Mid-South Community College

Right Skills Now – Bridge to Employment

Machining Certifications

Assessment By:
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and
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Executive Summary

Mid-South Community College, with collaboration from The Manufacturing Institute, initiated a study for the development of a new program for its technical certificates in Machining as a replacement of its existing program it deemed not to be aligned with regional industry needs nor with national skills credentials.

For the study, four approaches were executed:

1. Review of nationally accepted credentials, standards and certifications endorsed by the National Association of Manufacturers (NAM) and The Manufacturing Institute, the leading authorities in credentials for manufacturing processes;
2. Review of programs at representative, comparable institutions;
3. Review of Mid-South's industry input; and,
4. Evaluation of industry trends and factors that impact program development and content.

Upon completion of the study, the key recommendations are:

- **Establishment of four new Certificates of Proficiency for Machining**
  - CNC Operator, CNC Machinist, Conventional Machining/CAM/GD&T, and Engineering Technician
  - Accelerated and diverse scheduling options

- **Curriculum/content for certificates**
  - Integrate NAM-Endorsed credentials
  - Stackable certificates for career pathway progression
  - Multiple, diverse student populations
  - Minimum entry requirements, but with provision for remedial

- **Comprehensive assessment of regional industry factors**

- **Launch awareness and recruitment programs to optimize industry acceptance and student enrollment**

- **Increase employer-sponsored apprenticeships, in partnership with college**

- **Evaluate program effectiveness – create an evaluation plan, in collaboration with advisory committee/employers, to determine success of program**

Introduction

With the objective of designing and implementing programs to promote skills development and employment opportunities in fields such as advanced manufacturing, science, technology, and engineering, Mid-South Community College (Mid-South) was awarded a three-year, $2.5 million grant from the U.S. Department of Labor (DOL) Trade Adjustment Assistance Community College and Career Training (TAACCCT) Grant Program. DOL is implementing and administering the grant program in coordination with the U.S. Department of Education.

Mid-South president, Dr. Glen Fenter, at the time of the grant announcement, declared "This grant gives our institution an unprecedented opportunity to enhance our ongoing efforts to build a world-class workforce in our region. Industry experts have been telling us for several years there is a serious skills gap within advanced manufacturing and related fields. The TAACCCT grant will give us the resources we need to help fill some of those gaps."

Mid-South is collaborating with The Manufacturing Institute (MI) on the TAACCCT grant to implement the NAM-endorsed Manufacturing Skills Certification System designed to provide individuals with nationally portable, industry-recognized certifications combined with for-credit education programs. The focus areas for the grant are:

- Development of articulated education pathways that deliver competency-based, stacked, and latticed credentials recognized by critical industry sectors and related associations.

- Development of training programs targeted to the real needs of employers with 'middle-skill' jobs, a classification projected to account for nearly half of all job openings nationwide over the next decade; positions that require more than a high school diploma, but less than a four-year college degree.

- Development and sustainment of a rich cross alignment between education and employers with third-party certifications as a bridge in addressing the skills gap between the labor force and targeted, high tech industries.

- Development of a workforce that is competitive and relevant for the 21st Century economy.

- Ensure the college, related institutions, and regional industry moves forward with industrywide certification standards to enhance regional, national and global competitiveness.

- Establishment of strategic partnerships with regional employers for successful implementation and to enable them to be globally competitive for the optimal development of the regional economy.

Working with area industry and business organizations, Mid-South identified machining and production process technician programs as being the most critical area of demand for skills development in accelerated programs.

Mid-South contracted with MI for technical assistance and support in evaluating academic programs and mapping career pathways pertaining to Machining and Process Technology. MI, with the approval of Mid-South, subcontracted with Thomas P. Miller and Associates (TPMA), a consulting firm that specializes in workforce development research and analysis, to prepare a summary report about Machining Certifications.

The report consists of the following components to inform Mid-South on how to best design an accelerated career pathway for Machining:

- Analysis of Mid-South's current Machining program
- Analysis of national, industry-recognized Machining certifications
- Summary findings from best practice community and technical college Machining certificate programs
- Evaluation of industry trends and factors in Manufacturing
- Recommendations for Mid-South Machining certification programs
- Career pathway for Machining

Background and Current Status: Mid-South Machining Program

Mid-South is a public, two-year postsecondary institution located in West Memphis, Arkansas with an annual enrollment of approximately 2,000 students. Mid-South was founded in 1992 and is a comprehensive community college serving Crittenden County, Arkansas, with a population of 49,746 (US Census Bureau, 2013) and the Memphis Metropolitan Statistical Area (MSA), the 41st largest MSA in the United States with a population of 1,341,746 (US Census Bureau, 2013).

In addition to two-year associate degrees, Mid-South offers technical certificate programs in a variety of career fields including Machining. Mid-South presently offers three certificates of proficiency related to Machining:

- **Certificate of Proficiency in Machine Technology: Machine Attendant** – 18 credit hour program focused on training individuals in the design, application, and operating skills of computer integrated manufacturing. It is designed to provide

students with the foundational education, training, and direction to work in entry-level machining fields such as Metal Finisher.

- **Certificate of Proficiency in Machine Technology: Machinist I** – 18 credit hour program designed to further develop machining skills introduced in the Machine Attendant Certificate of Proficiency. The program prepares students to set up and operate CNC lathes and mills from specific information, interpret part drawings, and determine the proper tooling to complete a specified project. The program provides students with the ability to complete the National Institute of Metalworking Skills (NIMS) certification for Level I Machining Operations. Types of job opportunities for students who complete the certificate include higher levels of Machinist Operators.

- **Certificate of Proficiency in Machine Technology: Machinist II** – 18 credit hour program designed to provide students with the ability to determine process methods of machining, communicate process improvements, and identify necessary programming information. The program provides students with the ability to complete the NIMS certification for Level II machining operations. Types of job opportunities for students who complete the certificate include highest levels of Machinist Operator, Quality Inspector and other, higher level support or oversight positions.

Although likely developed based on identified needs at the time of inception, the certificate programs do not currently align to national standards, or as focused on current needs of area industries, as they could be. For example, the Machine Attendant certificate, while providing *broad* exposure, doesn't appear to provide sufficient *depth* of content to adequately prepare students to function in either a manual or CNC environment (primarily due to changes in complexity of equipment, thus requiring higher skills).

Extensive on-the-job experience and supervision would be required to gain the skill levels expected by employers. The Machinist I and II certificates, may also be insufficient to meet the standards and requirements of industry utilizing advanced technology and/or lean process methods. The curriculum for the three technical certificates for machining currently offered by Mid-South are detailed in Appendix 1.

Mid-South is exploring ways to strengthen its programs working in collaboration with local and regional manufacturers related to the high tech industry sectors of medical devices and implants and aviation/aeronautics. Mid-South has targeted four certificates of proficiency for implementation to replace the existing programs:

- CNC Machining Operator
- CNC Machinist
- Conventional Machining/ CAM/GD&T
- Engineering Technician

The overall objective for Mid-South is to provide workforce training for its Greater Memphis market area that contributes to meeting the skills gap for 21st Century technologies through the implementation of current training based on nationally recognized standards to establish strong entry level skills and stackable credentials to facilitate career pathways of its graduates. The target advanced manufacturing sectors are medical devices and implants and aviation/aerospace, as well as, several more base manufacturers. As such, the target positions range from accelerated program for entry CNC operators through all levels of machinists and more sophisticated support functions from design through quality management.

Analysis of Machining Programs

In developing recommendations, for a revitalized machining program targeted to projected needs of regional employers, TPMA executed four approaches: 1) review of nationally accepted credentials, standards and certifications endorsed by the National Association of Manufacturers (NAM) and The Manufacturing Institute, the leading authorities in credentials for manufacturing processes; 2) review of programs at representative, comparable institutions; 3) review of Mid-South's industry input (machining advisory committee minutes and surveys); and, 4) evaluation of industry trends and factors that impact program development and content. Each of these approaches is detailed below.

The purpose of the four approaches was to cover the full spectrum of issues that impact the current and future programs. This was in consideration of the complexity of the much touted skills gap in high skilled labor capabilities, the major changes in related technologies and processes over the past decade, and the significant potential for reshoring of manufacturing in Memphis industry sectors to which machining is critical. An understanding of these issues and their interrelationships is believed critical to development of a program and, from TPMA's analysis, reflects a challenge for Mid-South to meet a broad and deep range in technical training. This is emphasized because many approach curriculum development in a vacuum as a stand-alone or isolated process, when in actuality a matrix of inter-related issues must be addressed.

TPMA conducted its evaluation within the framework of the Manufacturing Career Competencies Model and the Career Pathways Model to ensure inclusion of all credential levels critical to manufacturing and, for the individual, all stages of career preparation and advancement. These models are shown in Appendix 2, 3 and 4. The next sections of this report provide a review of each of the four approaches. From compilation of these inputs, recommendations are provided in the subsequent section for the Mid-South program.

1) Review of National Skills Certification System

This section examines the first approach taken by TPMA which was the review of nationally recognized credentials. 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 (MI), with the encouragement of the federal government, 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 provides defined 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 nationally recognized certification system aligns to the U.S. Department of Labor's Manufacturing Competency Model (see Appendix 2) that outlines the minimum competencies required for individuals to enter and advance in a manufacturing career.

A primary purpose of this initiative is to provide focused, nationally recognized credentials that can be used by education institutions in program development that would better address the needs of industry. The program 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 enable job seekers to more quickly gain the skills required for employment in high demand occupations.

One example of accelerated training is the Rights Skills Now initiative, which seeks to provide students with the skills and aligned credentials to gain entry level employment, then advance their skills through completion of additional training and achievement of advanced, stackable credentials.

A key component of the Skills Certification System is to foster collaboration between regional industry, business associations and educational institutions towards accelerated achievement of workforce goals. Collaboration should be a given, but in fact, is quite often not executed for any number of reasons, which results in a number of disconnects and inefficiencies in employment demand and supply.

Full explanations of the NAM/MI Skills Certification System and Right Skills Now are available at the website: www.nam.org and click on "Manufacturing Institute, Skills Certification"; or go directly to the MI site at: www.themanufacturinginstitute.org/Skills-Certification/Skills-Certification-System.aspx.

NAM has defined standards for skills certifications in fourteen areas with another three in development, but the primary technical one for occupation specific competencies for machining is Machining & Metalworking, with related or support skills certifications defined by other areas within the Skills Certification System, including Foundation Skills, Cross-Cutting Technical Skills, Lean, Mechatronics and Quality.

Within each of the areas, NAM worked with sixteen applicable professional organizations to define the skills necessary to be deemed proficient within each given area, and have created assessments to validate individual's skills towards earning industry recognized credentials. The professional organization associated with direct technical skills and standards for machining is the National Institute for Metalworking Skills (NIMS) and those associated with related support skills include: ACT, Manufacturing Skill Standards Council, Manufacturing Skills Institute, Society for Manufacturing Engineers and American Society for Quality. Also, within the Machining career pathway, the National Career Readiness Certificate (NCRC) validates core entry academic competencies.

The following is a brief outline of these certifications.

- ***NCRC:*** The standards for achievement of the National Career Readiness Certification are established by ACT. Students can be assessed in one or more areas including Reading for Information, Applied Math, Locating Information, and Technology. Student scores or "levels" are aligned to industry recognized requirements for various occupations, including machining.
- ***NIMS:*** The National Institute of Metalworking Skills provides industry vetted certifications in a variety of occupational areas including machining. As the focus of this review was on machining, the related NIMS credentials are emphasized.
- ***MSSC:*** The standards for the Certified Production Technician are established through industry guidance and the Manufacturing Skills Standards Council (MSSC). To earn the CPT credential, students must successfully pass four separate assessments including 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.
- ***ASQ:*** The American Society for Quality established guidelines and training programs to develop and enhance skills and practices related to the achievement of superior quality in products and processes.
- ***SME:*** The Society of Manufacturing Engineers develops guidelines, standards and training programs dedicated to achievement of optimal manufacturing practices.

Full details on all the skills certifications areas and associated organizations are available at the website for The Manufacturing Institute:
http://www.themanufacturinginstitute.org/Skills-Certification/Certifications/NAM-Endorsed-Certifications.aspx#MM.

NIMS Machining Certifications and Credentials

Overall, NIMS has twenty-one credentials classified across three Machining skills level, but the system is flexible in terms of implementation of credentials and there is no requirement for a "minimum". An institution, in program development, may integrate one or all of the credentials according to local needs, so that individuals may earn one, or multiple credentials depending on training goals and/or job requirements.

The three levels and twenty-one credentials are summarized below with each level briefly explained in the following section.

NIMS Occupation & Skill Level	NIMS Credential
Machining Level I *Designed to meet entry-level requirements for on-the-job skills*	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
Machining Level II *Designed to meet journey-level requirements for on-the-job skills*	Manual Milling Skills II Turning II (manual) Drill Press Skills II Grinding Skills II CNC Milling Skills II CNC Turning Skills II EDM — Wire EDM — Plunge
Machining Level III *Designed to meet master-level requirements for on-the-job skills*	CNC Turning Skills III CNC Milling Skills III

The following summarizes the three NIMS skills levels with respect to potential for Mid-South.

NAM/MI NIMS Based CNC Machining Level I

This program is set up in a modulated format so an institution can select individual credentials from the above listing for Machinist I according to its local needs. For example, a program could include Conventional (Manual) Machining and CNC machining or focus on one or the other. The technical courses are focused accordingly on the level of desired processing technology, but the core, support skills courses that would typically be included in any program, include: Measurement, Materials and Safety and Job Planning, Benchwork & Layout. Under the program, all required technical competencies are provided by NIMS for each of the technical and support courses noted, but the institution then develops curriculum to meet its selected established competencies.

The NIMS program focuses on occupation specific technical skills, but does not address all support skills, such as print reading, modeling or metallurgy, nor does it address "soft skills" such as communications, team building, etc. Therefore, institutions typically add courses to address developmental challenges, post machining support skills, Lean organization or other competencies identified by institution and industry collaboration. For these courses, institutions can draw from other NAM-endorsed certifications developed by other professional associations, including MSSC, MSI, ASQ and SME. Details for the NIMS certification and related competencies can be found at https://www.nims-skills.org.

NAM's "Right Skills Now" curriculum draws from the NIMS Machining Level I credentials in offering a program meeting entry-level requirements for a base level machinist. Details on related competencies for Right Skills can be found at: http://www.themanufacturinginstitute.org/Skills-Certification/Right-Skills-Now/Right-Skills-Now.aspx.

In developing the model for the Right Skills Now program, NIMS and NAM, worked with Dunwoody College of Technology in Minneapolis. This program highlights the flexibility of the NIMS credentials, as Dunwoody, in implementation, opted to not adopt all credentials, but chose to focus on CNC Milling and Turning with the foundation support credentials of Measurement/Materials/Safety and Job Planning/Benchwork/Layout. Beyond the NIMS technical skills, Dunwoody added a required internship and courses in Manufacturing Careers Investigation, Algebra/Trigonometry/Geometry and Machine Math.

NAM/MI NIMS Based CNC Machining Level II

This certification is targeted to intermediate-level technical employment requirements and could be pursued as follow-on to Machining Level I, or by one with sufficient work experience to qualify beyond entry position.

As with the NIMS Machining Level I program, this certification is also flexible and one may be selective in credentials selection. There are a number of issues that must be considered by an institution, many of which are noted below in the industry assessment section, but the most critical is collaboration with industry as to the employment market and whether the demand is for employees of greater technical depth; or, broader technical and support functions.

NAM/MI NIMS Based CNC Machining Level III

This certification level is targeted towards master or highly experienced employment opportunity requirements and, accordingly, integrates higher levels of technical focus. Again, it is up to the institution as to the depth required by local industry for its education programs.

As will be covered in Recommendations, at this time, NIMS II and III are not perceived as of significant program contribution for Mid-South, although the content, or portions thereof, could be integrated into one of the proposed Mid-South certificates.

As previously noted, the NIMS certifications address machining technical skills required for proficient execution; and, for transferability within and across industry sectors. Credentials for non-technical skills are not addressed by NIMS, but through other organizations within the Skills Certification System (i.e. ACT, MSSC, ASQ, MSI, SME) and nearly all institutions with technical programs go beyond the pure technical to encompass.

For an institution, in this case Mid-South, key decision points with respect to NIMS are whether to focus on Conventional, CNC or Specialty processes, the degree of required depth, and whether the applicable technical credentials apply or if blended credentials are preferred. Further, many of the issues noted below in industry assessment impact the nature and content of a developing program. For Mid-South's new certification for Machining – CNC Operator, the "NIMS/Dunwoody program" was recommended by Mid-South staff in October 2013 and it was reviewed and approved by the industry advisory committee. This will be discussed in Recommendations section below, but in TPMA's assessment, this is a quite acceptable program and meets Mid-South and area industry needs for entry level Machine Operator. However, Mid-South should further evaluate the need for Specialty (EDM) and Conventional credentials for later implementation.

2) Review of Machining Programs at Comparative Institutions

A second approach by TPMA, in assessment for the Mid-South machining program, was review of Machining programs at comparative institutions. Although there are a number of strong programs across the country, TPMA, for consistency and validation purposes focused the selection of programs for comparison on the "M-List" of the Manufacturing Institute (MI). The M-List recognizes institutions (high schools, community colleges, technical institutes and universities) that are teaching manufacturing programs according to industry recognized standards contained in the NAM-endorsed Manufacturing Skills Certifications System.

The M-List is comprised of seventy-three institutions in twenty-four states, of which, thirty-seven institutions have some degree of certified Machining or Machining-related programs. For this study, TPMA scanned the thirty-seven with machining programs, selected seventeen for more detailed review; and, of the seventeen, selected eleven deemed to be provide greatest potential for insights in development of Mid-South's program. Major factors for the selection, and related examples of the institutions, included:

- Comprehensiveness – Wichita, Baltimore, Lehigh
- Industry applicability --Wichita, Forsyth
- Geographic region – Lorain, Francis Tuttle, Rock Valley, Forsyth
- Similar urban area – Baltimore, Saint Paul, Gateway, Forsyth, Francis Tuttle, Rock Valley, Ivy Technical
- Strong entry and progressive pathways – Wichita, Cape Fear

- Innovative reputation – Dunwoody, Central Carolina, Saint Paul, Gateway

Institutions from Manufacturing Institute M-List Reviewed for Comparative Purposes

The following were the seventeen programs reviewed for comparative purposes with the first eleven being deemed most applicable for Mid-South (also, in italics).

1. *Dunwoody College of Technology, Minnesota*
2. *Wichita Area Technical College, Kansas*
3. *Community College of Baltimore, Maryland*
4. *Central Carolina Community College, North Carolina*
5. *Saint Paul College, Minnesota*
6. *Gateway Community College, Arizona*
7. *Lorain County Community College, Ohio*
8. *Forsyth Technical College, North Carolina*
9. *Cape Fear Community College, North Carolina*
10. *Lehigh Career and Technical Institute, Pennsylvania*
11. *Rock Valley College, Illinois*
12. Central Piedmont Community College, North Carolina
13. Francis Tuttle Technology Center, Oklahoma
14. Southern Oklahoma Technical Center, Oklahoma
15. Pensacola State College, Florida
16. St Louis Community College, Missouri
17. Ivy Technical Community College, Indiana

The curriculums for these programs are summarized in Appendix 5, with highlights deemed applicable to Mid-South. Although all selected comparable programs are on the M-List and are NAM/MI recognized as being to industry standards and reflecting common, core credentials, it is important to note that there are no two programs that are identical, a point that emphasizes the modularity of the NAM Skills Certification System. Each institution customized its program based on assessment of local/regional manufacturers' needs and requirements. The primary program modifications include selection of technical focus, integration of soft skills, such as communication and teamwork; remediation or contextualized math and reading; and/or inclusion of related skills or job requirements that go beyond the core technical and support skills established by NIMS, such as product design, programming and quality. The focus of NIMS on technical skills and the lack of integration of critical other skills was noted in the previous section on national standards, as was addressing non-technical skills certifications through other national associations. Other program differences relate to math or English prerequisites. Nationally, industry input tends towards comprehensive programs that comprise the full skillset required for the current industry environment. This is, especially the case in Lean focused industry segments, which encompasses nearly all high tech sectors in today's economy, inclusive of the targeted sectors for Mid-South.

3) Review of Mid-South's Industry Machining Advisory Committee Input

The third approach in TPMA's analysis was the review of industry input, in particular, Mid-South's Machining Advisory Committee minutes and surveys.

Industry Sectors and Key Industry Customers

The primary manufacturing sector applicable to Mid-South is medical devices, but other representative sectors include automotive, aviation/aerospace and general industry. Greater Memphis has a significant cluster in medical devices, primarily orthopedic, and key medical device customers are Wright Medical, Microport, Medtronics, Smith & Nephew and Big River. Other key customers include Star Manufacturing and Ace Pump. Key support industries include Matrix Machining and Cardinal Machining. Machining technician positions are important to all of the noted sectors and industries.

Industry Input

Mid-South management established an eight member advisory committee from area medical device and machining companies for the Machining Technology program in mid-2013. To date, the committee has met twice to review the current program and proposed changes therein. The following reflects TPMA observations from the minutes of the two machining advisory committee meetings. These observations are preliminary and bear further discussion and verification.

- Current machining program does not meet the needs of area industry.
- Revitalized and revamped program is critical to the development of a talent pool for high skills recruitment.
- Support for national industry standards, including NAM, NIMS, ASQ and SME.
- More shop machining time needed in the program.
- Machinist Levels – strong support for proposed Machinist Operator certificate, as a starting point for entry personnel, feeder for higher skills certificates and to serve the needs of industry sector focused on limited skill personnel.
- At least as important, if not more so, is transition of higher skill certificates for development of skilled CNC and specialty equipment personnel beyond that of basic operators.
- Revitalized program cannot happen quickly enough.
- There is a significant need for broader and deeper skills beyond machine operation. This includes design assessment, models comprehension (versus paper prints), inspection and quality validation, Lean Six Sigma, full product lifecycle, process planning and documentation.

The concern for these areas is to be expected in considering the primary customer sectors are all focused on quality requirements of FDA (Food and Drug Administration), ISO (International Organization for Standardization) and/or AS (Aerospace Standards per SAE), and their requirements often flow down through their supplier base. With respect to curricula impact, exposure and comprehension of the non-operating functions noted in the

last point should be integrated throughout the machinist program for development of long term, career path potential. It particularly affects the higher certifications.

Skills Survey Observations

As part of the advisory committee meetings, a skills survey was executed by committee members at each meeting. The survey data and analysis process are in Appendix 6. However, observations on the data by TPMA that impact program development are as follows. These observations are preliminary and bear further discussion and verification.

CNC versus Conventional

CNC is the primary focus with respect to latest technology and industry needs, although Conventional (Manual) and Specialized operator skills needs are noted. With limited resources and the challenge of diverse programs, it is suggested priority focus be given to CNC, with more detailed surveys and assessment executed in order to appropriately assess the level of Mid-South resources to be devoted to Conventional and Specialized operator training (versus Conventional "exposure" in order to develop the skills basis for higher level certificates).

CNC Content Focus: Limited Skill Operator versus Broad Skilled Technician

TPMA suggests this issue needs further exploration and review of industry needs. The study objectives focused first on Right Skills Now for accelerated graduation of operators; and secondly on broader skill requirements in the other certifications. Both are important and supported by the data. There is emphasis, currently, in Greater Memphis business and workforce entities for accelerated programs for entry machinists (Rights Skills Now) in order to meet a pressing need. However, based on the survey data and Mid-South industry input, the industry requirement for the higher skilled certifications is also quite critical. This observation is based on the priority given in the survey for non-technical operational skills.

Of the top 9 CNC skills in the survey, 3 relate to vertical and horizontal operations, but 6 relate to understanding and execution of CAD, operational setup, offsets, coding and data input; and, 9 of the remaining 11 top 20 skills relate to foundation, support and quality functions (receipt, interpretation and manipulation of electronic data, setup and subsequent quality validation). Further, in the advisory committee meetings, there has also been significant discussion on non-direct operation functions. This also fits with the national trend in the machining industry, which calls for machinists with broader and more diverse skill base and higher level skills, as machining equipment has increased in functions and capabilities. As such, it is suggested the first certificate (Right Skills Now) be immediately implemented, as planned, but that the higher skill certifications be finalized and implemented as soon as possible.

Programming & Design Functions

The survey data reflects low priority (8 of the bottom 20) for the higher sophisticated functions of product design (versus print or model interpretation), full-scale programming (versus machine language), print development and finite element analysis. This could relate

to the composition of the advisory committee (if their focus is on shop personnel); but, if correct observation, this may impact the demand for Associate degree graduates. This particularly makes sense in consideration of input that the client industry is primarily targeted to production of established designs and R&D/early stage product work are done elsewhere. The issue merits further discussion and, possibly, more detailed survey.

New Process Technology

Additive (popularly termed "3-D" Printing) was the only 'new technology' skill noted in the survey, but it ranked in the bottom 20 of the 53. This may reflect low concern for disruptive technology in the current market, but that doesn't correlate with indications of investment in Additive by some area manufacturers. With technology and materials changing quite rapidly, especially in the medical devices and aero sectors, this issue requires regular monitoring and assessment of potential impact on the program. It may also affect facility (equipment and space) and faculty development in the future. Mid-South recently acquired several, basic 3-D printers and TPMA suggests exposure of the technology be integrated to higher certifications.

4) Review of Industry Trends and Factors

The fourth approach employed by TPMA was the review and consideration of a range of industry trends and factors that impact program development and content. There are a significant number of factors that should be considered in the development and execution of a program due to their impact on meeting current/changing needs, acceptance of the program, utilization of facilities, timing (i.e. programming, scheduling), content and mode of delivery.

Unfortunately, it is not uncommon for programs to be developed with low consideration of industry trends. The emphasis by NAM and MI on collaboration is an effort to overcome the tendency of business and education entities to function in vacuums without close communication.

The objective of NAM/MI is that collaboration will nurture training and education programs that will be better aligned to needs and more adaptable to changing industry and workforce trends. It was not part of the scope of this study to assess industry trends within the Mid-South market area and TPMA does not wish to infer all of these or the examples given, are reflective of the Mid-South market; nor is the listing all inclusive.

The issues noted are cited as representative of challenges that are often overlooked or not fully addressed in development and it is recommended Mid-South and its industry partners conduct a methodical assessment of its regional environment and how its proposed program is impacted in order to optimize the implementation of its program.

The following is a list of considered industry trends and factors and a brief discussion of each follows the listing.

Industry Trends and Factors Considered

- Manufacturing Forecast
- Occupational Demand
- Student Applicant Pool and Recruitment
- More than Just a Skills Gap
- Accelerated Programs
- Inclusion of Non-Technical and Soft Skills
- Conventional Machining Exposure (progressive or post-exposure)
- Nature of Processing
- Facilities and Equipment
- Skills Levels
- Mode of Machining Execution (Shop Organization)
- Component Part Specifications and Materials
- Materials and Shifts Thereof
- Technology Shifts
- Electronic Data Models versus Paper Blueprints
- Shop Organizational Styles – Hierarchy or Lean
- Metrics – Measurement for Success
- Pathway Developmental Programs

Manufacturing Forecast

The first element in program considerations and allocation of resources is assessment of what is required in the market service area, short and long term. The best possible assessment is particularly critical in technical pathways because of the expense of the shop facilities and the relatively low FTE/sq. ft. instructional and shop space. Resource allocation to programs in high demand, but may provide lower financial return, is one of the greatest challenges of community college management in striving to meet its opportunities in filling the national skills gaps in technical skills areas.

For the Greater Memphis area, the Arkansas Department of Workforce Services-Eastern Region and the Tennessee Department of Labor and Workforce Development forecast declining manufacturing employment; while the Workforce Investment Network (WIN) forecasts dramatically increasing employment, especially in high skill technical areas, but the growth forecast is higher than normal, national economy trends.

Forecast and trend assessment is challenging enough and conflicting reports on the same region make it more so. TPMA, while not experts on the economy and can't say who is "right", notes that most agency reports tend to be "data driven" which means they utilize actual event data from a given past period and the latest is normally two years old; or in this case, the

workforce agencies may be factoring the declining trends of the past decade, especially the impact of the Great Recession.

On the other hand, the WIN report integrates assessments of major, international consulting groups that massage shifting trends, industry interviews, etc. and forecast future impact. In this case, within the past two years, the consulting groups stress that there have been significant shifts in the competitiveness of U.S. manufacturing and an emerging trend that began some time ago does appear to be working in favor of "reshoring" of significant manufacturing on a national basis in a range of industries. This trend is particularly evident in the more complex, higher skill requirement products represented in the Memphis market. TPMA recommends further assessment and delineation of findings to enable more accurate demand forecast for machining graduates.

Occupational Demand

It is critical a thorough analysis of current and forecasted occupational specialty demands be executed as part of program development in order to optimize timing, content and overall execution. For example, excellent programs have been established and were well received by industry and students, but the graduation rate did not fit well with the desired hire rate resulting in frustration and dissatisfaction from students, employers, and the college. In addition, the specific skill requirements for high demand occupations must be considered to ensure program graduates have the minimum requisite skills to meet industry needs. This would include pre-hire assessments used by regional employers. There are solutions to these concerns, such as staggered starts/completion and advance commitments from industry, and employer input on job task analyses, but front-end analysis and collaborative planning between employers and the college can mitigate the issue. TPMA recommends further surveys and commitment discussions with industry on numbers and timing for hiring.

Student Applicant Pool and Recruitment

To ensure a sufficient supply of students are recruited to meet regional demand, it is essential an analysis of the potential student applicant pool be conducted with stratification of different groups that may have different program needs (i.e. high school students, military, returning adults). This issue is faced by many colleges as evidenced by development and implementation of high-tech programs only to find a small percentage of applicants could meet entrance requirements and course completion. For some colleges, the completion percentage (relative to applicants) has been in the six percent range, while the remainder of the original applicants, were not admitted due to substance or alcohol abuse, or inability to pass the entrance exam.

Further, of those admitted, a significant number failed to complete due to lack of child care, transportation, need for income, poor attendance habits, inability to do the academic work and other reasons. In such situations, a far larger labor pool is required in order to meet demand and resources are challenged by the cost of remedial and support programs.

To address the challenge, Mid-South, must analyze and understand its applicant pool and implement a strategic public awareness marketing plan that is targeted to each population segment and capability strata of the pool. Further, it must develop its program and supporting remedial education program to address the needs of those that fail to complete or cannot pass the entrance requirements.

However, it is not sufficient to begin with the population that applies for a program. The more successful programs, nationally, have worked to develop its talent pool through implementation of awareness and academic immersion programs from the middle school level. Examples of such programs include NCRC (National Career Readiness Certificate), early college, industry/college visits, supervised or independent special work study projects. An example of a good marketing and talent development program is the Lehigh Career Pathways program which targets from middle school up with a staged program progressing from information through exposure and on to direct participation in projects that integrate manufacturing skills and environment.

More than Just a Skills Gap

Most media attention and education policy has focused on the technical skills gap. However, in reality, there are a number of gaps, including: student performance gap interest gap (in manufacturing), expectations gap (realistic parameters for all parties), understanding gap (between industry and education institutions), strategy/action gap (from economic development and education entities adapting strategies), alignment gap (program planning and execution not aligned with market requirements), and resources gap (entities adapting to new technologies).

These gaps, in various combinations and degrees, apply across the country. It is critical for Mid-South to assess and understand the gaps in its region and develop programs accordingly. For example, with student performance, intensive remedial and college prep programs will be necessary. For the manufacturing interest gap, a creative and aggressive public awareness campaign is necessary in collaboration with industry, chamber and economic development groups. The other noted gaps require very high levels of communication and collaboration between all education, business and government parties It would be greatly beneficial if such programs were driven at the Governor's level in both states, but if not, local and regional entities should act with a very comprehensive initiative with strategies targeted from middle school ages on through applicable adult groups (challenged, adult re-training, military, etc.). None of the programs can be a "one size fits all" approach for prep education or for awareness, but requires umbrella campaigns with strategies adapted to each segment.

The "Made in Memphis" April 2013 report by the Workforce Investment Network, the Greater Memphis Chamber and the Southwest Tennessee Community College tackles the issue of job opportunities relative to applicant pool participation. In addition to dramatic changes in mode of delivery of training services, a major marketing campaign is proposed to "create public awareness of the benefits and pathways toward a manufacturing career".

Other states and regions have proposed, or are executing, similar campaigns. Marketing is not a part of curriculum development, but for a successful technical education program with strong support and acceptance from potential students and industry, such a program is essential.

Accelerated Program

It was an objective of this study to assess accelerated programs and mechanisms to implement. The issue is noted here as emphasis of its importance. To effectively address the national and regional skills gap, it is critical to implement adjustments in mode of delivery towards intensive, self-directed learning, block scheduling, and other modes of acceleration to enhance completion rate.

The traditional two to five semester format does not serve industry or students well with respect to development of skilled trades. TPMA highly recommends development of a block based program in which students have 3-6 hour classes and labs versus traditional class format. It is critical that teaching time be largely hands-on and shop based. If at all possible, apprenticeships or internships should be integrated into the certificate process. Apprenticeships are preferable over internships in order to maximize industry exposure at the earliest possible time, provide earnings opportunities, and enhance the learning experience for students as they are moving towards employment.

Depending on forecasted demand and entering student levels, it is also suggested that class completion be aligned to hiring demand through implementation of a "staggered start/completion" schedule. This requires a highly flexible class/shop environment in which students within a class are at different levels, but this is quite possible with utilization of Immerse2Learn and other customizable programs as currently being evaluated and developed by Mid-South instructors.

Inclusion of Non-Technical and Soft Skills

Mid-South's advisory committee meetings have included discussion of non-technical and non-operator skills. Deficits in non-technical skills have been given almost as much attention by industry groups, as deficits in technical skills. In review of comparative programs across the country, nearly all programs devote significant resources and program content to non-technical skills. Non-technical skills include communications (verbal and written), independent work/self-directed learning, team work, Lean process practices and general shop workflow. Non-operator skills include electronic data receipt and management, models analysis, machine setup, machine adjustments, jigs and fixtures, post-machining finishing, quality validation and post-process data recording.

All of these skills are critical to initial hiring and employee development, except perhaps for the largest, most segmented or specialized shops. Nearly all the comparative programs summarized in Appendix 5 integrate support skills and most also include soft skills. MSSC is the primary NAM-endorsed professional association that has developed standards and

credentials for the basis of such programs, inclusive of safety, communication, teamwork, quality and productivity processes.

Conventional Machining Exposure (progressive or post-exposure)

There is a national debate in machining circles with regard to how critical it is to have conventional machine experience as a base to CNC processing training. Most academic programs were developed in a linear manner beginning with hand tools and progressing through Conventional machines and on to CNC. Industry has largely shifted towards not requiring Conventional experience prior to CNC operator development. Many of the new academic programs have adjusted accordingly. TPMA's suggestions herein are based upon development of CNC operator skills without consideration of Conventional; but, to integrate Conventional training/experience with subsequent certificates in order to develop understanding of process and differences in design and various materials.

Nature of Processing

Industry input and survey data reflect a need for a comprehensive program that covers CNC and Conventional skills. However, as expected, there is clearly a priority for CNC operator and related skills training. Further, requirements cover the range of milling and turning processes, multi-axis, as well as EDM and screw training. While not clear for the product manufacturers, the major machining shop customers to Mid-South have 5-axis and specialty equipment operations. TPMA highly recommends integration of multi-axis and specialty equipment skills in order to appropriately serve the market.

Facilities and Equipment

Further discussion as to Mid-South's facility is required to support recommendations. However, as noted, industry has been rapidly shifting to multi-axis and EDM processing and, with respect to quality, CMM. It is critical students be trained as much as possible on equipment that is closely related to subsequent employment. It is also critical for students to have far more shop time than class time for the optimal learning experience. This is a concern expressed by the Machining Advisory Committee.

Skills Levels

Industry input and survey data reflect a requirement for two divisions: 1) entry level personnel with base CNC technical skills, but not necessarily significant depth in support skills (i.e. blueprints, quality); and, 2) higher skilled personnel with significant depth in broad support skills, CAD/CAM capabilities and/or the full production process. To meet industry needs, it is suggested the full spectrum of certifications, entry level CNC and higher level, diversified certifications, be pursued concurrently , but the potential for stackable certificates be maintained, versus establishment of Machinist I and then adding higher skilled certificates at later date. With certificates targeted to these areas of focus, it will be important to monitor and execute surveys for the need for skills depth (i.e. CNC II) for consideration of classes, if not certificate, in the higher technical skills.

Mode of Machining Execution (Shop Organization)

The nature of area industry requires a broad range of capabilities for machinists and related positions. These requirements stem from several perspectives. First is the mode of execution. The key manufacturers in the Mid-South market have major in-house machining operations, but also contract significant volumes to local machine shops. The large plants versus job shops operate quite differently and, typically, require different levels of employee skills. At the risk of being overly simplistic, the large, high volume plants tend to focus on production of "standard" parts with few changes over time, so their requirements for machinist training lean toward "operators" (with a diverse range of equipment) and specialized roles for input, follow-on and support functions. Specialized requirements, relatively low volume components and any design changes are most often contracted to the job shops. As such, the shops may have more sophisticated equipment and require employees of far broader capabilities. This is illustrated by the major machine shop customers to Mid-South that have 4 and 5-axis equipment, as well as, wire EDM and screw equipment. The respective demand, driven by equipment type and respective skills, depends on the organizational style of the shops with some having "operators" with other roles being largely independent and specialized; while others require broad skilled personnel that can receive/process data, program machines, setup, operate, perform quality control and execute final reports.

Component Part Specifications and Materials

The nature of the components involved in medical device, aircraft/aerospace and automotive tend to be more complex and entail higher levels of materials, such as Titanium, Inconel, Magnesium and high aluminum alloys versus basic steel and aluminum. Thus, higher materials knowledge and CNC processing are more likely to be required. The other industry sectors entail a mixture of basic and complex parts, more likely utilizing aluminum and steel. The higher end sectors and materials typically require CNC, very often multi-axis; while the other sectors usually entail simpler processes for CNC, or even Conventional, drilling and turning.

Materials and Shifts Thereof

An understanding of current and forecast materials to be used in industry operations is important in that traditional machining largely worked with steel, aluminum and aluminum alloys and many training programs were established accordingly. In recent years, there have been dramatic shifts towards more advanced metals and alloys, composites and ceramics, as well as, shifts in specialized coatings. This has been particularly applicable in aviation/aerospace and medical devices. There is a dramatic difference in skill levels required in design, jigs/fixtures and machining of these materials. The shift is driven by concerns for lower weight, higher performance, more efficient components, and, with medical devices, efforts to reduce infections related to contamination. Skill training is closely tied to the nature of materials being processed and training should be adapted prior to materials shifts by manufacturers.

Related to base materials, there is also a shift within the same sectors towards engineered coatings that provide similar benefits noted above, but at a cost or performance tradeoff to materials cost. Data references to such coatings are included in specification data and must be understood in order to make appropriate machine adjustments, perform finishing work, and/or inspect parts for quality.

Technology Shifts

Disruptive technologies to machining practices must be carefully monitored because it significantly impacts training programs and the lead time to develop skilled personnel. Machining technology has been undergoing dramatic changes driven by machine technology, product development, material shifts and other factors and these shifts are forecast to continue, if not accelerate. Additive manufacturing (AM) (commonly termed 3D Printing) is one example. Although it did not rank especially high in the advisory committee survey, Mid-South has acquired several basic 3D machines in anticipation of growth in the technology in consideration of several area industries utilizing on experimental and developmental basis. Nationally, the growth of AM development has been dramatic, although still largely related to R&D, low volume components, and component qualification stages.

All advanced sectors, of which medical devices and aviation/aerospace are considered, are experimenting, developing or shifting towards AM for at least a portion of new product and traditional product production. The primary reasons relate to reduction in material costs (relative to subtractive manufacturing), more efficient designs, lower weight, highly customizable designs (i.e. individual orthopedic insert versus 'one-size' for all).

As AM has advanced for plastics and metals, it has been increasingly realized that additive will probably not be a stand-alone technology for some years, but will entail an integration of the benefits of additive and subtractive (conventional and CNC). However, skills for additive alone, or for integration, are different than stand-alone conventional/CNC machining and progressive programs should anticipate these changes in order for its programs to be more adaptable to future trends.

Electronic Data Models versus Paper Blueprints

Electronic data transfer and management is currently standard operating procedure for industry. Paper blueprint reading and manipulation is acceptable as an introduction to the basic concepts and interpretative skills for they are essentially the same as for computer models, but it is critical for all students to have knowledge of primary modeling software and the ability to access, pull, manipulate and manage electronic files and data as nearly all industry and CNC machining have made the shift. With regard to interpretation and data transfer is the critical need for comprehension and capability to interpret models from SolidWorks and other CAD/CAM software systems.

Shop Organizational Styles – Hierarchy or Lean

It is important the manufacturing work environment and organizational style of industry be understood and integrated into the program as it can impact the probability of successful

employment if students are trained to function in highly structured or Lean environment for the Mid-South market almost certainly has a broad range of plants and shops that represent dramatically different styles from highly structured through those that embrace continuous improvement (i.e. Kaizen; Lean) to "get the job done" job shops.

In that medical devices, aero/aviation and comparable high tech sectors operate under ISO and other quality programs, it is probable they integrate continuous improvement programs, but a broad range will still be present. These sectors expect more than pure, machining skills expertise. As such technical, non-technical support and soft skills are impacted in program implementation.

Metrics – Measurements for Success

Metrics is referenced, not to be obvious, but because it is not unusual for programs to be developed and launched without consideration for metrics that will be utilized in progress evaluation. This may not be an issue at Mid-South, but as an integral component of development, it is highly suggested a comprehensive program be developed for evaluation of prospective and entering students, students' progress, dropouts' assessment, post-completion progress, industry needs, trends, etc.

Pathway Developmental Programs

Mid-South currently offers early technical college credits to juniors and seniors in high school as part of its career prep program. However, if not already underway, a more comprehensive approach is required from middle school through full career span. Exposure to advanced manufacturing and the opportunities therein is necessary beginning with the middle school years in order to develop a talent pool at the earliest stages. It is critical for Mid-South to collaborate with area high schools to intensify the awareness campaign, to integrate technical career options with Career Readiness Certificates, and if at all possible, work with industry to establish apprenticeship programs.

Presently, there appears to be only three organizations in greater Memphis to offer such. There is increasing evidence apprenticeship programs increase completion rates and enhance subsequent job performance. In anticipation of transition from high school to community college, it is critical K-12 and community colleges do evaluation testing with complimentary programs so there is a common understanding of capabilities upon completion of high school or GED and preparation for college entry.

As anticipated for this study and in the curriculum recommendations, it is essential the machining training program at the community college be divided into achievable blocks of certificates targeted to specific employment opportunities. Further, the certificates must flow or interrelate so that skills are stackable in order to enhance progressive education and employment opportunities for those that elect to advance beyond the basic skills level. It is also important to offer customized modules related to higher and changing skills to enable employees to maintain skills levels according to changing technologies. This emphasis has been considered by TPMA in development of curricula recommendations.

Recommended Machining Certificates for Mid-South Community College

This study focused on development of recommended curricula for four certificates for Mid-South's Machining program: (1) CNC Machining Operator; (2) CNC Machinist; (3) Conventional Machining/CAM/GD&T; and (4) Engineering Technician. The curriculum recommendations for these certificates are noted below. Additional recommendations, not directly related to curriculum but impacting curriculum offerings, content and execution are also provided.

The recommendations are based on the review and analysis of: 1) nationally accepted standards and credentials endorsed by the National Association of Manufacturers (NAM) and The Manufacturing Institute; 2) review of programs at representative, comparable institutions; 3) review of Mid-South's industry input, and, evaluation of industry trends; and, 4) factors that impact program development and content.

Open Enrollment versus Prerequisites / Entrance Requirements

Mid-South has an open enrollment policy and wishes to continue doing so. Presently, students are only required to have a high school diploma / GED to begin a certificate training program. Upon entry, students are evaluated and any deficiency areas are addressed through the learning lab and/or preparatory courses. However, due to the nature of machining and technical requirements, strong math skills are essential to success. In addition, many manufacturers require employment candidates complete a pre-hire assessment which typically includes basic math. As has been seen in West Memphis, and nationally, basic academic skills are generally low and students are not adequately prepared for college success.

An open policy is admirable, but as a component implementation of the Machining Certificates, especially the proposed accelerated program, Mid-South should further consider program entrance requirements, evaluation methods and the probable impact on remedial and developmental instructional programs. National best practices for basic skill development include the Integrated Basic Education and Skills Training (I-BEST) or the Scientific Management Technologies (SMT) programs.

As the proposed certificate programs will create a career pathway for students, the college must determine at what point students will be assessed for math and English skills (i.e., ACT Compass Test) and complete developmental coursework if required. Although the certificate courses noted below will include contextualized math instruction, it is recommended consideration be given to include a developmental level math course as a prerequisite or included in the Certificate of Proficiency for CNC Machining Operator.

A complete analysis of this issue was not a component of the TPMA study, but as a point of reference, Wichita Area Technical College, which has comparable, demanding, high tech occupational market as Mid-South, the minimum entry is high school diploma or GED and an

ACT Compass based entrance exam with minimum scores of 70 on reading, 45 on writing and 40 on math.

Recognizing the issues the college faces with a fairly large population of low skill individuals, and the difficulty retaining students who require extensive basic skills remediation, a basic readiness course may provide a solution. A Manufacturing Readiness course could be included in the certificate program or be scheduled prior to start of the certificate program with students placed in the course based on entrance scores. The Readiness course would emphasize (a) basic and contextualized math skills, (b) basic computer skills to increase independent learning and success utilizing computer-based training modules, and (c) study skills, time management, and "life" skills to proactively address issues that may impact successful completion of training.

As emphasized by The Workforce Investment Network's "Made in Memphis" report and as an identified national best practice, it is recommended that a readiness or preparation program integrate the ACT National Career Readiness Certificate (NCRC) and use of the WorkKeys online WIN system for self-paced remediation. It has been shown in a number of areas that such integration dramatically increases the probability of successful completion and at higher performance levels. This issue is particularly critical with the proposed accelerated program.

Certificate of Proficiency – CNC Machining Operator

The first certificate of proficiency is designed around the Right Skills Now Model and focuses on the knowledge and skills required for entry level employment as a CNC Machining Operator.

CNC Machining Operator
Certificate of Proficiency
"Right Skills Now"
Entry-level positions for CNC operation
Multiple Execution Modes: Concentrated (18 week program); High School Tech Prep (3 years);
Semester Evening (2-3 semesters); Semester Day (2-3 semesters)

Course Title	Credit Hours	Contact Hours
Measurement, Materials & Safety	3	90
Job Planning, Benchwork, & Layout	3	90
CNC Turning I	4	120
CNC Milling I	4	120
Career Preparation	1	30
Internship / Experiential Learning / Capstone	3	90
Totals:	**18**	**540**

Measurement, Materials & Safety and Job Planning, Benchwork & Layout: The first two proposed courses directly align to NIMS Level 1 credentials of the same titles. Course content (curriculum) would be developed to align to the standards provided by NIMS and as aligned to employer needs. Content areas for NIMS Measurement, Materials and Safety include: machine and tooling maintenance, hand tools, process adjustments (milling, grinding, tapping and threading, drilling), process improvements, gage blocks, surface finish, fits and allowances, measuring techniques and tools, SPC basics, inspection plan and sampling, and safety. Content areas for NIMS Job Planning, Benchwork and Layout include: Machinery Handbook applications, math applications, speeds and feeds, taper problems, tolerances/fits/allowances, reaming, measurement (precision and semi-precision), threads and tapping, layout (emphasis on semi-precision), drilling, milling, materials, sawing, filing, basic blueprint reading, and basic machining theory.

Recommended resources for content development of these two courses include: (a) NIMS Machining Level 1 Preparation Guide: Measurement, Materials & Safety and NIMS Machining Level 1 Preparation Guide: Job Planning, Benchwork & Layout, and (b) NIMS Duties and Standards for Machining Skills – Level 1. Although Mid-South is developing new curriculum/courses for these certificate programs, existing courses may provide content and resources for the development and implementation of these new courses. Current Mid-South courses with some aligned content to proposed courses include: Inspection and Testing, Shop Essentials, Intro to Metallurgy, Intro to Manual Machining, Tech Math, Statistics for Machining, Metalworking Theory, and Blueprint Reading/Engineered Drawings. It is assumed that Mid-South will be working in collaboration with Immersive (Immerse to Learn curriculum) to ensure appropriate content is included to effectively prepare students for written and performance exams to earn NIMS credentials.

CNC Turning I and CNC Milling I: The two technical courses would align to NIMS Machining Level I credentials of the same titles. In addition, NIMS offers Level I credentials for CNC Turning: Programming Set-up and Operations and CNC Milling: Programming Set-up and Operations. Due to condensed time frame for the first level certificate (CNC Machining Operator), and to meet the skill requirements of regional employers, course content may include a combination of programming/setup and operations skills. It is recommended that Mid-South prepare a task list that includes the specific performance outcomes for each of the four NIMS Level I CNC milling and turning credentials noted above.
The Mid-South Machining Advisory Committee could then review the task list and indicate which tasks/skills are essential for entry-level employment and which ones would be provided on-the-job. In general, it is recommended that content for these two technical courses align to NIMS CNC Lathe and Mill Operator outcomes which can be referenced through NIMS Credentialing Achievement Records (CARs) for each process. It is also recommended that Print Reading/Electronic Data Management and G&M Programming be integrated into the CNC Milling and Turning Courses.

Additional resources for curriculum / content development include NIMS Machining Level I Performance Guides for CNC Milling and Turning: programming and setup. Level II

performance guides are also available for CNC Turning and CNC Milling (operations) should Mid-South elect to increase content for higher level operating skills and include both Level I and some Level II curriculum/outcomes. The decision would be dependent on the results the task assessment by the Advisory Committee relative to local employment requirements. It should be noted that CNC Milling & Turning courses included in this (Right Skills Now) certificate are the only proposed CNC Operations related course. Subsequent certificates emphasize conventional machining, advanced processes, programming, and quality. Should further analysis and input from regional manufacturers indicate a need for higher skilled CNC Machinists, additional courses and/or certificates may be necessary.

Career Preparation: This course is currently offered by Mid-South and should be included in the CNC Machining Operator certificate as recommended by Advisory Committee members. This course provides information on career planning (which should emphasize the machining career pathway), job search preparation (including resume development and interviewing skills), and professionalism skills (to include basic employability issues such as attendance and effective work habits). A review of course content is recommended with subsequent modification, as needed, to include essential communication and teamwork skills. Depending on the program entrance requirements and/or readiness courses implemented by Mid-South, the career preparation course might also include basic academic skills to include testing and student achievement of the ACT National Career Readiness Certificate (NCRC).

Internship / Experiential Learning: To enhance attainment of workplace skills and employment success, an internship/experiential learning opportunity is recommended. Mid-South's current internship course can be used and would provide students with a minimum of 60-90 hours of practical work experience. As Mid-South is in the early stages of employer engagement and has limited commitment for hosting interns at the present time, an internship alternative should be considered. For example, a structured capstone course may be utilized to include hands-on activities in Mid-South's machining lab.

Similar versions of this certificate program have been directly implemented at Dunwoody Community College and a number of other institutions have used the program as a guide, but have added various courses to address soft or related skills. Two notable customized programs are Lehigh Career and Technical College and Central Carolina Community College. Other programs that offer insights for Mid-South include Wichita, Cape Fear and Rock Valley. These programs are summarized in Appendix 5.

With regard to comparable programs, it is important to note the differences in credit hour/contact hour conversions and the impact on program development. The table provided above (Certificate of Proficiency course list) includes proposed credit hours and minimum contact hours needed to effectively provide students with the knowledge and skills required by employers. For the proposed Mid-South program, it is estimated 540 contact hours are needed which translates to 30 contact hours per credit hour. If Mid-South were to apply its standard credit/clock hour conversion ratio, the proposed 18 credit hour program

would only be 345-375 contact hours, which would insufficient to meet program goals. For comparison purposes, the Right Skills Now program at Dunwoody College is 13 credit hours and 558 contact hours and South Central College's program is 20 credit hours and 544 contact hours.

To better serve the needs of students and employers, and accelerate completion, it is highly recommended that Mid-South's program be implemented in a block schedule. The proposed certificate program can be completed in 18 weeks with students attending class 6 hours per day, five days a week. In addition to the described accelerated, block schedule program, self-paced or staggered start/completions are recommended depending on the market assessment with regard to forecasted hire rates in order to balance completion and absorption rates.

As this accelerated program will be limited to individuals who are unemployed or are otherwise able to attend a full time program, it is also suggested that Mid-South consider optional schedules, such as part-time evening courses completed over 2-3 semesters, to accommodate additional populations such as working adults who are seeking a career change. For example, students could attend class 3 hours per night, 4 nights per week and complete the program in one year (Career in a Year).

As previously discussed, this certificate program will be aligned to NIMS Standards and Credentials. These standards can be used as a content guide only or the college can fully integrate and offer written/performance exams to allow students to attain relevant credentials. It is strongly recommended that applicable NIMS credentials be included in the certificate program(s) to provide reinforcement and validation of a student's capabilities.

In addition, credential attainment levels could be monitored and data used to modify curriculum as appropriate to improve credential attainment and workplace success. It is presumed the course content for the two foundation skills (Measurement, Materials & Safety and Job Planning, Benchwork & Layout) would be fully integrated and credential testing would be facilitated.

For CNC technical credentials, NIMS has four credentials with application to the proposed Right Skills Now program. This includes separate credentials for programming setup and full operations, respectively, for turning and milling. A final recommendation for these technical credentials is pending final analysis by Mid-South and the Machining Advisory Committee.

Selection of appropriate credentials will be dependent on CNC Turning and Milling course content, priority tasks/skills, and available lab time. Assuming emphasis will be placed on "Operator" skills, the NIMS CNC Turning and CNC Milling credentials would be appropriate and recommended. However, it is also expected that an operator would be required to complete basic setup and programming so the curriculum will likely include a combination

of setup and operation skills, and may not adequately prepare students for all four NIMS level 1 technical credentials.

With further review, Mid-South may be able to develop a means by which all six CNC credentials could be available or it may be decided that two (or more) technical credentials would be included in subsequent certificate of proficiency programs, especially with potential addendum for CNC-Machinist. The primary concern for content versus timing is that the emphasis on broader support skills versus deeper technical skills for the top two certificates of proficiency, students may not be adequately prepared to successfully achieve the NIMS Level 1 credentials for CNC milling and turning (programming/setup and/or operations) without progressing through the CNC Machinist certificate.

Students that complete the Operator certificate would have three pathway choices: 1) elect to enter the job market as an operator; 2) proceed to Machinist certificate for more advanced machining skills; or, 3) proceed to the programming oriented certificate for Conventional Machining /CAM/GD&T. From alternatives two and three, one could then enter the job market or continue to a higher skilled certificate or associate degree.

Certificate of Proficiency – CNC Machinist

This certificate of proficiency focuses on the knowledge and skills required for entry and intermediate employment as a CNC Machinist. It is targeted to those that complete the CNC Operator certificate or have sufficient base machine operator experience to qualify for entry. Qualifying entrance criteria should be defined by Mid-South and its advisory committee, but would approximate CNC Operator certificate completion or minimum of six months experience as a CNC operator.

CNC Machinist
Certificate of Proficiency
Entry and intermediate positions for CNC machining
Multiple Execution Modes: Concentrated [8 week program); possibly High School Tech Prep (1 year);
Semester Evening (2 semesters); possibly Semester Day (2 semesters)

Course Title	Credit Hours	Contact Hours
CNC Milling II	4	90
CNC Turning II	4	90
EDM Wire	4	90
Manual Turning and Milling	4	90
Internship / Experiential Learning / Capstone	3	90
Totals:	**15**	**450**

Technical Courses (CNC Turning II, CNC Milling II, EDM Wire and Manual Turning/Milling): These technical courses would align to NIMS Machining Level II credentials of the same titles. As with the CNC Operator certificate, the condensed time frame and local skill requirements may require adjustment from the standard NIMS content. Therefore, it is again recommended that Mid-South prepare a task list that includes the specific performance outcomes for each of the four NIMS Level II credentials noted.

The Mid-South Machining Advisory Committee could then review the task list and indicate which tasks/skills are essential for entry-level employment and which ones would be provided on-the-job. Also, as with the CNC Operator certificate, it is recommended that content for these technical courses be aligned to NIMS outcomes which can be referenced through NIMS Credentialing Achievement Records (CARs) for each process. Additional resources for curriculum/content development include NIMS Machining Level II Performance Guides.

For the NIMS skills, to provide additional credibility, upon completion of the Certificate of Proficiency from Mid-South, the instructor should encourage students to pursue applicable NIMS certificate(s). In this process, the student would execute skills task lists (Credentialing Achievement Records (CAR) under the oversight of the instructor. For those successfully completed, the instructor would submit Affidavits of Completion to NIMS, at which time the student could take the applicable NIMS exams for receipt of NIMS skills certificates. Thus, the students would have the college academic certification, as well as, respective industry certifications to reflect strengths in particular skills. This would also provide the college greater flexibility in execution of its program in reflecting a range of skills accomplishment.

Internship/Experiential Learning: To enhance attainment of workplace skills and employment success, an internship/experiential learning opportunity is recommended. As noted above, Mid-South's current internship course can be used and would provide students with a minimum of 60-90 hours of practical work experience. As Mid-South is in the early stages of employer engagement and has limited commitment for hosting interns at the present time, an internship alternative should be considered. For example, a structured capstone course may be utilized to include hands-on activities in Mid-South's machining lab.

Certificate of Proficiency – Conventional Machining /CAM/GD&T

This certificate of proficiency was customized and based on industry input, market assessment, and requested areas of emphasis from Mid-South. This certificate will enable operators (and graduates of the Right Skills Now certificate and/or machinist certificate) to develop product development and programming skills through instruction in materials and conventional processes, and advancing knowledge and skill in support and non-technical skills.

The certificate is targeted to positions that have recently developed with the advancement of CNC technologies in which the technician serves a much broader role. Conceivably, one receives and interprets computer models of components and develops machine setups, jigs/fixtures, etc. and inputs the critical variables for machine processing and CNC Operators. If required, as may be the case with smaller shops, interaction with customer engineers may be quite common with the CAM Tech providing input and expertise on optimal processing that may be integrated to the component design.

It is necessary to integrate expertise in conventional operations and metallurgy to enable a deeper understanding of how different materials react in machining. The SolidWorks software directly relates to model manipulation. Inclusion of instruction related to quality, life cycle, and shop communications directly relate to integrated support functions.

Conventional Machining/CAM/GD&T
Certificate of Proficiency
Entry and Advanced level for design and process related positions
18 Credit Hours

Proposed Course(s)	Credit Hours	Tentative Content / Credential Alignment
Manual and CNC Machining Setup	4	NIMS Programming and Set up for both manual and CNC machining. GD&T, Jigs & Fixtures, processes.
Material Science	3	Metallurgy, properties of materials, heat treatment and related processes.
Conventional Machining Operations	4	Manual machining: Lathe, Mill, and Grinding
Introduction to MasterCAM	3	Basics of engineered drawing, emphasis on computer aided manufacturing (CAM) and electronic prints.
Introduction to Quality & Product Life Cycle Processes	3	Building on the quality/inspection content from the measurement, materials & safety course.
Shop Communications & Organization	1	Interpersonal communication skills, teamwork, lean organizations, and related support skills
Total:	**18**	

The approach to the next level certificates is based on the observation that the Mid-South area industry reflects a need for broader support skills and not necessarily deeper technical skills (as discussed previously). The custom approach is similar to that being executed by

Baltimore, Saint Paul, Gateway, Lorain and Rock Valley. These colleges also offer good insights on content relative to Mid-South's proposed third certificate. Mid-South's proposed second certificate is rather unique with the conventional machining and CAM emphasis. However, it is recommended that industry requirements be monitored and, if there is demand for greater depth in technical skills, then training courses and perhaps a certificate of proficiency be established for NIMS Level I and/or II skills in CNC and Conventional Machining.

In addition to the aforementioned NIMS credentials, the Certificate of Proficiency - Conventional Machining/CAM/GD&T should also consider integration and/or preparation for students to earn additional industry recognized credentials. For example, MasterCAM certification would be strongly encouraged. In addition, the American Society for Quality (ASQ), Certified Quality Process Analyst (CQPA) or Certified Quality Improvement Associate (CQIA) provide detailed Bodies of Knowledge (BOKs) for integration of content/outcomes into proposed courses. Inclusion of Technical Math and/or Statistics should also be considered.

Certificate of Proficiency – Engineering Technician

Based on industry input and market assessment, this certificate is targeted to high skilled modeling, machine programming and product and process quality validation, as well as, an introduction to Additive manufacturing. Certificate holders would be fully versed in shop flow processes and integration of design/fabrication interfaces, optimal metals and processes, required tooling and follow-on quality validation. To ensure that students entering the program have the requisite skills for successful program completion, it is expected they would have completed a machinist certificate, either Operator or Machinist (or possibly both), and the certificate for Conventional Machining/CAM/GD&T; or have sufficient industry experience as defined by Mid-South and the Machining Advisory Committee.

Engineering Technician
Certificate of Proficiency
Advance placement positions for programming, quality and process optimization
18 Credit Hours

Proposed Course(s)	Credit Hours	Content to be determined (TBD)
Product Life Cycle, Quality and Continuous Improvement	3	TBD
Parametric Modeling, Assemblies & Drawing	3	TBD
CMM Programming	3	TBD
SolidWorks for MasterCAM	3	TBD

Introduction to Additive Manufacturing and related advanced technologies	3	TBD
TBA - Depending on content from prior certificates and skill levels of students, instruction in engineered drawings, computer applications, and/or CNC operations may be included.	3	TBD
Total:	**18**	

Curriculum Content Development

To guide the critical process of developing course content/curriculum, it is recommended that national, professional industry standards be utilized and integrated. For credentials delineated by the professional associations noted previously, there is extensive content material and resources available on their websites and/or directly from the associations, and are modularized according to specific credentials.

Many of these resources, particularly related to NIMS credentials, were previously referenced. The U.S. Department of Labor's Advanced Manufacturing Competency Model (See Appendix 4) also provides an excellent reference for creating career pathway programs. Manufacturers expect students to possess (1) personal effectiveness competencies, (2) basic academic competencies, (3) general workplace competencies, (4) industry-wide technical competencies, and (5) occupation-specific competencies. All of these must be considered in the development of a career pathway training program. In addition, the NAM-endorsed Skills Certification System provides standards and credentials that align to each level of competencies.

In development of an accelerated program for the CNC Operator and CNC Machinist Certificates, online, self-paced coursework will be essential, especially if the recommendations are accepted for block scheduling and staggered start/completion. The integration of online with traditional classes and shop enables considerably more flexibility than is otherwise possible.

Mid-South personnel have indicated they are working with Immerse2Learn for contracted assistance in development of a customized and modular program that utilizes NIMS credentialing standards as a guideline. Immerse2Learn has an excellent reputation and credibility and should meet Mid-South's needs in this regard.

For the certificates for Conventional Machining/CAM/GD&T and Engineering Technician, course content should align to the tasks/skills rankings as provided by the Machining Advisory Committee. Perhaps most important, Mid-South should work closely with the Machining Advisory Committee and other regional employers/partners to further refine industry needs. This would include confirming minimum hiring requirements, pre-hire

assessment processes, and creating detailed task lists and gathering information on more specific skills required for employment (for example, utilizing NIMS standards to clarify the depth and breadth of CNC programming skills).

Throughout the curriculum and certificate development process, Mid-South must reference and consider how each certificate will articulate to the next level (See Appendix 4 – Machining Career Pathway Model) to ensure students are able to "stack" credentials, return to Mid-South to continue their education and advance their careers, and do so with little or no duplication of coursework.

Also, early assessment of student's interests and capabilities will be critical with regard to selection of an appropriate career path and possible pursuit of higher level programs. It should also be noted that if a student started with the Operator certificate and then progressed through the other three machining related certificates, they would have earned over 60 credit hours, or equivalent to an associate degree, but not have the math and liberal arts courses needed to earn the AS degree.

Although it is most likely that students will exit after completion or possibly several of the certificates, college personnel should monitor student objectives and direct them early towards the AS curriculum as appropriate. The curricula of the technical certificates and the AS degree should also be reviewed for optimal articulation and transfer credit to optimize progressive pathways.

Recommendations for Mid-South Machining Program

The following is a summary of the recommendations for the Mid-South Machining Program.

1. Certificates of Proficiency – Establish four (4) new Certificates of Proficiency for Machining

CNC Operator

- Targeted to entry level CNC operator training with a focus on CNC Operations
- Comprised of two NIMS foundation skills credentials and two NIMS technical skills credentials
- Include a Career Preparation course, with potential inclusion of basic skills remediation and ACT NCRC testing / credential
- Integrate contextualized math, print/electronic data transfer and G&M programming
- Integrate Internship or experiential learning according to industry participation
- Establish multiple schedules for program to accommodate diverse populations:
- Accelerated 18 week program on block basis (540 contact hours based on 6 hour days and 5 day weeks)

- High school Tech Prep program over three years (two within high school and one post high school)
- One year program, more traditional schedule (3 hours day, 4 days a week) with day and evening options

CNC Machinist

- Targeted to entry and level 2 CNC machinist training
- Comprised of four NIMS technical skills credentials
- Integrate Internship or experiential learning according to industry participation
- Establish multiple schedules for program to accommodate diverse populations:
- Accelerated [8] week program on block basis (330 contact hours based on 6 hour days and 5 day weeks)
- Two semester program, more traditional schedule (i.e. 3 hours day, 4 days a week) with day and evening options
- Provide for in high school tech prep program for exceptional students that complete the Operator certificate and are qualified to enter Machinist program.

Conventional Machining/CAM/GD&T

- Targeted to entry and advanced level programming, but could also be entry level conventional machining
- Includes two NIMS-based courses for technical skills credentials, as well as MasterCAM certification
- Accelerated/block schedule, one year program, or conventional semester basis; 18 credit hours

Engineering Technician

- Targeted to advance placement programming, quality and process optimization positions
- Content to include product life cycle, quality and continuous improvement, modeling, CMM programming, SolidWorks, and an Introduction to Additive Manufacturing
- Accelerated / block schedule, one year program, or conventional semester basis; 18 credit hours

2. Curriculum – Curriculum for all certificates should be based upon or integrate:

- NAM-Endorsed credentials with primary sources being NIMS, ACT/NCRC, MSSC, ASQ and SME
- Stackable – courses should be established to enable career pathway progression through certificates
- Multiple entry populations – Anticipate diverse audiences (high school graduates, veterans, adult re-skilling, dislocated workers, low skilled)
- Minimum entry requirements for math and English based upon ACT Compass and/or NRCR testing, but with provision for targeted remedial courses that integrate contextualized occupational topics to enable early exposure to occupational issues

- As curricula are finalized, review the higher certificates for possible transition to an associate degree in order to optimize student's time and investment.

3. Market and Industry Analysis – Mid-South and its industry partners should conduct a methodical and comprehensive assessment of its regional environment and how its proposed program is impacted in order to optimize program development and implementation. Although all factors noted in section 4 herein should be reviewed, as well as, industry input on others, minimum factors that should be considered are:

- Manufacturing forecast – what are the growth projections and skill requirements over the next decade and what is the projected timing in the short term for hiring by quantity and skills
- Student Applicant Pool Capabilities – what potential student population segments are represented; what are their capabilities; what preparation and support services might be required; and how might program content and mode of delivery need to be adjusted
- Technology and Materials shifts – what shifts does industry anticipate in technologies that may impact program content, equipment and facilities
- Skills– Technical and Non-Technical – which skills and performance levels are (and will be) required for hiring and employment success and adjust curriculum content accordingly. A task list that includes specific performance outcomes and timing for each of the proposed courses should be prepared for review by the Machining Advisory Committee
- Equipment – survey industry on the equipment on which graduates will work and integrate comparable equipment to the Mid-South shop at the earliest possible time. In the interim, if different from current capability (i.e. 5-axis and/or additive), work towards agreements with industry to expose students to equipment as an integral part of curriculum.

4. Awareness and Recruitment Programs – To optimize industry acceptance and student enrollment:

- Design and launch a targeted, multi-pronged initiative to enhance public awareness of the "new manufacturing environment", employment opportunities and potential earnings
- Execute in collaboration with regional business and education groups. This concept is supported by the Workforce Investment Network in the "Made in Memphis" report executed in 2013.

5. Advisory Committee Planning – Future agenda/discussion items should include job descriptions/assigned tasks, minimum hiring requirements, how many employers pre-test prior to employment and what skills are assessed, wage differentials based on training/skill, coordinating/hosting interns, creating apprenticeship programs with local employers, etc.

6. Regional Survey of Manufacturers – Survey/engage a broader audience of manufacturers (beyond advisory committee) to obtain more robust data on regional needs.

7. Manufacturing Readiness Program or Preparation Program – Estimated 2 weeks in length, completed PRIOR to the start of the machining Right Skills Now program, may be necessary for low skill individuals who may need remediation and/or more intense support services to ensure their successful completion in the program.

8. Monitor industry requirements with Respect to Possible Demand for Greater Depth in Technical Skills – If demand increases training courses and perhaps a certificate may be needed for NIMS Level II skills in CNC and Conventional Machining.

9. Apprenticeships – Study the establishment of an apprenticeship program that would be concurrent with the academic program in which the college and employers would develop an agreement for the employer to contract hire, on provisional basis, pre-screened students that met minimum requirements. The student would divide time between class/lab and the workplace to obtain on-the-job and related training to gain and enhance skills. Upon completion of the academic program the employee would transition to full time employment.

10. Evaluate program effectiveness – Create an evaluation plan, in collaboration with advisory committee/employers, to determine success of program. Outcomes may include: number of enrollees, number of graduates, number of NIMS credentials attained and/or pass rate (this will be important to determine weaknesses in the curriculum – which areas of the test(s) are students failing), and employer satisfaction with interns/hired graduates (i.e. What skills do they see are missing?)

Appendices

1. Current Mid-South Certificates of Proficiency
2. Manufacturing Competency Model – U.S. Department of Labor
3. Career Pathway Program Design Flow Chart
4. Mid-South Manufacturing Career Pathway Model
5. Comparative Institution Programs and Curriculum
6. Analysis of Advisory Committee Skills Requirements Survey

Appendix 1:
Current Mid-South Certificates of Proficiency

The following reflects the course content of Mid-South's three certificates of proficiency.

Machine Technology
Machine Attendant
Certificate of Proficiency
18 Credit Hours

Introduction to Metallurgy	3
Inspection & Testing	3
Introduction to Manual Machining	3
Introduction to CNC Machines	3
Introduction to Blueprint Reading	3
Shop Essentials	3

Machine Technology
Machinist I
Certificate of Proficiency
18 Credit Hours

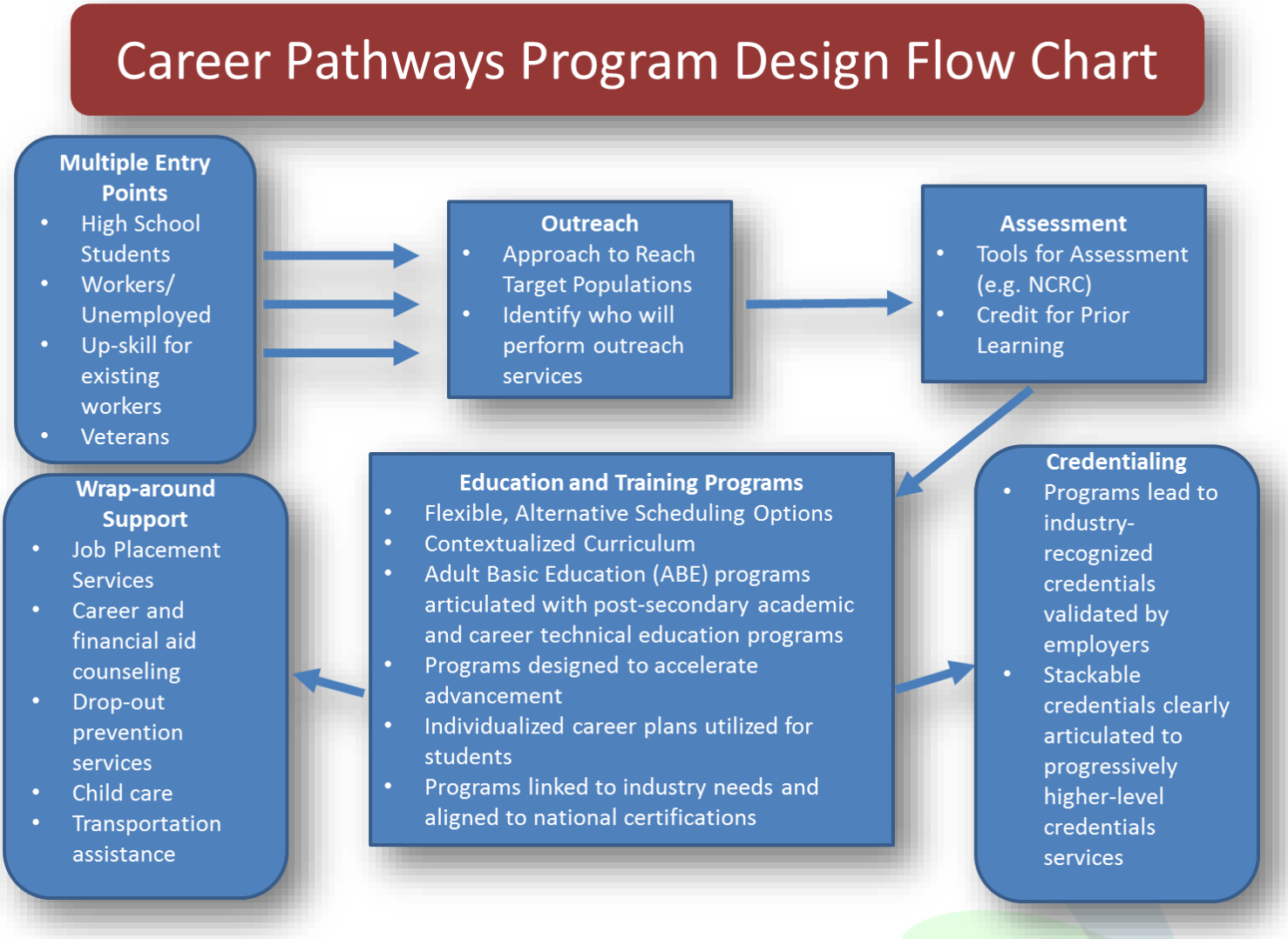
Statistics for Machining I	3
Intermediate Blueprint Reading	3
CNC Safety & Proper Function	3
Metalworking Theory I	3
Basic Manual Machine Setup & Operation	3
Basic CNC Machine Setup & Operation	3

Machine Technology
Machinist II
Certificate of Proficiency
18 Credit Hours

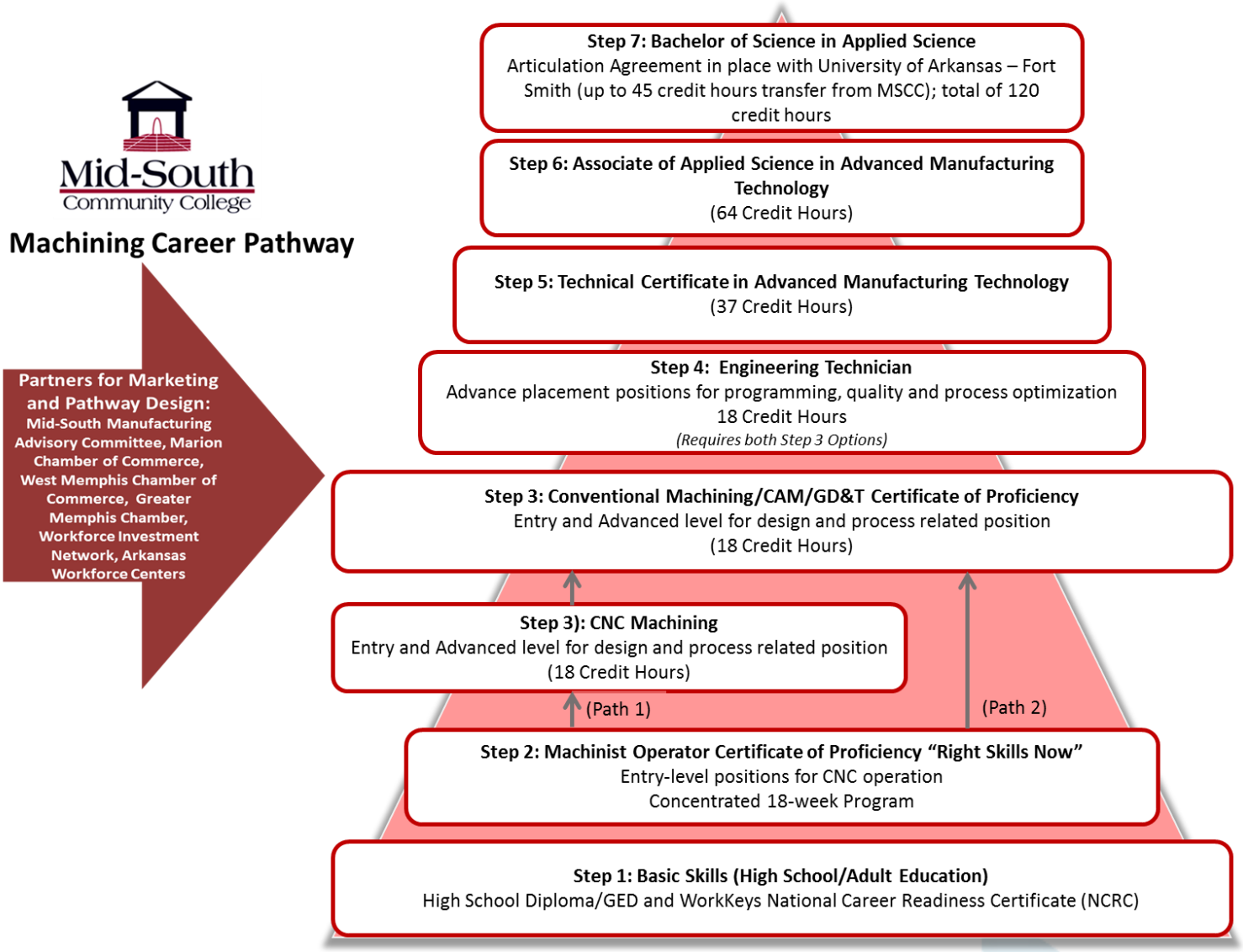
Statistics for Machining II	3
Engineering Drawing & GD&T	3
Metalworking Theory II	3
Computer Aided Manufacturing Basic Programming	3
Advanced CNC Machine Setup & Operation	3
Specialty Equipment: EDM & Swiss-Style Setup & Operation	3

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

Appendix 3:
Career Pathway Program Design Flow Chart



Appendix 4:
Mid-South Manufacturing Career Pathway Model



Appendix 5:
Comparative Institution Programs and Curricula

Selected from The Manufacturing Institute's M-List

Source: http://www.themanufacturinginstitute.org/Skills-Certification/M-List/M-List.aspx

The Manufacturing Institute's "M-List" recognizes high schools, community colleges, technical schools, and universities that are teaching manufacturing students to industry standards. Specifically, these schools offer students the opportunity to earn NAM-Endorsed Manufacturing Skills Certifications as a standard part of their manufacturing education programs. Although there are seventy-three institutions on the M-List for one program or another, only thirty-seven have programs or courses in Machining.

TPMA scanned the thirty-seven and selected seventeen to be of significant interest in consideration of program recommendations for Mid-South. This is not to say the remaining twenty programs might not have valid points for Mid-South.

There are institutions that have Machining programs that may be quite good, but for whatever reason have not applied for M-List status and were reviewed relative to Mid-South.

The following are summations of the eleven NIMS-based machining programs selected by TPMA for review relative to Mid-South. These should not be viewed as "THE List", or necessarily even as "models", but should be viewed as representative of recognized programs at industry standards from which one can learn and draw in the development of their own, targeted program. Points are noted, but each reviewer of the programs might well pick up on different highlights they deem applicable or not, for Mid-South.

Dunwoody College of Technology
Minneapolis, Minnesota
http://www.dunwoody.edu/manufacturing/right-skills-now-cnc

- First Right Skills Now (actually test model) established in the machining area
- Focused on four NIMS credentials: two general support and two CNC technical
- Added three courses in Manufacturing Careers Investigation, Algebra/Trigonometry/Geometry and Machine Math
- Added a required internship
- Recommended by Mid-South staff for Machinist Operator Certificate and approved by advisory committee
- TPMA concurs and highly recommends the math and the internship, or preferably, apprenticeship
- TPMA also recommends other soft skills

Dunwoody College of Technology
Certificate of Proficiency
CNC Operator
(Right Skills Now)
Fast-track, high-skill for entry-level Conventional and CNC operators
Concentrated 24 weeks (18 weeks classes; 6 weeks internship)

Course	Hrs: Credit/Class	Hrs: Credit/Lab	Total Hrs: Credit/Time
Measurement, Materials & Safety	1/18	1/54	2/72
Job Planning, Benchwork & Layout	1/18	1/54	2/72
CNC Milling I	1/18	2/108	3/126
CNC Turning I	1/18	2/108	3/126
Internship	1/18	3/162	3/162
Total	**5/90**	**9/486**	**13/558**
Manufacturing Careers Investigation			
Algebra, Trigonometry & Geometry			
Machine Math			

Beyond the entry position, Dunwoody goes straight to a two-year degree, which apparently works in the Minneapolis market. For Mid-South, staff and TPMA recommend interim, higher level technical certificates as part of the career pathways focus.

Wichita Area Technical College
Wichita, Kansas
http://www.watc.edu/machining-technology

- Wichita has the most comprehensive program, which is driven by aviation dominated market with all major aviation manufacturers and hundreds of supporting machine shops. Highest of skill demands and, appropriately, highly focused.
- Possibly only program with separate, highly focused entry certificates in CNC Milling and Turning, BUT also a combined CNC Operator certificate.
- All three entry programs include soft "professional standards" and non-technical blueprints, safety/OSHA and math.
- Combined program integrates Quality and Metallurgy
- Advanced technical certificate that encompasses full range of processes and major components of design
- Highest level with two-year associate degree

- Mid-South could study the combined Operator and the Advanced Technical for its higher level certificates

Wichita Area Technical College
Wichita, Kansas
CNC Mill Machining
Certificate of Completion
Entry level CNC Mill operator
16 Credit Hours

Global Professional Standards	2	
Blueprint Reading	2	
CNC Mills	6	
Principles of Machining I	2	
Safety/OSHA	1	
Math Fundamentals	3	

Wichita Area Technical College
Wichita, Kansas
CNC Lathe Machining
Certificate of Completion
Entry level CNC Lathe operator
16 Credit Hours

Global Professional Standards	2
Blueprint Reading	2
CNC Lathes	3
Principles of Machining I	2
Safety/OSHA	1
Math Fundamentals	3
CNC Operations	3

Wichita Area Technical College
CNC Operator
Technical Certificate
Entry and Advanced CNC Operator
20 Credit Hours

Global Professional Standards	2
Blueprint Reading	2
CNC Mills	3
CNC Lathes	*3*
Machining Blueprint	*1*
Quality Control & Inspection	*1*
Metallurgy	*1*
CNC Operations	*3*
Safety/OSHA	1
Math Fundamentals	3

Wichita Area Technical College
Machining Technology
Technical Certificate
Advanced Machine and Shop Technology
46 Credit Hours

Global Professional Standards	2
Blueprint Reading	2

Machining Blueprint	1
Machining I	*3*
Machining II	*3*
CNC Mills	6
CNC Lathes	3
CNC Operations	3
Safety/OSHA	1
Quality Control & Inspection	1
Bench Work	1
Metallurgy	1
Machine Tool Processes	1
Math Fundamentals	3
Public Speaking or Communications	*3*
CATIA Parts Designer	*4*
CATIA Assembly Design	*4*
CATIA Prismatic Machining	*4*

Community College of Baltimore
Baltimore, Maryland
https://www.ccbcmd.edu/sait/tech_studies/manufacturing.html

- Extended, intensive approach versus "quick" certificate
- Strong integration of support, soft and design skills
- Programming certificate too focused for Mid-South, but learning opportunity
- Internship
- Offers pure, Conventional Operator certificate
- For Mid-South -- strong merit in terms of offering beyond the base program; or, to be creative and offer "base certificates" with modular, "addenda" credentials; Internship

Community College of Baltimore
CNC Machinist Certificate
Entry-level in Conventional or CNC setup & operation, basic design, inspection, basic programming
35 Credit Hours

Technical Blueprints & Schematics	3
Introduction to CAD or Intermediate AutoCAD	3
Numerically Controlled Machines	3
Machine Tool Processes I	4
Machine Tool Processes II	4

Geometric Dimensioning & Tolerancing	3
CNC Programming or CNC Specialization Programming	3
Measuring & Gauging	3
CNC Milling Machine Operation	3
CNC Lathe Operation	3
Principles of Manufacturing	3

Community College of Baltimore
CNC Programming Certificate
Entry-level in basic design, inspection, basic programming
24 Credit Hours

Technical Blueprints & Schematics	3
Introduction to CAD or Intermediate AutoCAD	3
Numerically Controlled Machines	3
Geometric Dimensioning & Tolerancing	3
CNC Programming	3
Advanced CNC Programming	3
CNC Specialization Programming	3
Principles of Manufacturing	3

Community College of Baltimore
Manual Machinist Certificate
Entry-level in manual machines setup and operation
26 Credit Hours

Technical Blueprints & Schematics	3
Machine Tool Processes I	4
Machine Tool Processes II	4
Geometric Dimensioning & Tolerancing	3
Turning Technology	3
Measuring & Gauging	3
Milling Machine Operation	3
Principles of Manufacturing	3

Central Carolina Community College
Sanford, North Carolina
http://www.cccc.edu/curriculum/majors/machining

- Quick, entry certificate focused on one heavy machinery customer. Will adapt as other customers develop. Works for them.
- Integration of Metallurgy and Blue Prints
- Apprenticeship program (not noted in material)

- No intermediate program, but working with industry customer for customized, modular programs
- For Mid-South – good, entry program consideration; Apprenticeship

Central Carolina Community College
Certificate Computer-Integrated Machining
17 Credit Hours

Blueprint Reading	2
Machining Technology	6
Machining Calculations	2
Measurements, Materials & Safety	1
Physical Metallurgy	2
Blueprint Reading: Mechanical	2
CNC Milling	2

Saint Paul College
St Paul, Minnesota
http://www.saintpaul.edu/programs/transconstru/Pages/Right-Skills-Now.aspx

- Strong entry program with lots of shop time
- Integrated processes – includes Internship
- For Mid-South – shop time, possible integrated consideration, internship; also have a very good Tool Making program, should Mid-South view that as a future area

Saint Paul College
Certificate Machine Operator
(Right Skills Now for Manufacturing)
Entry-level machinist in Conventional or CNC milling or turning
20 Credit Hours

Introduction to Manufacturing Processes	4
Engineering Drawings	4
Materials Processes I	4
Materials Processes II	4
Industry Internship	4

GateWay Community College
Phoenix, Arizona
http://www.gatewaycc.edu/production-technology

- Not entry level program
- Interesting requirement for advanced entry placement and one year work experience

- Advanced, combined CNC program with integration of design
- For Mid-South – consideration for evolution of higher certificates

GateWay Community College
Certificate of Completion
CNC Production Technology
24 – 30 Credit Hours (depends on advance placement on two courses)

1 Year Manufacturing Work Experience	0
Basic Math or Higher Level or Advance Placement	0-3
Print Reading or 1 Year Experience or Advance Placement	0-3
Inspection Techniques	3
Applied Geometric Dimensioning & Tolerances	3
CNC Programming	3
CNC Mill Operations	3
CNC Lathe Operations	3
Advanced CNC Operation	3
Manufacturing Processes & Materials	3
Solid Design I Unigraphics or Solid Design I SolidWorks	3

Lorain County Community College
Elyria, Ohio
http://www.lorainccc.edu/Academic+Programs/Associates+Degree+and+Certification+Programs/met-cmp-coc.html

- Probably not entry level, but re-training
- Integration of soft skills, blueprints and higher level controls, drafting and processes
- For Mid-South, potential for re-training and/or consideration for evolution of higher certificates

Lorain County Community College
Technical Certificate
Computer-Aided Machining/Manufacturing Processes
19 Credit Hours

Introduction to Computer Numerical Control	2
College 101	1
Technical Problem Solving	3
Industrial Blueprint Reading	2
Manufacturing Processes I	3
Introduction to Computer Aided Drafting	2

Advanced CNC Milling or CNC Lathe	3
Manufacturing Processes II	3

Cape Fear Community College
Wilmington, North Carolina
http://www.cfcc.edu/engineering/mac

- Good, basic entry certificate
- Machining Technology integrates support skills
- Good example for Mid-South, with exception of lack of inclusion of soft skills
- No intermediate certificates

Cape Fear Community College
Certificate Machining Technology
18 Credit Hours

Machining Technology I	6
Introduction to CNC	2
Machining Technology II	6
CNC Milling	2
CNC Turning	2

Rock Valley College
Rockford, Illinois
http://www.rockvalleycollege.edu/Courses/Programs/MET/metcertificates.cfm

- Good, basic entry certificate
- Machining Processes integrates support skills
- For Mid-South, good example, with exception of lack of inclusion of soft skills
- Good entry certificate with process and design focus
- For Mid-South, probably not enough "process" and too much "design", but worthy of review

Rock Valley College
Certificate
Manufacturing Engineering Technology – CNC
18 Credit Hours

Manufacturing Processes I	3
CNC Machine Setup, Operations, Programming	3
Introductory CAD and Print Reading	3
Graphics/SolidWorks CAD I	3
CNC/CAM Operations I	3
CNC/CAM Operations II	3

Rock Valley College
Certificate
Manufacturing Engineering Technology – CAD
15 Credit Hours

Manufacturing Processes I	3
Introductory CAD and Print Reading	3
Computer Drafting AutoCAD	3
Graphics/SolidWorks CAD I	3
Graphics/SolidWorks CAD II or Intermediate AutoCAD Production Drafting	3

Lehigh Career and Technical Institute
Schnecksville, Pennsylvania
http://www.lcti.org/site/Default.aspx?PageID=393

- Totally "NIMS" based to the point of including in titles
- Interesting not to be credit hour based
- Strong example for entry and intermediate positions
- For Mid-South, strong technical examples, but needs soft and support skills

Lehigh Career and Technical Institute
Certificate
Precision Machining I
"Credential" and not Credit Hour based

NIMS Measurement, Materials & Safety
NIMS Job Planning, Benchwork & Layout
NIMS CNC Milling I
NIMS CNC Turning I
NIMS Drill Press Operations I

Lehigh Career and Technical Institute
Certificate
Precision Machining II
"Skills Credentials" and not Credit Hour based

NIMS Measurement, Materials & Safety
NIMS Job Planning, Benchwork & Layout
NIMS CNC Milling I
NIMS CNC Turning I
NIMS Drill Press Operations I
NIMS Manual Milling I
NIMS Turning Operations
NIMS Turning Operations: Chucking
NIMS Grinding Skills I

NIMS CNC Turning: Setup & Ops
NIMS CNC Milling: Setup & Ops
NIMS Manual Milling II
NIMS Manual Turning II
NIMS Drill Press II
NIMS Grinding II
NIMS CNC Milling II
NIMS CNC Turning II
NIMS EDM – Plunge

Forsyth Technical College
Winston-Salem, North Carolina
http://www.forsythtech.edu/catalog/1314/program/Computer-Integrated/Machining-diploma

- Advanced program with extensive integration of support skills
- Co-op work program
- For Mid-South – consideration for partial integration to higher level certificates and/or for interim between certificates and associate degree

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The following colleges are also recognized Machining Programs on the M-List, but were not reviewed by TPMA as a part of this study.

Arizona
Maricopa County Community College

California
Laney College
Reedley College

Florida
Pensacola State College

Illinois
Richard J. Daley College - City Colleges of Chicago

Indiana
Ivy Tech Community College of Indiana

Iowa
Kirkwood Community College

Minnesota
Hennepin Technical College
South Central College

Missouri
St. Louis Community College

Nevada
Truckee Meadows Community College
Western Nevada College

North Carolina
Central Piedmont Community College
Cleveland Community College
Randolph Community College

Ohio
Cuyahoga Community College

Oklahoma
Francis Tuttle Technology Center
Green Country Technology Center
Meridian Technology Center
Pioneer Technology Center
Southern Oklahoma Technology Center
Tulsa Technology Center

Pennsylvania
Central Pennsylvania Institute of Science and Technology

Texas
Houston Community College

Washington
Bellingham Technical College
Shoreline Community College

Appendix 6:
Analysis of Advisory Committee Skills Requirements Survey

The Industry Advisory Committee for Machining met in October 2013 and March 2014. At each meeting, the members of the committee were asked to rank 53 skills associated with a machining program/workplace on a scale of 1 – 10, with 10 being highest. Mid-South consolidated the responses for each survey. Copies of the committee minutes and the surveys were provided to TPMA and the table herein reflects the analysis of the consolidated surveys.

Mode of Analysis
In review of the survey data, it is noted it is "best available" with respect to industry input, but it should be interpreted broadly in considered of the informality and factors that reduce the statistical strength. These factors include: equal weighting of categories; more skills reflected for CNC than Conventional, so that ranked results could be distorted accordingly; and, shift in assessment over the five month period, but it is unknown if this was due to changed perceptions, greater analysis, higher attendance at the March meeting, different persons present or other factors.

TPMA, in working to draw reasonable observations from the survey data, attempted to balance the survey data and factor weightings, through the following methodology:

1) for each survey, multiplied the "x's" by the respective point value (if one "x" under 3, the value would be 3; if 4 x's under 6, the value would be 24);
2) added the values for each skill; and,
3) rank-ordered the 53 skills according to respective total values.
4) put each individual survey results in alpha order;
5) added the two values for each of the 53 skills to give a combined value;
6) rank-ordered the combined results according to combined point value;
7) for different perspectives, then:
    a) noted straight rank order (shows rank, but not weighted differences);
    b) to factor weighted priorities, calculated the full point range spread (84) between highest and lowest and, under separate column, noted the point spread between each (factors two points being, i.e., 2 points apart or 9 points apart); and,
    c) classed each skill according to whether "Foundational" ("F")(basic to operation setup, et al), "Support" ("S")(safety, et al), "CNC" operation ("C"), "Manual" ("M")operation, and "Quality" ("Q") (this is not to emphasize one over the other, but simply effort to make it easier to scan for CNC or Manual operations and committee concerns for Foundational skills, etc.

Observations on the data are reflected in the study body.

Legend:
Skill Types or Skill Categories:
MMS – Measurement, Materials and Safety, including Quality inspection/measurement
RS – Related or Support Skills, such as Benchwork, Layout, Print Reading, CAD/CAM, maintenance
M – Manual or Conventional Machining Operations
C – CNC Programming and Machining Operations

Mid-South Certificates
1 – CNC Machining Operator (Right Skills Now)
2 – CNC Machinist
3 – Conventional Machining/CAM/GD&T
4 – Engineering Technician

Skills	Total Points	Straight Rank (53 skills)	Skill Type	Mid-South Certificate
INTRO – Interpreting engineering drawings	106	1	RS	1
INTRO – Use of measurement tools	104	2	MMS	1
INTRO – Safety, MSDS and PPE	100	3	MMS	1
CNC -CAD/CAM programming	98	4	C	1,3
CNC - Speeds and feeds (specifically for CNC)	95	5	C	1,2,3
INSPECT – Reading calipers and micrometers	91	6	MMS	3
CNC - Vertical Mill Set up and operation	90	7	C	1,2,3
MANUAL – Vertical Mill operation	90	8	M	3
INSPECT – Reading depth and height gages	89	9	MMS	1,2,3
MANUAL – Lathe operation	89	10	M	3
CNC- Tool Offsets/Work Offsets	88	11	C	1,2,3
ENGINEERING- GD&T	88	12	RS	3
CNC – Other machine tools; EDM, Swiss turning,	87	13	C	2
CNC – Turning	85	14	C	1,2
INSPECT – Use of an optical comparator	84	15	MMS	3,4
CNC – Computer program entry (importing)	82	16	C	1,2,3
CNC – Cutter compensation and Wear offsets	82	17	C	1,2,3
INTRO – Use of shop mathematics	82	18	MMS	1,2,3,4
CNC – G and M codes	81	19	C	1,2
CNC – Manual program entry	81	20	MMS	2,3
CNC – Milling	80	21	C	1,2
INSPECT – CMM Measurements	80	22	MMS	3

MANUAL – Speeds and feeds	80	23	M	3
CNC – Tool and machine maintenance	78	24	C	1,2
CNC – Turning (live tooling)	76	25	C	1,2
CNC – Tool and Work Holding (Lathe)	75	26	C	1,2
ENGINEERING – CADD Parametric Modeling	75	27	RS	4
CNC – 4th Axis*	74	28	C	1,2
CNC – Canned Cycles	74	29	C	1,2
CNC – Horizontal Mill Set up and operations	74	30	C	1,2
MANUAL – Tool and machine maintenance	74	31	M	3
INTRO – Use of hand tools (hammers, wrenches etc.)	73	32	MMS	
ENGINEERING – CAM Programming multi axis machine tools	71	33	RS	3,4
ENGINEERING – CAM Programming 2 axis machine tools	70	34	RS	3
ENGINEERING – Component Design	70	35	RS	
MANUAL – Drilling, tapping, threading and …	70	36	M	3
INTRO – Material properties	69	37	MMS	3
ENGINEERING – Programming CMM	66	38	RS	4
INSPECT – Use of a microscope	66	39	MMS	4
MANUAL – Tool holding and work holding	65	40	M	3
ENGINEERING- Additive Manufacturing (3D Printing)	64	41	RS	4
MANUAL – Cutting fluids	64	42	M	3
MANUAL – Tapers	64	43	M	3
CNC – Horizontal Pallet Operations	63	44	C	1,2
CNC – Conversational programming	62	45	C	1,2
ENGINEERING – Creating Blueprints	62	46	MMS	4
ENGINEERING – PLM	61	47	RS	4
MANUAL – Use of a band saw	60	48	M	3
CNC – Tapers	59	49	C	1,2
MANUAL – Use of a pedestal grinder	58	50	M	3
ENGINEERING –Strength of materials Finite Element Analysis	57	51	MMS	
MANUAL – Use of a drill press	57	52	M	3
CNC – Tool and work holding (Vertical Mill)	39	53	C	1,2
MANUAL – Use of a surface grinder	24	54	M	3

The following is the survey executed by the seven attendees at the March 2014 Advisory Committee meeting. The listing was prepared and submitted by Mid-South personnel. Each member was asked to rank each skill on scale of 1-10 (10 highest) according to importance with their industry, or their knowledge of area industry.

Advisory Committee Survey March 2014
Critical Skills Assessment

	1	2	3	4	5	6	7	8	9	10
INTRO – Safety, MSDS and PPE			x					x		xxxxx
INTRO – Interpreting engineering drawings						x x	x			xxxx
INTRO – Material properties				x			x	xx		x
INTRO – Use of hand tools (hammers, wrenches etc.)			x		x x			x	x	x
INTRO – Use of measurement tools								x	x	xxxx
INTRO – Use of shop mathematics								xx		xxx
MANUAL – Tool and machine maintenance								xxx		xx
MANUAL – Cutting fluids				x	x		x x			x
MANUAL – Speeds and feeds								xx		xxx
MANUAL – Use of a band saw			x		x	x	x	x		
MANUAL – Use of a drill press					x	x	x	x		
MANUAL – Use of a pedestal grinder					x		x x	x		
MANUAL – Use of a surface grinder			x		x			xx		
MANUAL – Drilling, tapping, threading and …				x			x	x		xx
MANUAL – Tool holding and work holding							x x	x		x
MANUAL – Vertical Mill operation						x		xxx x	x x	
MANUAL – Lathe operation						x	x x	xx		xx
MANUAL – Tapers				x	x		x	x		x
INSPECT – Reading calipers and micrometers								x		xxxx
INSPECT – Reading depth and height gages								x		xxxx
INSPECT – CMM Measurements						x		x	x	xx
INSPECT – Use of a microscope	x				x	x	x			x
INSPECT – Use of an optical comparator							x			xxxx
CNC – G and M codes			x		x x			x		xxx
CNC – Milling							x x			xxx

CNC – Canned Cycles						x	x x	x		xx
CNC – Vertical Mill Set up and operation		x x				x		x		xxx
CNC – Horizontal Mill Set up and operations								x		xxx
CNC – Horizontal Pallet Operations		x					x	x		xx
CNC – 4th Axis*			x				x	x		xx
CNC – Tool Offsets/Work Offsets				x x			x	x		xxx
CNC – Speeds and feeds (specifically for CNC)								x	x	xxx
CNC –Cutter compensation and Wear offsets								x	x	xxx
CNC – Manual program entry						x	x			xxx
CNC – Computer program entry (importing)								xx	x	xx
CNC – CAD/CAM programming			x x				x	xx		xx
CNC – Conversational programming						x x		xx		x
CNC – Turning	x x		x				x x	x		xx
CNC – Tapers	x						x	x		x
CNC – Turning (live tooling)			x					xx		xx
CNC – Tool and work holding (Vertical Mill)				x			x	x		xx
CNC – Tool and Work Holding (Lathe)				x			x	x		xx
CNC – Tool and machine maintenance							x	xx		xx
CNC – Other machine tools; EDM, Swiss turning,								xxx		xx
ENGINEERING – Creating Blueprints			x			x	x x	x		
ENGINEERING – GD&T								x		xxxx
ENGINEERING – CADD Parametric Modeling						x	x x	x		x
ENGINEERING – CAM Programming 2 axis machine tools					x	x	x	xx		
ENGINEERING – CAM Programming multi axis machine tools						x x	x	xx		
ENGINEERING – PLM			x	x		x	x	x		
ENGINEERING – Component Design						x	x x	xx		
ENGINEERING – Strength of materials Finite Element Analysis	x	x				x		xx		
ENGINEERING – Programming CMM						x		xx		x
ENGINEERING – Additive Manufacturing (3D Printing)	x			x		x	x	x		