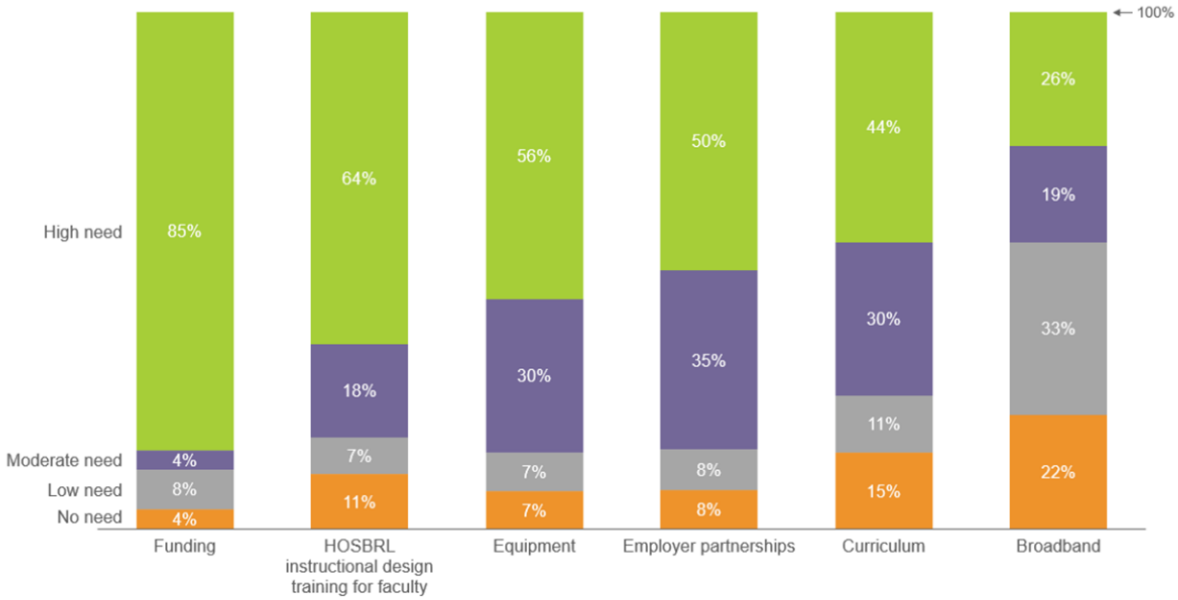
Despite high trainee demand and agreement on positive benefits, only half of training provider respondents surveyed believe HOSBRL is a valuable way of providing training to the students they serve, and fewer than 20% of respondents (five CTCs and one apprenticeship program) currently offer training that includes all HOSBRL elements. One respondent illustrates the misalignment well: "We have prospective trainees that have reached out to find out if we offer HOSBRL. We had to during the height of COVID but have since returned to our pre-COVID operations. Student achievement and competency dropped significantly during this time and the majority of students complained of the lack of in-person, hands-on training."

While the pandemic encouraged training providers to wade partially into HOSBRL delivery, high-quality, effective remote learning, even as just one component of the delivery model, is resource-intensive and difficult to implement. As one instructor put it, "When it comes to asynchronous activities is a completely different style of instruction. Just copying over synchronous [material] is not a successful recipe. When it comes to convincing instructors [about the value of HOSBRL], you have to provide resources and training to start over from scratch. You can't replicate that on this different system. How you do assessments, how you interact, etc. it should be treated completely differently [than traditional instruction]."

When asked about the resources needed to deliver optimal HOSBRL effectively, 85% of training providers identified funding as a high need, followed by HOSBRL instructional design training for faculty (64%), and equipment (56%).

[31] Office of Elementary & Secondary Education, US Dept of Education Governor's Emergency Education Relief Fund (2020)

HOSBRL Survey: Training provider resource needs to deliver HOSBRL effectively



Funding was by far the highest need. When probed, funding was revealed to be connected to the other resource needs listed. When asked to describe what funding would be used for, the most common responses across all training providers included funding for:

- Hiring specialized trainers/instructors
- Faculty training
- Kits, computer hardware/software and computer system maintenance
- Compensation for instructor training time
- Incentives to encourage employer partnerships
- Hiring staff to manage more employer partnerships
- Curriculum development
- Equipment and capital facilities to house equipment

When training providers were pivoted to remote alternatives in 2020, they were asked to do so with limited resources to support the shift. Instructors were tasked with changing their curriculum to meet the new remote requirements without adequate training and development in remote instructional design, often navigating a dearth of resources without much guidance or context for application. Now, after more than two years of fully remote or hybrid instruction, some instructors may be hard-pressed to see the value in HOSBRL. According to one CTC survey respondent, “Our current [manufacturing] curriculum does not support HOSBRL and our faculty are not trained to develop/modify current curriculum to HOSBRL. Our faculty also do not agree that remote learning has been effective during COVID and would likely need some strong training to change that perception.”

Employer skepticism of HOSBRL’s effectiveness and the lack of resources for proper implementation can leave training providers with limited incentive to meet student demand for HOSBRL. Again, only 16% of training providers surveyed said they had ever been asked by an employer to create a hands-on, skills-based, remote training. As one employer noted, “It’s hard to create good remote learning for the technical skills. It requires expertise and money, like CG modeling. We do have remote instruction for some. We do it because we need to, but it’s not the best method. The content is made to be taught in-person.”

Here are some examples of the potential to scale with HOSBRL training in Washington with appropriate resources:

Advanced Manufacturing Apprenticeships (AJAC)

AJAC's pre-apprenticeship program is currently offered as a HOSBRL program today.

Hands-on: Trainees participate in boot camps and a hands-on certification process, assessed by an expert instructor to evaluate for competency.

Skills-based: Trainees are set up to intern with employers. During these internships, trainees are provided tool kits ($350/trainee) and get skills training from an on-the-job mentor who can guide them on industry specifics. AJAC is working with employers to align homework more closely with skills training to allow trainees to make more direct connections between home and skills demonstrated on the job and enhance overall learning.

Remote: The program trains with live-lecture Zoom sessions and uses Canvas as the primary learning management system for projects and weekly check-ins. The Canvas learning is structured with an accessible instructor who holds standard office hours to support students. There are also virtual employer tours and local guest speakers to help students/job seekers make informed career pathway choices.

In the wake of COVID, AJAC staff have put in considerable time and energy into moving their supplemental instruction entirely online. The remote component of their training has allowed them to scale their instructional capacity more effectively and serve trainees statewide at all times of day.

However, resource limitations continue to inhibit AJAC's potential reach. To truly scale, AJAC would need resources for more trainers and kits to send to apprentices and employers. Trainees would need computers with sufficient processing capacity for advanced software, have baseline digital literacy training, access to reliable broadband, and licenses for software such as CAD/CAM.

Machinists Institute

As part of its training offerings, the Machinist Institute offers an apprenticeship program for cohorts of five to ten employer-hired apprentices per instructor. The cohorts are an opportunity for older, more experienced apprentices to take on mentorship roles and build other skills with younger or newer workers to the sector. As part of its HOSBRL curriculum, Machinist Institute does the following:

Remote: Utilizes Tooling U-SME, a nationally recognized online learning and learning management system with over 600 classes, industry-recognized certification, custom programs and learning consulting services designed for the manufacturing sector. Most apprenticeship classes spend about 50% of their time with theory and other online content. There are assessments that allow instructors to understand where an apprentice is at so that they know how to focus instruction when apprentices are in the lab.

Hands-on: The other half of apprentices' time is spent in lab with an instructor. Instructors tailor the in-person hands-on lab work based on the assessments that apprentices across the cohort complete via Tooling U-SME. In some cases, apprentices are completing their hands-on training on-site with employers (such as an apprentice in Oregon unable to come to Machinist Institute's lab site). In such cases, instructors work with the employer/site instructor to ensure the apprentice is getting the experiences they need and is assessed in accordance with curriculum standards.

Skills-based: Tooling U-SME's content has been developed with industry experts and in alignment with industry standards. The content and assessments completed both and reviewed by lab instructors or site instructors cover topics from foundational to advanced.

Machinist Institute has seen promise in this HOSBRL model and sees the hybrid mix as an ideal scenario for maximum learning, particularly because it expands access to manufacturing apprenticeships. One of current inhibitors is regarding resourcing for equipment. While the program provides laptops for trainees, advanced classes require trainees to come into the computer lab because they need access to more expensive software that needs to be run on more expensive laptops. Tooling U-SME is also expanding its virtual reality curriculum, which could be a great opportunity to explore, but Oculus or VR headsets and other simulators are still cost-prohibitive.

Core Plus

Core Plus provides K-12 students across Washington with hands-on learning and transferable skills that lead to career pathways in aerospace, construction and maritime. At the start of the COVID-19 pandemic, Core Plus reallocated funds to stipend four veteran Core Plus teachers to turn the first 180 hours of the Core Plus framework into videos and online content that could be used across the state. Instructors went to manufacturing shops and were provided equipment to record demonstrations. The first 180 hours are aligned to industry standards and core across all sector programs, allowing for easy translation to construction and maritime, curriculum that was just launching at the time, in addition to Core Plus' original aerospace curriculum.

Core Plus selected Canvas as the learning management system (LMS) to deliver these materials statewide, seeing it as an opportunity to integrate into and show alignment with the LMS already used in Washington CTCs. Canvas, however, was not a tool that all K-12 schools used locally. The program then needed to create workarounds so that the content could be accessible to all Core Plus teachers. Core Plus program leaders also used Zoom as a tool to facilitate a community of practice across teachers. Teachers met bi-monthly to share best practices and lessons from implementing the new videos and lessons developed by Core Plus. Leaders from industry were also able to join these meetings to provide insights into how shop floors were pivoting in the time of the pandemic, providing real examples that teachers could share with students.

Due to social distancing requirements, each school delivered the content differently, according to their district's guidance around live instructional time. There was a mix between synchronous and asynchronous delivery. The Core Plus curriculum was largely knowledge based. In the program, students can earn two different certificates from demonstrating competency: A knowledge-based certificate, and a skills-based certificate based on hands-on work. Most students earned only the knowledge-based certificate at that time. Some Core Plus teachers had the resources to provide students with kits that could be checked out for hands-on learning opportunities, but this was not consistent across all schools. Most Core Plus programs did without hands-on learning during that time, indicating equity gaps for students across different districts.

In the return to in-person learning activities, the development of this content will offer Core Plus an opportunity to use a flipped classroom model, where students can complete the knowledge-based components at home, allowing teachers to devote more time in class to hands-on lab work. This shift in time also opens an opportunity to consider Core Plus as a career launch program that offers an opportunity for students to get paid work experience.

Training providers are waiting on market signals from trainees and employers to go further with investments in HOSBRL. The disconnect between low HOSBRL demand from employers and perceived high demand from trainees begs some questions from the training provider perspective: Would high-quality HOSBRL lead to more demand from employers, or should trainee demand drive greater investments in infrastructure to make quality HOSBRL more widely available?

8. As extended reality technologies develop, hands-on, skills-based remote learning could become a more effective tool for training of all types. Policymakers should continue to monitor these advances on an ongoing basis and continue to assess employer, educator, and trainee demand

Currently, extended reality (XR) technology, consisting of assisted, augmented, mixed and virtual reality, is nascent but growing rapidly with new tools already developed for HOSBRL application in the manufacturing sector. Large manufacturing companies like Boeing are already using HOSBRL and XR in their work; for example, to guide repair in small areas like the inside of airplane wings or teaching Master Cam classes remotely. Some CTC courses used the technology to simulate industrial painting. Engineering firms like Simutech, education companies like Transfr VR, and research and development centers like the Oregon Manufacturing Innovation Center (OMIC) are all expanding opportunities for HOSBRL using XR technologies. Vancouver, Washington-based RealWear has created an industrial head-wearable device that frontline workers can use in manufacturing and other industries to receive expert guidance on projects remotely, support digital workflow interfaces, and allow digital assistance in hard to reach places.

These companies and programs are at the cutting edge of applying XR technology in the sector. However, broad usage is still far from the norm. One trainee said that "[XR] technology is in its infancy … it has potential, but there are limitations to it (in its current form). If you are someone who wears glasses and can't wear contacts, you can't use it. If you have other visual impairments, you may not be able to adjust the color to use it fully."

Employers were also cautious about XR technology. HOSBRL trainings must be designed with consideration of the limitations of technology, particularly in terms of market readiness. While technology may be ready for use in classrooms or training sites, it may not be approved for use on an industrial floor, where the hands-on component of training could take place. To be used on the floor of some manufacturing subsectors, technology must meet certain safety and security standards. This could include technology having a wireless connection to reduce trip hazards or working on the designated wireless frequencies, which companies might regulate, while maintaining signal continuity. While an investment in technology can broaden HOSBRL training applications, it must be done judiciously with real industry standards and regulations in mind.

Advances in XR technology will continue to evolve and should be monitored as it expands its use potential for the manufacturing sector. Employers and training providers should continue to stay apprised of advances in this technology and partner to leverage XR for training purposes.

Recommendations

The key findings in this report indicate opportunities for Washington to target investments and strategies that enhance the usage of HOSBRL where it is likely to have greater impact for the manufacturing sector. The following offers a set of seven related recommendations for the Washington State Legislature to grow the impact of HOSBRL, not to be generalized to the universe of remote or virtual instruction more broadly, to set

the state up for scaling HOSBRL models for manufacturing training when the timing is assessed to be appropriate.

1) Continue to invest in traditional, on-site manufacturing training, such as registered apprenticeships and career connected learning. Our research does not suggest it's time for a comprehensive phase out of this form of training in favor of HOSBRL.
2) Invest to infuse HOSBRL (through XR) in Career Explore and Prep programs like Core Plus, Career Connect Washington, and K-12 system Career & Technical Education to build opportunities that introduce students to the manufacturing sector at scale.
3) Develop a grant program for K-12, community and technical colleges (CTCs), and registered apprenticeship programs that serve rural, ELL, and medically restricted trainees to build out HOSBRL programs explicitly for these populations, who are most positively impacted by having HOSBRL options.
4) Provide resources to SBCTC and OSPI to develop, expand and refine universal manufacturing (such as Core Plus), including adding HOSBRL elements.
5) Delegate the Aerospace & Advanced Manufacturing Center of Excellence, with other centers such as the Marine Manufacturing & Technology, Semiconductor & Electronics Manufacturing, or Agriculture and Natural Resources where appropriate, to keep the pulse on innovations in HOSBRL, bring back reports to the Manufacturing Council annually, and make recommendations for high-quality HOSBRL training opportunities ready for greater investment
6) Create an annual forum for manufacturing employers to share HOSBRL training innovations and discuss the potential for common training (such as a featured session at AWB's Manufacturing Week or Workforce Summit).
7) Make grants to small employers, or manufacturing associations that support small and medium-sized employers, to create common training curriculum with the infusion of HOSBRL.

Conclusion

Currently, there is not a case for the broad investments into HOSBRL that would require shifting equipment and/or retraining staff, particularly in pursuit of the state's legislative goal of "doubling the state's manufacturing employment base, the number of small businesses, and the number of women and minority-owned manufacturing businesses in the next 10 years." HOSBRL has its place within the manufacturing training ecosystem; however, there is no indication that it is time to rethink changes to manufacturing training broadly. While innovations in HOSBRL indicate the potential for expanding access to manufacturing training, it is not a training modality that is ready to scale in Washington at this time.

While training providers began to build capabilities around HOSBRL during the COVID-19 pandemic, it continues to be a delivery model, separate and distinct from remote learning alone, that the state should monitor. The state can support local training providers, employers and students by tracking HOSBRL innovation, supporting the scaling common programs, and sharing best and promising practices for HOSBRL delivery. The state can also play an important role in broadening access to HOSBRL manufacturing training for those communities that would benefit greatly from the option, while tracking developments and demands in the market for more HOSBRL training. HOSBRL is an emerging field with developing technology, and state-level actors in both the private and public training sectors can play a key role in seeding the creation of manufacturing materials in the HOSBRL framework for broader usage in the coming years.

Appendix A: Acknowledgements

This work was led by Washington State Department of Commerce Office of Economic Development & Competitiveness, under the direction of Carolyn Busch, director of workforce innovation and industry sector program coordinator, and Sarah Lee, governor's sector lead, director of advanced manufacturing.

We would like to thank the individuals and organizations who served as expert advisors, providing guidance that informed research design, and supporting outreach for this report:

- AJAC
- Association of Washington Business
- AWB Institute
- Center of Excellence Aerospace & Advanced Manufacturing
- Impact Washington
- Machinists Institute
- Renton Technical College
- Washington Office of Superintendent of Public Instruction
- Washington State Board of Community & Technical Colleges
- Washington State Labor Council

We would also like to thank all our many survey respondents and interviewees, who took the time to generously share their insights, expertise, and candor in our research efforts. They came from the following organizations:

- Aero-Plastics, Inc.
- AJAC
- ATS
- Association of Washington Business
- AWB Institute
- Bethel School District
- Boeing BCA Manufacturing Workforce Development
- Boilermakers Local 104 and Puget Sound Employers Apprenticeship
- Center of Excellence High-Tech Manufacturing
- Center of Excellence Marine Manufacturing & Technology
- Chief Leschi Schools
- Clover Park Technical College
- Columbia Basin College
- Control Dynamics Inc.
- Core Plus
- Dakota Creek Shipyard
- Edmonds College
- Elma School District
- ESD 123
- Evergreen Public Schools
- Granite Falls School District
- Heat and Frost Insulators and Allied Workers
- Machinists Institute

- North Seattle College
- Northwest Career & Technical Academy
- Out of the Box Manufacturing LLC
- Pasco School District
- Pearson Packaging
- Peninsula College
- Puyallup School District
- RealWear
- Renton School District
- Richland School District
- Schweitzer Engineering Laboratories
- Shoreline Community College
- Skagit Valley College
- Snohomish School District
- South Puget Sound Community College
- Spokane Community College
- Teamsters 117
- Transfr VR
- Tri-Tech
- Twin Harbors Branch Skills Center
- Vancouver Public Schools
- Wagstaff Inc
- Walla Walla Public Schools
- Washougal School District
- West Sound Tech
- West Valley School District
- Yelm Community Schools

Finally, we would like to thank the members of the Manufacturing Council who advised and provided feedback throughout the research process:

- Amit Arora, Jubilant Hollister Stier
- Allison Budvarson, Out of the Box Manufacturing LLC
- Susan Champlain, Boeing
- Ted Cummings, United Steelworkers Local 338
- Maud Daudon, Career Connect Washington
- Jon Holden, International Association of Machinists 751
- Kris Johnson, Association of Washington Business
- Junus Khan, Carbitex
- Jessica Koski, Blue/Green Alliance
- Todd Mitchell, Heat and Frost insulators Local 7
- Greg Pallesen, Association of Western Pulp and Paper Workers
- Shana Peschek, Machinists institute
- Gaylan Prescott, United Steel Workers, District 12
- Jennifer Stiefel, Heritage Distilling Company
- Phil Stephenson, PACCAR

- Russ Vaagen, Vaagen Timbers
- Dave Whitehead, Schweitzer Engineering Laboratories
- Brenda Wiest, Teamsters Local 117
- Deloit Wolfe, Impact Washington
- Jan Yoshiwara, State Board of Community and Technical Colleges