

Career Pathway Implementation Report: Steel Fabrication



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Introduction

The *Career Pathway Implementation Report: Steel Fabrication* was developed on behalf of the Greater Memphis Alliance for a Competitive Workforce (GMACW) in order to assist the partner institutions: Arkansas State University Mid-South (ASU Mid-South), Southwest Tennessee Community College (Southwest), Tennessee College of Applied Technology – Memphis (TCAT-Memphis), and William R. Moore College of Technology (Moore Tech). The consortium is expanding and enhancing a regional, industry-driven career pathway with robust articulation, stackable credentials, and meaningful connections to work-based learning and career coaching.

Throughout this report, we have focused on the following career pathway elements consistent with GMACW’s priorities for regional development:

- Greater articulation of non-credit, contact-hour programs with credit-bearing degree pathways;
- Alignment of industry-recognized certifications with degree pathways;
- Contextualized integration of basic skills content into career-technical credit-bearing pathways;
- Integrated student support services, personal effectiveness and workplace readiness training;
- Strategies for program acceleration, including Prior Learning Assessment and online programming;
- Improved work-based learning experiences.

TPMA’s approach to career pathway development aligns with the U.S. Department of Labor’s (USDOL) Six Key Elements of Career Pathways and Career Pathways Toolkit¹. To prepare the GMACW Steel Fabrication Career Pathway, we have used the following methods:

- **Review relevant Labor Market Information (LMI)** to confirm demand and understand regional skill needs. This included a review of the 2013 “Made in Memphis” report developed by Younger Associates as well as data accessed through EMSI.
- **Analyze competencies vs. credentials.** TPMA developed a competency list of the core knowledge, skills, and abilities needed in the fabrication career pathway using information primarily from O*Net Online (www.onetonline.org); this list was then compared to the skills and standards measured by nationally recognized credentials. Due to their wide recognition, rigorous and industry-driven development, American Welding Society (AWS) skill competencies were identified as a unified measure to establish baseline standards and credentials for each level of the career pathway. On April 27, 2016, TPMA and the Manufacturing Institute presented a high-level overview of the competencies and credentials discussed in this report to the Steel Fabricators Council. Their feedback has been integrated into the recommendations that follow.

¹ https://www.doleta.gov/usworkforce/pdf/career_pathways_toolkit.pdf

- **Conduct curriculum review of related programs.** Arkansas State University - Mid-South, Southwest Tennessee Community College, Tennessee College of Applied Technology-Memphis, and William R. Moore College of Technology provided TPMA with copies of the curricula, syllabi, and learning outcomes related to welding, which serves as the academic core of the steel fabrication pathway. TPMA reviewed these materials for their alignment with the competency list described above. In addition to the competency crosswalk, TPMA analyzed the existing and potential alignment between programs as well as their compatibility with AWS certifications and other industry recognized credentials. The results of this analysis have been distilled into the career pathway and related recommendations—in particular, TPMA has looked for opportunities to strengthen the institutions’ partnerships (with each other and with local industry) and students’ opportunities for targeted career guidance and work-based learning opportunities.
- **Conduct site visits and interviews** with program faculty and staff to better understand programming, resources, and challenges at each institution.
- **Research best practices.** TPMA explored national best practices with an emphasis on manufacturing/career readiness programs and seamless career pathways among various institutions.

Industry Demand

Career pathways work best when they are designed in direct response to local industry demand. Education providers must work closely with businesses to:

- Understand the needs of regional employers,
- Identify targeted occupations and essential skills required to perform job tasks, and
- Ensure appropriate assessment measures are in place to validate attainment of skill and award relevant credentials to program graduates.

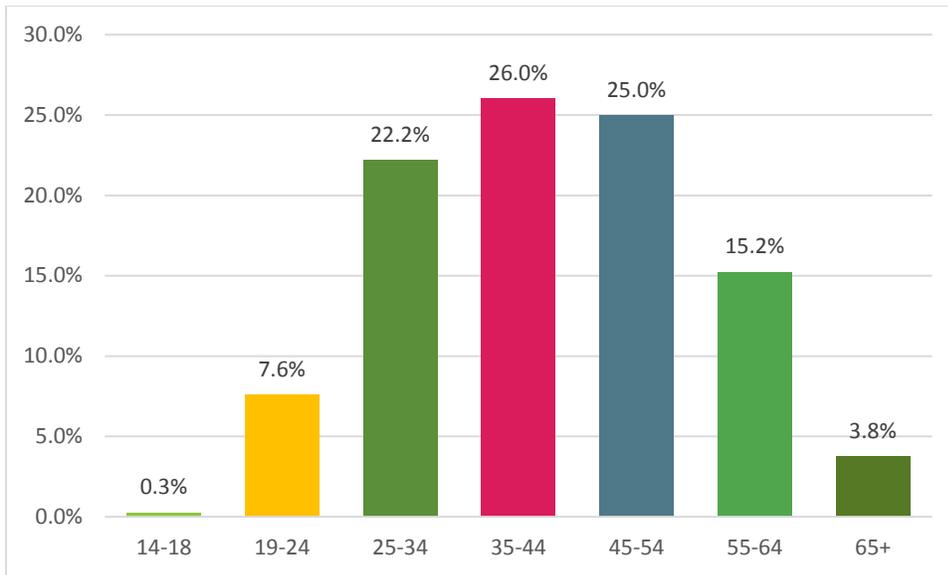
TPMA began with a study of Labor market information (LMI) regarding **welders (51-4121.06 - Welders, Cutters, and Welder Fitters²)**. EMSI data indicate the demand for welders in the Greater Memphis region will increase over the next 10 years. This is due to two factors: first, EMSI predicts an 8.1 percent increase in the total number of welding jobs in the region (Table 1); second, 19 percent of Memphis area welders were aged 55 or older in 2016 and nearing retirement by 2026 (Table 2).

Table 1

Region	2016 Jobs	2026 Jobs	Change	% Change
GMACW	1,198	1,295	97	8.1%
United States	424,562	460,132	35,570	8.4%

² According to O*Net Online, the primary responsibilities of this occupation are to “use hand-welding or flame-cutting equipment to weld or join metal components or to fill holes, indentations, or seams of fabricated metal products.”

Table 2: Welder (51-4121.06) Employment by Age



Based upon projected growth and demand, we expect to see 49 job openings annually over the next ten years.

However, it is important to note that local trends may not be reflected in sources such as EMSI as quickly as they can be observed and reported by area employers or economic development agencies. Furthermore, when new jobs are filled through word of mouth rather than being formally posted, those jobs are not reflected in aggregated data. For these reasons, LMI must be complemented with first hand reports of hiring needs either through surveys, interviews, or focus groups.

On April 26, 2016, the Manufacturing Institute and TPMA attended the Mid-South Steel Fabricators Council meeting. The employers in attendance at this meeting validated the continued demand for skilled welders, but also indicated a need for individuals who can perform many functions within a fabrication environment, including fitting, machine operation, press brake operation, welding, finishing, quality control, and maintenance.

In order to better understand labor market demand across all steel fabrication related jobs, TPMA has supplemented the welder data with projections for the following occupations³ in the Greater Memphis region:

51-2041.00 – Structural Metal Fabricators and Fitters: Fabricate, position, align, and fit parts of structural metal products.

³ Not included in this analysis is 51-4012.00 - Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic. Steel Fabrication Council Members reported a demand for CNC Burn Table Operators and Programmers, but at this time, Labor Market Information does not differentiate between CNC Machine Tool operations and CNC Welding operations. For that reason, we have not included CNC Programmers in the pathway. EMSI reports a projected increase of 14 jobs (15.9%) in this occupation between 2016 and 2026 in the GMACW region.

Table 3

Region	2016 Jobs	2026 Jobs	Change	% Change
GMACW	360	372	12	3%
United States	80,683	85,863	5,180	6%

51-4031.00 – Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic: Set up, operate, or tend machines to saw, cut, shear, slit, punch, crimp, notch, bend, or straighten metal or plastic material.

Table 4

Region	2016 Jobs	2026 Jobs	Change	% Change
GMACW	521	494	(27)	(5.2%) ⁴
United States	189,850	169,419	(20,431)	(10.8%)

51-4122.00 - Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders: Set up, operate, or tend welding, soldering, or brazing machines or robots that weld, braze, solder, or heat treat metal products, components, or assemblies. Includes workers who operate laser cutters or laser-beam machines.

Table 5

Region	2016 Jobs	2026 Jobs	Change	% Change
GMACW	217	205	(12)	(5.5%)
United States	60,431	56,480	(3,951)	(6.5%)

51-4192.00 - Layout Workers, Metal and Plastic: Lay out reference points and dimensions on metal or plastic stock or workpieces, such as sheets, plates, tubes, structural shapes, castings, or machine parts, for further processing.

Table 6

Region	2016 Jobs	2026 Jobs	Change	% Change
GMACW	44	39	(5)	(11.4%)
United States	13,489	12,335	(1,154)	(8.6%)

In each of these occupations, approximately one-fifth of the workforce is over age 55. This will be a huge workforce development challenge facing the steel fabrication industry in the Greater Memphis

⁴ When LMI indicates negative growth, no new jobs are projected; however, as is the case in this example, there may still be demand due to turnover. In the manufacturing sector, this is often because of the rapidly aging—and therefore retiring—workforce.

region, and one that can't be put off. Over the next 10 years, GMACW and its partners have the opportunity to develop a pipeline of skilled labor. New and younger employees will need not only formal education, but also opportunities to develop skills on-the-job by working closely with experts in the field.

One of the most pressing needs among steel fabricators, and one of the clearest illustrations of the challenge described above, is for fitters. According to the council, fitters are typically older workers with considerable on-the-job experience. In terms of numbers, the demand for fitters isn't as great as the demand for welders; however, the fitter's role is integral to the steel fabrication sector. Without a pipeline of talented fitter-trainees, the expertise and institutional knowledge of current fitters may be lost. Because of initial Steel Fabrication Council discussions, a subcommittee formed to focus on developing competencies and curriculum recommendations for fitters as well. A companion to this report was developed to capture these recommendations.

Industry-Recognized Credentials

NAM-Endorsed Skills Certification System

In response to the high percentage of manufacturers reporting hiring issues and the growing national concern for the shortage in skilled workers in manufacturing and trade skills, the National Association of Manufacturers (NAM) and its affiliate, the Manufacturing Institute, launched a major initiative to define and develop skills criteria and standards for a broad range of manufacturing skills (designated as the “Skills Certification System”). The Skills Certification System defines standards and certifications in a variety of areas, ranging from basic academic and core manufacturing skills, to occupation-specific and advanced skills for defined career pathways. This NAM-Endorsed certification system aligns to the USDOL’s Advanced Manufacturing Competency Model (see Appendix 2) that outlines the core competencies required for individuals to enter and advance in a manufacturing career.

A primary purpose of the Skills Certification System is to identify focused, nationally recognized credentials that can be used by education institutions in program development that would better address the needs of industry. The system is modularized to enable customization to local needs. Further, broad utilization of the system enhances acceptance and enables the acceleration of training for local and regional workforce segments to create a larger, more productive skilled labor pool, and enables job seekers to more quickly gain the skills required for employment in high demand occupations. One example is the Rights Skills Now model, which provides accelerated training in a credit pathway with embedded industry certifications and work-based learning, therefore allowing immediate work while also supporting completion of an associate degree.

Why Certifications?

Skills certifications are becoming the “new currency” in the marketplace. Employers are seeking clear ways of determining what workers know and are able to do on the job. Workers are seeking alternatives or add-ons to degrees to demonstrate marketable competencies. Educational systems, from high school through four-year institutions, are looking for efficient ways to provide seamless, effective programs. Industry certifications are a win-win proposition. Certifications provide an objective way for:

- Students to validate the talent they can bring to the job,
- Educational providers to establish the value of their product, and
- Employers to have a level of certainty about the competencies of an individual before hiring them.

While third-party certification can be awarded after testing, totally apart from the education process itself, embedding certifications within education pathways benefits the student, the educational provider, and the employer.

The Manufacturing Institute has been collecting documentation on the value of certifications over the past ten years. Some of the major observations on value include:

Benefits for Students

- Documents knowledge and skills gained through education or life experiences
- Offers a competitive advantage when looking for work or career advancement
- Increases career opportunities and earning potential
- Enhances transferable skills across industries within manufacturing or other sectors

Benefits for Educators

- Outlines critical foundation and workplace skills employers are demanding
- Identifies technical skill sets employers require, particularly in high growth occupations
- Provides clear guidance for updating/aligning curricula with industry requirements
- Standardizes learning outcomes across similar programs nationally

Benefits for Educational Systems

- Enhances efficiencies of the education and workforce delivery systems
- Supports sector-based strategies, linking closer to an economic development agenda
- Increases acceptance of credits for articulation across programs and institutions
- Promotes student completion

Benefits for Employers and Communities

- Access to a skilled workforce they can further develop through on-the-job training
- Ability to focus during the hiring process on the candidate “fit” within the company
- Reduced training costs and turnover, enhanced workplace safety, and increased productivity
- Improved quality of the workforce and workforce expertise in a community or region

Additional information on the National Skills Certification System is available at the website:

www.themanufacturinginstitute.org/Skills-Certification/Skills-Certification-System.aspx.

ACT WorkKeys National Career Readiness Certificate (NCRC)

The NCRC validates core academic competencies in three areas: Applied Mathematics, Locating Information, and Reading for Information. Scores on these assessments determine the certificate level—bronze, silver, gold, or platinum—an individual can earn. These assessments measure a range of essential work skills, including the ability to:

- Perform basic mathematic operations relevant to the workplace
- Read and understand documents commonly found in the workplace
- Find information presented in common workplace graphics
- Set up and solve complex work-related math problems

- Determine the relevance of written information to work-related tasks
- Apply information derived from graphics to work-related problems

The state of Tennessee has endorsed the NCRC and recommends it for job seekers. For more information, please visit: <http://www.workforceinvestmentnetwork.com/career-readiness-certificates>.

The Manufacturing Institute has defined standards for skills certifications in a variety of technical areas. With regard to the steel fabrication career pathway, the most relevant certifications are from the Manufacturing Skill Standards Council, the American Welding Society, the National Institute for Metalworking Skills, the National Center for Construction Education and Research, and the Fabricators and Manufacturers Association, International.

Manufacturing Skill Standards Council (MSSC)

The standards for the Certified Production Technician (CPT) are established through industry guidance. To earn the CPT credential, students must successfully pass four separate assessments: manufacturing processes and production, safety and teamwork, quality, and maintenance awareness. Students can earn individual certifications for each of these topics or the full CPT designation. Additional information can be found at www.msscusa.org.

American Welding Society Certifications (AWS)

There are many different processes for metals joining, with the most common falling under different arc welding techniques. The arc welding processes that make up the “big four” – most commonly used in industry and taught in welding programs – include:

- Gas Metal Arc Welding (**GMAW**) also referred to as **MIG**
- Gas Tungsten Arc Welding (**GTAW**) also referred to as **TIG**
- Shielded Metal Arc Welding (**SMAW**) also referred to as **Stick**
- Flux Cored Arc Welding (**FCAW**) also referred to as **Flux Core**

AWS produces codes and standards for each welding process through 29 technical committees that are made up of industry volunteers. Currently AWS has published approximately 230 technical standards and works with businesses to create individualized specifications as needed. The most commonly used set of standards is AWS D1.1, for steel structural welding. While many employers conduct their own internal welding test for new hires, some manufacturers and educators have observed that more individuals and companies are deferring to the AWS certification system, as more engineers require their welders to be certified.

Certification: The AWS certification system that is most relevant to steel fabrication occupations is Certified Welder (CW). Individuals may be certified for different processes, such as those listed above, to weld to specifications that include different metals, filler metals, thickness, gases, and positions. The process and metals used for training, such as carbon steel, stainless steel, or aluminum, is best

determined by local employers since it can vary greatly across businesses and industries. Welds are also categorized as either Fillet (F) or Groove (G), which designates how the base metals are going to be joined. Some welding positions are considered easier than others, such as welding a flat plate (1F) versus a pipe in a fixed horizontal position (5G). Since a higher numbered position will qualify an individual to weld any of the positions that rank below, more advanced welders are expected to be certified in more challenging positions.

Metal Plate		Metal Pipe	
1	Flat	1	Horizontal (Rolled)
2	Horizontal	2	Fixed Vertical
3	Vertical	5	Fixed Horizontal
4	Overhead	6	45 Degree Fixed
		R	Restricted

In addition to the CW system, AWS also has a certification system for professionals, such as Certified Welding Inspectors and Certified Welding Educator. In addition to advanced technical skills, an individual must have significant work experience and pass additional exams to become certified in these areas.

A school does not have to be accredited to hold welding classes aligned with AWS standards. However, in order for individuals to become certified, their weld will have to be tested at an accredited facility. At this time, there are no accredited testing facilities in the Greater Memphis area. GMACW and its education partners would benefit from pursuing accreditation, as this would bring additional revenue and credibility to participating welding programs.

Education Standards and Resources: AWS also produces educational resources for secondary and post-secondary training centers, called Schools Excelling through National Skills Standards Education (SENSE). This is not a curriculum, but a set of modular and competency-based guidelines meant to assist schools in training welders and the specifications to include in their own curricula. Since AWS standards are developed by industry professionals, reflective of industry needs, and are widely recognized by employers, it is a best practice to align as closely as possible with AWS certifications. Incorporating SENSE into program curriculum will ensure that welding courses cover the most common welding processes. This allows students to gain broad experience and knowledge on the different methodologies, while also providing room for students to specialize on a process that may be most in-demand in the local area or of most interest. SENSE has two levels:

- Level I – Occupational Orientation, Safety [SMAW, GMAW, FCAW, and /or GTAW], Welding Process Technology, Thermal Cutting Processes I, and Welding Inspection & Testing I.

- Level II – Trade Math, Welding Metallurgy, Welding Inspection & Test Methods II, Welding & NDE Standards, and Thermal Cutting Processes II.⁵

National Institute for Metalworking Skills (NIMS)

NIMS offers a number of machining credentials in very specific skill areas and across three skill levels. These certifications provide skill standards for individuals responsible for operating machines (Level 1), training other machine operators (Level 2), and supervising other machine operators (Level 3). For all three levels, NIMS focuses on three general competency areas: bench skills, metal cutting skills, and inspection and quality assurance skills. For the purposes of this report, the most relevant credentials are at Level 1. Students can earn individual NIMS credentials in the following areas:

<p>Machining Level I Designed to meet the entry-level requirements for on-the-job skills</p>	<p>Measurement, Materials & Safety Job Planning, Benchwork & Layout Manual Milling Skills I Turning Operations: Turning Between Centers Turning Operations: Turning Chucking Skills Grinding Skills I Drill Press Skills I CNC Turning: Programming Setup & Operations CNC Milling: Programming Setup & Operations CNC Turning: Operations CNC Milling: Operations</p>
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NIMS credentials require both written and hands-on testing supervised by a sponsor (trainer or instructor) and reviewed by a committee of industry experts. Best practices indicate that education providers should align the credentials above to specific courses so that students can take NIMS tests in lieu of traditional exams. This eliminates subjectivity from the assessment process and increases students’ credential attainment.

In the Greater Memphis region, the Medical Device Council has worked with GMACW partner schools to develop curricula and career pathways aligned with NIMS credentials. The council has embraced NIMS credentials as a means of assessing students’ proficiency in key machining skills.

For more information on these and other NIMS credentials, please visit: www.nims-skills.org.

National Center for Construction Education and Research (NCCER)

NCCER is recognized as one of the premier workforce development organizations for the construction and maintenance industry with nearly 700 accredited training organizations and over 350 accredited

⁵ <http://pm-mn.com/2015/09/feature-story-whats-new-from-the-american-welding-society/>

assessment centers. The NCCER system measures technical competencies in over 55 craft areas from the entry to management level within the construction and maintenance industry.

For steel fabrication, NCCER's four-level welding curriculum is most relevant. It covers topics such as Oxyfuel Cutting, Welding Symbols, and Stainless Steel Groove Welds. NCCER's curriculum also correlates to the AWS SENSE (Schools Excelling through national Skills Education) standards and guidelines for Entry Welder. For more information, visit: <http://www.nccer.org/welding>.

Fabricators and Manufacturers Association, International (FMA)

FMA offers the only comprehensive certifications in fabrication. At the entry level, FMA offers a Fundamentals of Metal Fabrication Certification that is typically appropriate for a community college or technical school graduate. At the more advanced level, FMA offers the Precision Sheet Metal Operator Certification, which requires up to four years of education and/or experience. Because GMACW is focused on one- to two-year certificate and degree programs, the Fundamentals certificate is most appropriate. It requires individuals to be competent in six core topics:

- Metal Fabrication Safety
- Applied Shop Math
- Inspection/Quality Control/Hand Tools/Measurement
- Blueprint Reading for Metal Fabrication
- Metallurgy for Metal Fabrication
- Precision Sheet Metal Equipment

For more information on the testing procedure, and how to become a certified testing center, please visit: <http://www.fmanet.org/training>.

Steel Fabrication Education and Training

Overall, success in the steel fabrication pathway requires knowledge of mathematics, mechanical skills, construction, design, and production. Common skills include operating welding torches and machine tools, operation monitoring and control, analysis and critical thinking, problem solving and decision making, and blueprint reading. For a complete list of competencies associated with these positions, please see Appendix 1.

Education Requirements of Target Occupations: Most occupations in this category require training in career and technical education, related on-the-job experience, or an associate degree. Although many employers only require a high school diploma for entry-level employment, relevant training, skill acquisition, and certifications may enhance employment opportunities for individuals.

For the purposes of this report, TPMA reviewed the welding curricula offered at four GMACW partner schools. Currently, partner schools do not offer programs specifically geared toward fabrication or fitting; however, TPMA has identified opportunities to add relevant training in these areas. An analysis of ASU Mid-South's machining and process technology pathways was completed in 2014-2015, as was

Southwest’s machining program. Because fabrication requires skills that cross into other occupations, a full picture of the education landscape will take into account these previous reports. In addition, TPMA has developed a companion to this report titled Recommended Fitter Academic Pathway and Competency List; this document focuses on the urgent need to develop a training program for fitters in the Greater Memphis Region.

TCAT-Memphis: The stated purpose of the full-time welding program at TCAT-Memphis is to provide classroom and hands-on instruction to prepare students for careers in construction, production line assembly, and repair and maintenance.⁶ This one-year, 1,296-hour program includes nine units of instruction:

- Orientation
- Oxyacetylene Cutting
- Plasma Cutting
- Oxyacetylene Welding
- Shielded Metal Arc Welding
- Pipefitting
- Blueprint Reading
- Gas Metal Arc Welding
- Gas Tungsten Arc Welding

According to the TCAT-Memphis website, the program is AWS certified; however, curriculum is not aligned to specific credentials. Instead, students are able to complete AWS assessments upon instructor approval. Students can earn certificates in Gas Metal Arc Welding, Shielded Metal Arc Welding, and Tack Welding, as well as the combination welder diploma described above.

According to the program syllabus, work ethic and attitude are included in the course objectives and expectations. A representative of the program explained that students are expected to treat class like a job—they must arrive on time, in uniform, with proper safety gear. Communication and dispute resolution are built into the hands-on coursework as students complete projects together.

TCAT-Memphis’s welding program is unique in that it is an open-enrollment, open-entry program. Students can begin class on any Monday or Tuesday except during holiday breaks, and they progress through the curriculum at their own pace. While flexible, student-centered scheduling is a best practice in career pathways, this model does raise some challenges for the instructors, who have to supervise students with varying levels of skill and experience. Ensuring consistency and quality of the graduates will be essential for continued successful placement.

Recent graduates of Tennessee high schools are eligible for scholarships to attend TCAT-Memphis at no cost through the Tennessee Promise Scholarship Act of 2014⁷. For this reason, TCAT-Memphis is an ideal fit for Step 2 of the GMACW fabrication career pathway beginning on page 16. (Note: Step 1 is high school vocational programs and/or adult education in career readiness.) To maximize students’ opportunities to continue their formal education, TCAT-Memphis and the other GMACW education

⁶ <http://tcatmemphis.edu/fulltime-programs>

⁷ <http://www.tcatmemphis.edu/tennessee-promise-scholarship-act-2014>

providers should explore articulation agreements that would place TCAT welding graduates in the second year of associate degree programs in welding at ASU Mid-South or Moore Tech.

Moore Tech offers a one-year welding certificate that was designed to align closely with the Moore Tech advisory board's needs. The certificate program covers electric arc welding, plasma arc cutting, oxyacetylene cutting, oxyacetylene welding (both ferrous and nonferrous metals), TIG (Tungsten Inert Gas), and MIG (Metal Inert Gas). Students are prepared to take the AWS D1.1 exam after the first year.

Additionally, Moore Tech is offering a second-year program that will culminate in an associate of applied science degree. It includes the welding skills and processes described above as well as training in advanced plasma cutting, pipe welding, and robotic welding. Students interested in the associate program must also take math, physics, professional development, psychology, and technology. These five courses introduce students to the academic, employability, and entrepreneurial skills needed in the industry.

Recently, Moore Tech and its partners have invested more than \$2.3 million in a new welding facility. The regional career pathway should take into consideration how this new facility can benefit the system; for instance, with additional capacity and space available, Moore Tech is able to offer customized and short term training for special projects. The Steel Fabricators Council indicated that one of the gaps it finds in welding graduates is a lack of "real world" welding experience—i.e., welding outside of a controlled environment. Moore Tech has outdoor space in addition to the lab, and may be able to create a space to practice in more difficult and/or less controlled situations. Council members also noted that there is a need for trained burn-table operators, and Moore Tech has the equipment and capacity to provide customized training in this occupation.

With its new facility and recently approved associate's degree, Moore Tech is well positioned to provide advanced welding training. The administration reported an interest in adding Certified Welding Inspectors and Certified Welding Engineers to their staff; this would align closely with the fourth and final level of the pathway as well.

In order to provide welding students in the Greater Memphis region with the most flexibility possible, we recommend that Moore Tech explore articulation agreements with the other GMACW welding and fabrication programs so that students can easily move between programs should they need to.

Southwest Tennessee Community College (Southwest) does not offer a welding program at this time. However, there is one welding course included in the process control technology – maintenance technician concentration. Welding I covers welding safety, oxyfuel cutting, plasma arc cutting, air carbon arc cutting and gouging, base metal preparation, weld quality, SMAW equipment and setup, SMAW electrodes, beads and fillet welds, joint fit-up and alignment, groove welds with backing, and open V groove welds. TCAT-Memphis and Southwest should explore an articulation agreement so that TCAT graduates who choose to pursue an AAS degree at Southwest can earn credit for Welding I.

As noted above, fabrication requires exposure to many manufacturing processes. Southwest currently offers courses in process control and machining, and has invested heavily in new equipment for the medical device industry (grinders, finishers, etc.). With these assets, Southwest would be positioned to offer a short-term fabrication certificate. We recommend a 12 to 16 credit hour (one semester) certificate of proficiency that would include the existing welding course as well as coursework in

quality, safety, and machining. This certificate could align with two or more of the following industry-recognized credentials:

- MSSC CPT (see page 8)
- NIMS Level 1: Measurement, Materials, and Safety AND Job Planning, Benchwork, and Layout (see page 10)
- AWS D1.1 (see page 9)

ASU Mid-South offers four short-term certificates of proficiency: Flux-Core Arc Welding, Gas Metal Arc Welding, Gas Tungsten Arc Welding, and Shielded Metal Arc Welding. Each of these certificates includes courses in career preparation, blueprint reading, shop essentials, and industrial safety as well as two technical courses specific to the welding process. Each certificate is stackable and aligned with AWS assessments, according to the ASU Mid-South website; the lead instructor confirmed that all students must be able to pass the AWS 2F assessment to graduate. Students who complete three of the certificates are eligible to take a fabrication class, which includes instruction in pipe welding.

Students interested in additional welding courses at ASU Mid-South can apply these courses to an Associate of Applied Science General Technology degree. They also must take 15 credits of electives, which can be selected from programs in diesel maintenance, machining, or mechatronics. To complete the associate's degree, students must take two English courses, one math course, computer fundamentals, and one social science course.

Similar to TCAT-Memphis, the program at ASU Mid-South was designed to simulate the workplace. Attendance and work ethic are important pieces of student evaluation.

One of ASU Mid-South's advantages is the low cost of tuition, \$90 per credit hour, which for most students is covered fully by Pell Grants. A welding kit, which contains a helmet, gloves, and some basic tools, is available in the bookstore so that students can use financial aid to purchase it. Mid-South also has a program for low-income parents to provide childcare and transportation support. These wrap-around supports are a boon to low-income and underserved student populations.

ASU Mid-South is positioned to provide training at the second and third levels of the steel fabrication pathway. Although there are no existing articulation agreements with TCAT-Memphis, Mid-South is able to review TCAT graduates for Prior Learning Assessments and often awards up to 30 credit hours for prior learning. Mid-South's Prior Learning Assessment policy would also allow Moore Tech and Southwest students to gain credit for Mid-South courses.

Fitter Training

As noted above, members of the Steel Fabricators Council have requested additional training for fitters. Council members provided suggestions regarding the skills needed, as well as the format of the program. Because of the unique nature of the fitter role, council members also suggested that the fitter pathway would be more in line with students who are interested in art and creating objects, with a strong level of attention to detail. Company representatives indicated that they would like schools to lead these types of students into fitter pathways before the students are hired by the companies.

They suggested that companies should create videos of the different type of tasks and environments fitters are exposed to so that students have an idea of the positions. These videos can show things like

how to make steel move, apply pressure, line up correctly, where and how to tack, how they use mathematics and how to measure. These videos could be hosted on the newly designed MemphisWorks.com career awareness and job-matching platform.

Council members suggested that the fitter pathway include basic and advanced options. The advanced option fits well with the two-year degree format already used at Mid-South, Southwest, and Moore Tech. However, the approval process for new two-year degrees is rigorous and time-consuming. For those reasons, and to begin filling the gap for fitter training as quickly as possible, the Council has chosen to focus on short-term, non-credit training that is designed for incumbent workers who already have some knowledge of welding and fitting.

At the basic level, all fitters must have core foundational academic skills before being able to move into a trainable environment. This includes:

- Applied math: calculations using feet and inches, fractions, and metrics conversions. Fitters will likely not need to draw in metrics, but must be able to convert drawings from metrics and reverse.
- Basic trigonometry: solving for angles, calculate circumference, etc.
- Advanced blueprint reading
- Measurement, tolerance, and related tools
- Use of tape measures, compasses, protractors, etc.
- Problem solving and troubleshooting

In addition to the academic skills listed above, fitters will need classroom exposure to machine operation, particularly press brakes; basic welding; and nomenclature used in the steel fabrication sector, including “beam,” “channel,” “pipe,” and “tube.” Upon completion of this coursework, program completers would be prepared for on-the-job training in which they would begin by evaluating welders, and then be paired up with other fitters. The trainee would likely be responsible for repetitive fitting tasks while shadowing/observing the experienced fitter to learn more complex tasks. This training would likely be at least one year in length.

At the advanced level, students in fitter training would need to demonstrate the ability to:

- Assemble structural steel using a blueprint
- Tack steel pieces in place
- Manipulate steel plates using sheet dogs, wedges, and other tools
- Apply pressure, heat, etc., to manipulate steel
- Create a jig to hold an assembly of parts together for production of identical pieces

Because the occupation requires knowledge of different disciplines, tools, and scenarios, the trainee will likely require years of experience before being able to take on all the responsibilities of the job. For this reason, apprenticeship and other work-based learning models should be considered. A work-based learning guide will be developed for GMACW partners in 2017.

For more information about TPMA's recommendations for Fitter Training, please see the Recommended Fitter Academic Pathway and Competency List.

Recommended Steel Fabrication Career Pathway

Based upon our research and the existing programs available in the GMACW region, TPMA recommends the following Fabrication Career Pathway.

Step 1 – Foundational Skills (Exposure)

Step 1 provides generalized, exploratory entry points and preparation for various manufacturing career pathways, including welding, for high school students and transitioning adults. At this level, students gain foundational academic and technical skills as demonstrated by credentials including OSHA 10, WorkKeys National Career Readiness Certificate (NCRC) Levels 3 and 4, and the Manufacturing Skill Standards Council Certified Production Technician (MSSC CPT), as well as a basic understanding of the careers available in manufacturing. Students should be exposed to a variety of occupations and manufacturing environments through tours, speakers, and job shadowing as appropriate. In Tennessee, this is supported by the Career and Technical Education high school welding program of study (<https://www.tn.gov/education/article/cte-cluster-advanced-manufacturing>). At the adult level, there may be significant alignment with Southwest’s Industrial Readiness Training (IRT), a non-credit, short-term program.

Graduates who choose to exit the program after Step 1 will be qualified for entry-level production worker positions.

To be eligible to sit for the MSSC certification exam, previous coursework is not required. However, students are more likely to successfully pass the assessments after completing MSSC’s curriculum, which can be completed in as little as four weeks. We recommend developing articulation or Prior Learning Assessment agreements that would allow students who achieve the MSSC CPT credential to earn up to 12 college credits at ASU Mid-South, Moore Tech, or Southwest.

To ensure graduates are work-ready, the above programs should include a focus on employability skills (soft skills), the ability to explore various steel fabrication careers through projects, and exposure to the different types of welding. There should be clear expectations about the work conditions and requirements to be a successful welder, fitter, or machinist during the first year of the high school technical education program. It is during this time that a student will gain exposure to different manufacturing processes but may not have the technical competencies needed to become a practitioner. Post-secondary students who do not have welding exposure and enroll in a skill-specific short-term program will need to also focus on these fundamental skills and career exploration.

Soft skills, such as maintaining focus, staying on task, willingness to ask questions, work ethic, attendance, and managing time and productivity pressures should also supplement time spent in the lab practicing skills. Since many businesses are focused on hiring “trainable people” who have the ability to be precise and can demonstrate basic employability skills, students at this level could be hired as grinders or other lower-level positions that support the fabrication process.

While it used to be common for steel fabricators to hire people with straightforward welding skills, it is now required that entry-level workers understand detailed technical aspects to help diagnose issues. This makes continued education particularly important to develop a deeper understanding of metallurgy, blueprint reading, and different metal joining processes and procedures.

Common Occupations: Cutting, Punching, and Press Machine Setters, Operators, and Tenders. (job titles may include “helper,” “assembler,” and “operator.”)

Step 2 – Work-Ready (Entry level)

Step 2 in the steel fabrication pathway is best suited to welding positions which typically require minimal formal education followed by on-the-job training. Individuals at this level need exposure to SMAW, GMAW, FCAW, GTAW, and thermal cutting processes in addition to basic safety, welding symbol and blueprint reading, and inspection/testing basics. Students should also gain exposure to setting up and using different machines, developing technical competencies, and problem solving skills. Welders will have the ability to test for at least one AWS certification in one process in a position between 1F and 3G, using carbon steel or stainless steel. The most common certification earned by entry-level welders is using SMAW or GMAW processes and D1.1 Structural Steel standard specifications.

Students who complete the TCAT-Memphis, Moore Tech, and ASU Mid-South one-year or shorter certificate programs will most likely be prepared for positions aligned with Step 2 of the career pathway.

At the end of Step 2, some individuals on the welding pathway may decide that they want to take another branch of the pathway and focus on developing the skills to become a fitter. This transition is best for individuals who possess excellent math and design skills, prefer variety in their daily work, and enjoy problem solving.

Common Occupations: Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders; and Welders, Cutters, Solderers, Brazers (commonly: welders). Additional fabrication-related occupations may include machine operator, entry-level machinist, and press brake operators.

Step 3 – High-Need Skills (Advanced level)

At Step 3, students may choose to continue along a welding track, gaining greater competence in welding processes in more challenging positions, with more challenging metals, and earning higher-level AWS certifications. Students should also focus on developing a deeper understanding of types of metals and gases; reactions; and the interplay of temperature, atmospheric, and process changes, which will allow for better problem solving when on the job. For the GMACW region, an increased focus on advanced technologies, such as robotics welding, may be particularly useful.

Students who complete Moore Tech’s or Mid-South’s second-year welding courses and earn an AAS degree may be competitive for these positions; however, it is likely that additional work-based learning

and relevant work experience would also be required. TPMA strongly recommends adding a work-based learning component (such as an internship or co-op) to the final semester of coursework. This would require active partnership with the Steel Fabricators Council members.

The basic fitter training program described above would also fit into Step 3, with graduates prepared to begin work as a fitter-trainee under a more experienced mentor. According to the council, fitters can often make 20-25 percent more per hour than welders and also experience greater job security because of the unique service they provide in a fabrication environment.

Common occupations: Welders, Cutters, Solderers, Brazers; Structural Metal Fabricators and Fitters (commonly: fitters); Layout Workers, Metal and Plastic. Other fabrication-related occupations at this level may include machinist, maintenance technician, and quality assurance technician.

Step 4 – Subject Matter Expert

Step 4 is often achieved only after many years of experience; the individuals in these roles often have extensive institutional knowledge and should be tapped as mentors for the emerging workforce. In order to reach this level of the pathway, individuals have two options for increasing their skill level; they can either continue their formal education or focus on developing their skills through on-the-job training.

Individuals who elect to continue their education may pursue a bachelor of applied science at the University of Memphis or the University of Arkansas Fort Smith, both of which have articulation agreements with GMACW partner schools. It is important to note that, even with a four-year degree, a person pursuing the peak of Step 4 will need extensive work experience.

In addition to post-secondary credentials, those who have focused on welding skills may also choose to pursue additional AWS credentials, such as:

- CWI – Inspectors (must have 5+ years of practical work experience plus technical competencies)
- CWS – Supervisors
- Quality, non-destructive testing examiner
- CWEng – Certified Welding Engineer

Those individuals who choose to focus on on-the-job training will most likely develop the skills to complete more complicated welds and positions, some of which are reported to take as much as 10-15 years of practice to master. At this level, the AWS exam for two-inch pipe in the 6G position are relevant for assessing welders' skill level.

Advanced fitter training is another likely path for these individuals; this specialty requires excellent hand-eye coordination, special awareness, and advanced technical skills (such as the ability to read complicated blueprints).

Common Occupations: Welders, Cutters, Solderers, Brazers; Structural Metal Fabricators and Fitters; Layout Workers, Metal and Plastic; Welding Engineer.

Additional Considerations

It is also important to note that successful career pathways are comprised of more than just training, credentials, and aligned occupations.⁸

Essential features of quality career pathways include:

- Well-connected and transparent education, training, credentialing, and support service offerings (often delivered via multiple linked and aligned programs);
- Multiple entry points that enable well-prepared students as well as targeted populations with limited education, skills, English, and work experience to successfully enter the career pathway; and
- Multiple exit points at successively higher levels leading to self- or family-supporting employment and aligned with subsequent entry points.

Essential functions in quality career pathways and programs include:

- Participant-focused education and training;
- Consistent and non-duplicative assessments of participations' education, skills, and needs;
- Support services and career navigation assistance to facilitate transitions; and
- Employment services and work experiences.

The GMACW Steel Fabricators Council provided insight into the importance of these career pathway elements, highlighting the need for employability skills and work experience. Additional opportunities to provide internships, job shadowing, and other experiential learning would likely be well received by this group of employers while simultaneously strengthening the education providers' curriculum and outcomes.

⁸ Additional information of creating high quality career pathways can be obtained through the Alliance for Quality Career Pathways (a project of CLASP) at: <http://www.clasp.org/issues/postsecondary/pages/aqcp-framework-version-1-0>

Steel Fabrication Career Pathway

Step 1 | Foundational Skills

Generalized, exploratory entry points and preparation for various manufacturing career pathways.

- High School Technical Education
- Industrial Readiness Training (Southwest)

- OSHA 10
- WorkKeys National Career Readiness Certificate (NCRC)
- Manufacturing Skill Standards Council Certified Production Technician (MSSC CPT)

Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic
Wages: \$12.00 - \$17.00 per hour

Step 2 | Work-Ready

Exposure to SMAW, GMAW, FCAW, GTAW, and thermal cutting processes in addition to basic safety, welding symbol and blueprint reading, and inspection/testing basics.

- TCAT-Memphis (One-year program)
- Moore Tech (Certificate)
- ASU Mid-South (Certificate)

- AWS D1.1 Structural Steel
- NIMS Level 1

Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders
Wages: \$13.00 - \$18.00
 Welders, Cutters, Solderers, Brazers
Wages: \$16.00 - \$24.00
 Other occupations may include: machine operator, entry-level machinist, and press break operators.

Step 3 | High-Need Skills (Advanced Level)

Develop advanced skills with more challenging metals, processes, and positions

OR

Basic fitter training for students with a "maker" mindset

- Moore Tech (AAS)
- Mid-South (AAS)

- AWS Certified Welder – various
- NIMS Level 1
- FMA Fundamentals of Metal Fabrication
- *Steel Fabricators Council Basic Fitter Certification (in development)*

Welders, Cutters, Solderers, Brazers
Wages: \$16.00 - \$24.00
 Structural Metal Fabricators and Fitters
Wages: \$13.00 - \$20.00
 Layout Workers, Metal and Plastic
Wages: \$15.00 - \$24.00
 Other occupations may include machinist, maintenance technician, quality assurance technician, and fitter.

Step 4 | Subject Matter Expert

Extensive on-the-job training/work experience

OR

Additional formal education

- University of Memphis
- University of Arkansas Fort Smith

- CWI – Inspectors (must have 5+ years' experience)
- CWS – Supervisors
- Quality, non-destructive testing examiner
- CWEng – Certified Welding Engineer
- *Steel Fabricators Council Advanced Fitter Certification (in development)*

Welders, Cutters, Solderers, Brazers
Wages: \$24.00 and up
 Structural Metal Fabricators and Fitters
Wages: \$20.00 and up
 Layout Workers, Metal and Plastic
Wages: \$24.00 and up
 Welding Engineer
Wages: \$29.00 and up

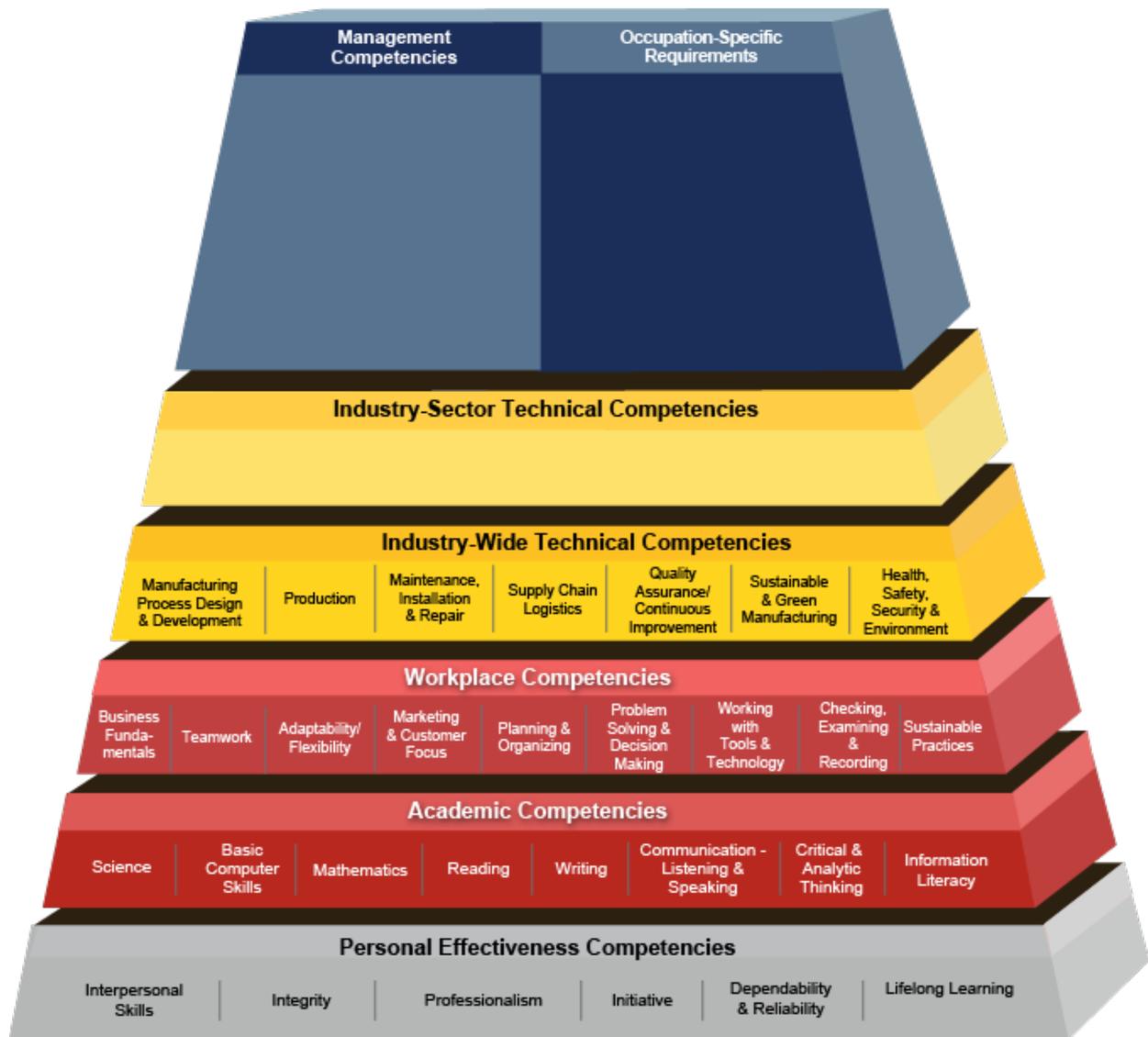
Appendix 1: Welding Competency-Curriculum Crosswalk

The following table represents a high-level analysis of the *Welding* programs offered at TCAT-Memphis, Moore Tech, Southwest Tennessee Community College, and ASU Mid-South. Historically, these institutions have focused specifically on welding rather than steel fabrication in more general terms. In order to complement this crosswalk—and respond to the Steel Fabricators Council’s workforce needs—TPMA has also developed an academic pathway and competency list specifically for Fitters. Please see the document titled “Recommended Fitter Academic Pathway and Competency List” for occupation specific recommendations. The competencies below are organized and color coded based upon the Advanced Manufacturing Competency Model (<http://www.careeronestop.org/competencymodel/competency-models/advanced-manufacturing.aspx>).

		TCAT	Moore Tech						STCC	Mid-South						
			WELD 111	WELD 112	WELD 113	WELD 211	WELD 212	WELD 213	MTEC1000	Weld1053	Weld1113	Weld1123	Weld 1133	Weld 1143	Tech1003	Tech 1013
Assemble structural steel for welders	Occupation															
Chip and grind off excess weld, slag or splatter	Occupation							x								
CNC programming	Occupation					x										
Flux Cored Arc Welding	Occupation	x	x													
Gas Metal Arc Welding (Mig)	Occupation	x	x							x	x	x	x			
Gas Tungsten Arc Welding (Tig)	Occupation	x		x					x	x						
Inspecting completed work for conformance to specifications	Occupation		x			x			x							
Oxygen-Acetylene Cutting (OAC)	Occupation	x	x			x		x	x			x				
Operate welding equipment	Occupation							x	x	x	x	x	X			
Perform preventative maintenance on equipment	Occupation							x								
Pipe Welding	Occupation				x											
Plasma Arc Welding	Occupation	x		x	x		x	x	x				x			
Read Weld Symbols	Occupation		x					x		x	x	x	x			
Robotic Welding	Occupation						x									

Set-up and layout	Occupation		x						x	x	x	x	x			x		
Shielded Metal Arc Welding (stick welding)	Occupation	x	x							x		x						
Structural steel movement and manipulation	Occupation																	
Welds components in flat, vertical, or overhead positions	Occupation	x		x							x	x	x	x				
Manufacturing Process Design and Development	Industry																	
Production	Industry																	
Maintenance, Installation, and Repair	Industry																	
Supply Chain Logistics	Industry																	
Quality Assurance / Continuous Improvement	Industry																	
Sustainable & Green Manufacturing	Industry																	
Health, Safety, Security & Environment	Industry																	
Adaptability / Flexibility	Workplace																	
Analyze charts	Workplace															x		
Blueprint Reading	Workplace	x	x													x		
Business Fundamentals	Workplace																	
Checking, Examining, and Recording	Workplace																	
Communication with supervisors, peers, or subordinates	Workplace	x																
Gathering and using information	Workplace																	
Judgment and Decision Making	Workplace															x		
Marketing and Customer Focus	Workplace																	
Measurement	Workplace															x	x	
Monitoring (equipment / devices)	Workplace															x		
Operating vehicles and equipment	Workplace	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Planning and Organizing	Workplace																	
Problem Solving and Decision Making	Workplace																	
Safety (chemical Hazards, lock-out/tag-out procedures)	Workplace	x	x	x	x	x	x	x	x	x						x		
Selecting and using hand tools and power tools	Workplace		x								x	x	x	x	x		x	x

Appendix 2: Manufacturing Competency Model - U.S. Department of Labor



Appendix 3: National Best Practices in Welding and Fabrication

Cuyahoga Community College – Fast-Track Welding Boot Camp (M-List)

This program combines fundamental skills in Stick, MIG, and TIG welding technologies and prepares students to earn 3 certifications in 10 weeks (280 hours). Students are trained on Lincoln Electric equipment and test for AWS certifications upon completion of the program. Career coaching and workplace skills are also covered during the program. Students are required to have a high school diploma or equivalent, predetermined WorkKeys assessment levels, and a background check before enrolling.

For more information, visit: <http://www.tri-c.edu/workforce/industrial-welding/fast-track-welding-boot-camp.html>

Dunwoody Technical College – Welding and Metal Fabrication (M-List)

Students at Dunwoody Technical College can pursue a two-year degree program in Welding and Metal Fabrication. The course of study is made up of two stackable certificates: a one-year welding certificate and a one-year machining certificate. Successful students will earn both AWS and NIMS credentials, and be prepared for a number of fabrication environments.

For more information, visit: <http://www.dunwoody.edu/manufacturing/welding-metal-fabrication/>

Ferris State University – Welding Technology AAS and Welding Engineering Technology BS

The program at Ferris State University provides students with a clear pathway from a two-year, technical degree to a four-year bachelor's degree, stacking technical competencies with academic skills. In addition to core welding skills, students are exposed to metal fabrication through courses in material science, computer aided design, electronics and machine tool disciplines.

For more information, visit: <http://catalog.ferris.edu/catalog/2016-2017/program/4982>

Iowa Advanced Manufacturing Consortium (I-AM)

The Iowa-Advanced Manufacturing (I-AM) Consortium was formed to collaboratively build the training capacity necessary to meet industry demand in a number of sectors, including welding. Integration of AWS was a major element of I-AM's TAACCCT funded project, and several AWS testing facilities were designated during the grant period. Two I-AM participants are highlighted below:

Des Moines Area Community College – Iowa Welding Institute (M-List)

DMACC's welding program is an open-entry, open-exit program with several different concentrations, each of which is aligned to a set of AWS credentials and exams. Students enter the program based on their existing abilities, thus creating an opportunity for experienced welders to pursue certification without having to repeat basic skills in class. The institute also offers Blueprint Reading Certification. DMACC is an AWS accredited testing center.

For more information, visit: <https://www.dmac.edu/programs/welding/Pages/welcome.aspx>

Iowa Lakes Community College – Welding Technology Program

Through a variety of advanced training pathways, students may enter the welding program at Iowa Lakes Community College to complete a diploma program, gain certifications specific to their career goals, or complete a basic Performance Welding course in conjunction with another Trade and Industry Program. Program students may attend evening or daytime classes at an accelerated pace to quickly attain the skill-level needed to advance their career. One-week sessions are offered for continuing education over spring break and during the summer months when daytime program students are on break. Students can obtain a Welding Technology Certificate (21 credits) or a Welding Technology Diploma (38 credits).

For more information, visit:

http://www.iowalakes.edu/academic_programs/career_and_technical_education_programs_of_study/industrial_technology/welding_technology/

<http://www.elevateiowa.com/careers/career-pathways/welding-technician-and-technology>

Ivy Tech Community College – Welding Institute (M-List)

The Welding Institute was developed with the AWS SENSE framework and prepares students to become successful professional welders. The program is 40 weeks (five 8-week terms), with classes meeting 34 hours per week. Welding Institute students learn welding process and equipment, welding metallurgy, welding codes, blueprint reading, and the care and maintenance of equipment. Students will be trained in Gas Metal Arc (MIG), Gas Tungsten Arc (TIG), Shielded Metal Arc Welding (SMAW), and Pipe and Tube welding. Several certifications from the AWS and the American Society for Mechanical Engineers (ASME) are integrated into the coursework. Academic components such as reading, writing, and math exercises are also fully integrated into coursework. All credits earned can be applied towards an Associate of Applied Science degree at Ivy Tech Community College.

For more information, visit: <http://www.maspark.org/what-is-masp/training-and-workforce-development-center/>

Lancaster County Career & Technology Center (M-List)

This program is a full-day welding program for high school seniors using the AWS SENSE framework. Students learn a range of processes and practice on various metal products in preparation for weld certifications. Dual credits are integrated into the coursework for students that plan on continuing their education. Classes are also offered for adults. Students can take short term programs (10 weeks or less) on specific skills, such as Electric Arc Welding, MIG, TIG, or blueprint reading. The Center also offers year-long full-time day and evening programs in Welding Technology.

For more information, visit: <http://lancasterctc.edu/programs/welding-technology/>

Lehigh Career & Technical Institute (M-List)

LCTI is home to two schools, the Career and Technical High School and the Adult Workforce Education School. High school students have the option to attend half-day or full-day with academic work integrated for full-day students. The Welding Technology program prepares students for AWS Entry Level Certification and the nine performance tests that make up the certification. Career research, blueprint reading, and other skills are also included in the curriculum.



Evening courses for adults are offered in 14 week blocks, one day a week for 3 hours, and at two levels. Welding I is focused on the fundamental welding concepts and building experience hands-on with basic processes. Welding II provides additional hands-on practice and covers additional processes, metallurgy, and welding positions.

For more information on LCTI's secondary programs, visit: <http://www.lcti.org/prospective-student-course/welding-technology/>

For more information on LCTI's post-secondary program, visit: <http://www.lcti.org/adult-education-course/welding/>

LeTourneau University – Materials Joining Concentration, Engineering B.S.

The Engineering Department at LeTourneau offers a specialization in materials joining, which provides students exposure to materials, mechanical, structural and electrical engineering. The hybrid specialization is one of the only ABET accredited engineering programs with a welding focus in the country. LeTourneau is also home to the largest materials joining laboratory in the United States.

For more information, visit:

http://www.letu.edu/opencms/opencms/Academics/Engineering/degrees/Engineering_BS/MJ_concentration.html

Lorain County Community College (M-List)

Lorain County Community College in Elyria, Ohio, offers a short term Technical Certificate (19-20 credit hours) in Welding Technology, a one-year Technical Certificate (34 credit hours) in Welding Technology or Welding Operator, and an Associate of Applied Science (66 credit hours) in Welding Technology. Programs are stackable and articulation agreements are in place. Shorter term programs are focused on the hands-on skills needed to work as a welder. Longer term programs add onto these courses but focus on technician skills – serving as a liaison between engineers and welders – instead of just hands-on technical skills.

Lorain County Community College is also home to the National Center for Welding Education and Training, a partnership between business, education, AWS, and the government that has affiliates across the country. Also called Weld-Ed, the partnership provides guidance on welding education, support for instructors, program support, and much more. Weld-Ed has built state-of-the-art welding facilities located on the College's campus.

For more information about Lorain County Community College programs, visit:

<http://www.lorainccc.edu/Academic+Programs/Associates+Degree+and+Certificate+Programs/Engineering-Manufacturing.htm>

For more information about Weld-Ed, visit: <http://www.weld-ed.org/>

Mississippi Gulf Coast Community College – WIRED Customized Training Courses

A Workforce Innovation in Regional Economic Development (WIRED) US Department of Labor grant has helped fund the development of a customized training program for Mississippi Gulf Coast Community College. This new curriculum includes more stringent testing guidelines that enable students to earn "stackable"--as well as nationally recognized--credentials prior to program completion. The curriculum sequences students through the multiple welding processes in a way that

ensures students successfully test according to American Welding Society (AWS) standards. The program includes a Certificate track (30 credits), that stacks onto a Diploma with an additional 15 credits. On top of the Diploma, students can earn an Applied Science of Occupational Education Degree (AASOE) for an additional 15-16 credits.

An additional source of funding allowed the college to create a mobile welding trailer/classroom that can move between campuses and employers. This has allowed for much more flexibility with the influx in welding trainees both in the training programs at the college and for employers that are up-skilling their current employees.

For more information, visit:

http://catalog.mgcc.edu/preview_program.php?catoid=8&poid=562&returnto=468

The Ohio State University- Welding Engineering, Materials Joining Technical Track

This program offers technical materials joining skills for engineers who would like to specialize in process technology, materials science, design, inspection, and quality control. Students learn metallurgy, plastics and composites, and undergo design and simulation coursework to learn heat flow, thermal and residual stresses, and fracture and fatigue applications, in addition to regular engineering coursework.

For more information, visit: <https://mgel.osu.edu/curriculum/technical-track-welding-engineering>

Pennsylvania College of Technology – Welding and Fabrication Engineering Technology

Students seeking a BWE from Penn State are prepared to bridge the communication barriers between engineers and the welders who will be executing an operation. Oxyfuel, SMAW, GMAW, GTAW, basic CNC programming, blueprint reading, high level mathematics, non-destructive testing, metallurgy, and robotic welding are all required as part of the curriculum, ensuring students can perform the process and have a deep understanding of both the engineering and practical skills needed.

For more information, visit: <https://www.pct.edu/catalog/majors/bwe.shtml>

Salt Lake Community College – Welding Fabrication & Inspection Degree

Welding Fabrication & Inspection degree-seeking students at Salt Lake Community College receive a foundation of industry practices, welding theory, and knowledge of metal alloys and metallurgy processes. Graduates from the program are competent in layout, fabrication, inspection, fitting, cutting and forming metals and determining electrodes/wire and filler metals required by industry. Students have the opportunity to learn techniques for certification testing, blueprint interpretation, and written procedures required by industry. Welders desiring to improve their position by upgrading their skills in specific welding processes or applications; or welders desiring instruction certification, fabrication, or inspection are encouraged to enroll in the program.

For more information, visit: <http://www.slcc.edu/welding/degrees.aspx>