C·O·E CENTERS OF EXCELLENCE
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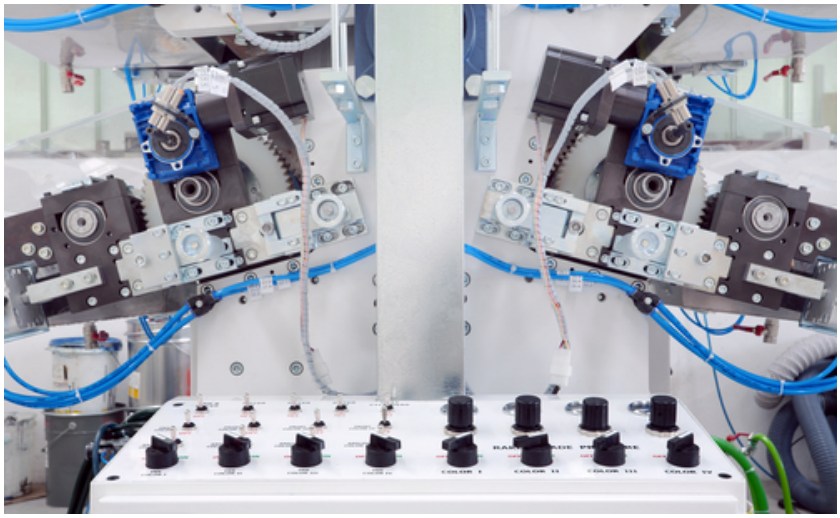
EMPLOYER SURVEY RESULTS

ADVANCED MANUFACTURING

Los Angeles County, Orange County, Central Valley

DECEMBER 2013



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C·O·E CENTERS OF EXCELLENCE

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Mission: The Centers of Excellence, in partnership with business and industry, deliver regional workforce research customized for community college decision making and resource development.

Vision: We aspire to be the premier source of regional economic and workforce information and insight for community colleges.

Centers of Excellence, Economic and Workforce Development Program

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Executive Summary

The Centers of Excellence (COE) studied the advanced manufacturing sector in Los Angeles County, Orange County, and the Central Valley to better understand the demand for skilled workers, job requirements, and skill gaps. Advanced manufacturing is an essential part of the state and regional economies and each year, billions of dollars in products are manufactured in California.

The findings of this report result from a variety of research sources and methods, including primary research from both employers and community colleges. This report focuses on the growth and job requirements of the following eight manufacturing occupations (Figure 1).

Figure 1: Advanced Manufacturing Occupations Studied

392 advanced manufacturing employers participated in the survey. In total, they reported employing 3,788 individuals in the 8 occupations studied. Employers anticipated creating nearly 1,800 new jobs over the next five years.

Research conducted for this report indicates a significant impact of the advanced manufacturing sector in the workforce and economy of the geographic areas studied. As automation and digital supply chain management become standard across manufacturing companies, advanced manufacturing will continue to evolve and become more complex. Top trends in advanced manufacturing impacting the workforce include automation, 3-D printing, and high-speed machining.

Table 1: Overall Job Growth in Advanced Manufacturing

Occupation	Current # of Employees	5-Year Job Growth	% Growth Rate
CNC Machinist Operator	1,225	653	53.3%
CAD/CAM Programmer	550	90	16.4%
Tool/Die Maker	452	149	32.9%
Quality Control Inspector/Supervisor	609	357	58.6%
CAD/CAM Engineering Technician	146	90	61.6%
CAD/CAM Designer	434	242	55.8%
CNC Programmer	319	186	58.3%
CNC Engineering Technician	53	29	54.7%
Total	**3,788**	**1,796**	**47.4%**

Introduction and Scope

According to *Time* magazine, the manufacturing sector in the United States is growing for the first time in many years[1]. *Time* reported 500,000 manufacturing jobs were created in the U.S. in the past three years, meaning for the first time in more than a decade the number of factory jobs has increased rather than decreased. According to the U.S. Bureau of Labor Statistics, 12 million Americans are directly employed in manufacturing (9% of the workforce), and the average earnings in 2011 for a U.S. manufacturing worker was $77,060 compared with $60,168 for workers in all industries[2]. One of the primary drivers of this growth in the manufacturing sector is lower energy costs. However, while the number of jobs in manufacturing is increasing, the types of jobs, education, required knowledge and skills are vastly different and evolving. Advanced manufacturing in the U.S. is largely centered on cutting-edge technologies. Occupations such as machinists are decreasing in number while positions such as software designers are increasing.

As the manufacturing sector becomes increasingly complex, colleges have the opportunity to produce a pipeline of highly skilled employees. Advanced manufacturing largely involves the use of technology to produce goods in highly-automated operations. Factories rely on more machines and fewer workers, but workers must be skilled and master the use of sophisticated machines. Many of the new occupations in advanced manufacturing require at least a two-year technical degree to compliment artisan skills such as welding and milling. Higher education institutions must prepare workers with the knowledge and skills necessary to enter or remain in advanced manufacturing.

This report is prepared by the California Community Colleges Centers of Excellence and reports survey data of 392 manufacturing companies in the following regions: Los Angeles County, Orange County, and the Central Valley. Appendix A contains information on how to use this report. The following table breaks down the number of respondents by county.

Table 2: Advanced Manufacturing Survey Participants by County

Advanced Manufacturing Facility Location by County					
COUNTY	**Total**	**% of total**	**COUNTY**	**Total**	**% of total**
Los Angeles	191	48.7%	**Tulare**	5	1.3%
Orange	126	32.1%	**Tuolumne**	4	1.0%
Fresno	19	4.8%	**Merced**	4	1.0%
Stanislaus	16	4.1%	**Calaveras**	2	0.5%
Kern	13	3.3%	**Kings**	1	0.3%
San Joaquin	11	2.8%			
Total Respondents	**392**				

Methodology

The findings of this report result from of a variety of sources and research methods, including primary research and interviews from both employers and community colleges. See Appendix B for details about the methodology used in this report.

To form an accurate understanding of advanced manufacturing and workforce needs, a literature review and executive interviews were conducted. Eleven executive interviews were conducted with industry and education representatives to develop the survey instrument. The COE then surveyed advanced manufacturing firms

[1] Foroohar, Rana. Made in the U.S.A., *Time*, April 22, 2013
[2] http://www.bls.gov/ooh/

between June and August 2013. A total of 23,274 employers who were thought to use advanced manufacturing were identified in Los Angeles County, Orange County, and the Central Valley. Several thousand companies participated in screening interviews to identify advanced manufacturing companies. During the initial screening, 1,216 advanced manufacturing companies were identified and 1,184 agreed to participate in the full survey. The survey focused on a set of 8 occupations identified as important for the industry and relevant for community colleges. The survey included questions pertaining to current employment, 5-year occupational growth, and hiring difficulties. Respondents were also asked about current training offered to employees, as well as interest in training/education programs. Of the 1,184 firms that agreed to participate in the full survey, 392 firms (33%) responded to the survey.

Defining Advanced Manufacturing

Traditional manufacturing is defined as the planning, managing and processing of materials into intermediate or final products, and related professional and technical support activities such as production planning and control, maintenance and manufacturing/process engineering. The term 'advanced manufacturing' has become widely recognized as the evolution of high-technology progresses into the manufacturing processes, however there are a variety of definitions and criteria used to describe this sector. Some definitions focus on the technology used in the manufacturing process, while other definitions focus on the product output. There are also some definitions of manufacturing that focus on the level of research and development conducted at the facilities[3]. For the purpose of this report, advanced manufacturing is defined as *the extensive use of computer, high precision, and information technologies integrated with a high performance workforce in a production system capable of furnishing products in small or large volumes with both the efficiency of mass production and the flexibility of custom manufacturing in order to respond rapidly to customer demands*[4].

Advanced manufacturing involves the use of specific technology to improve products and/or processes, with the technology described as 'advanced', or 'innovative.'[5] The table below highlights some advanced manufacturing technologies and processes.

Table 3: Sample Advanced Manufacturing Technologies and Processes

Advanced Manufacturing Technologies	Computer Technology (CAD, CAE, CAM)
	High Performance Computing (HPC) for modeling, simulation, or analysis
	Advanced Robotics (or other intelligent product systems)
	Automation
	Contol Systems (for process monitoring)
	Industrial Platform Technoloties
	3-D Modeling and Printing
Advanced Manufacturing Processes	Quality Control
	Supply Chain Integration
	Lean Production Technologies
	Sustainable Manufacturing
	"Smart" Manufacturing

[3] "Productivity growth in high-tech manufacturing industries," Bureau of Labor Statistics
[4] National Council for Advanced Manufacturing, www.ncfam.org
[5] National Defense University, 2002

Manufacturing Overview

Advanced manufacturing plays an important role in California's current and future economic growth. Recently, California Governor Jerry Brown signed legislation that is "designed to spur economic development in the state, particularly in the manufacturing sector[6]." In fact, regional meetings held by stakeholders in advance of this year's California Economic Summit identified manufacturing as one the key sectors identified for focus by the Summit.[7] Support for manufacturing is also coming from the federal level. The Obama administration has a program called "Investing in Manufacturing Communities Partnership," a part of a national manufacturing strategy. According to Joel Kotkin, a contributor to *Forbes* magazine, "Conventional wisdom for a generation has been that manufacturing in America is dying. Yet over the past five years, the country has experienced something of an industrial renaissance. We may be far from replacing the 3 million industrial jobs lost in the recession, but the economy has added over 330,000 industrial jobs since 2010, with output growing at the fastest pace since the 1990s."[8]

Manufacturing in Los Angeles County, Orange County, and the Central Valley is projected to experience growth in the next five years. This study focuses on the growth of the following eight advanced manufacturing positions: CAD/CAM Designer, CAD/CAM Programmer, CAD/CAM Engineering Technician, CNC Machinist/Operator, CNC Programmer, CNC Engineering Technician, Quality Control Inspector/Supervisor and Tool/Die Maker. Appendix C contains detailed profiles for each of the occupations studied.

As technology and processes have evolved, the role of manufacturing has drastically changed from a 'traditional', labor-reliant sector to an 'advanced', automation-reliant sector. These changes have shifted the role of the workforce and created a need for advanced manufacturing training. Table 4 highlights some of the significant changes in manufacturing over the past decades.

Table 4: 'Traditional' vs. 'Advanced' Manufacturing

Traditional Manufacturing	Advanced Manufacturing
• Products built manually on an assembly line	• Product built by automated machine
• Low average hourly wage	• Average hourly wage: $24.11
• Education not required/demanded by employer	• 53% of workers have some college education; 10% have a graduate or professional degree
• Top industries: cars, appliances, and textiles	• Top industries: food, chemicals, and complex machinery

Advanced Manufacturing Trends

Manufacturing has evolved from a highly labor-intensive set of mechanical processes to an increasingly sophisticated set of technological processes. This trend will continue as manufacturing technology keeps advancing. Some of the current trends influencing advanced manufacturing include:[9]

- Widespread role of information technology
- Use of modeling and simulation
- Accelerated innovation in supply chain management
- Rapid adaptability of manufacturing to respond to customer needs and external impediments

While advanced manufacturing can focus on specialized metals, robotics, and bio-manufacturing, one rapidly evolving technology being developed may "foster a new wave of manufacturing outfits that will have as much

[6] Coghlan, Ed. *Keep an Eye on California Manufacturing*, July 2013
http://www.caeconomy.org/reporting/entry/keep-an-eye-on-california-manufacturing
[7] California Economic Summit, November 8, 2013
[8] http://www.forbes.com/sites/joelkotkin/2013/05/15/americas-manufacturing-boomtowns/
[9] *Emerging Trends in Advanced Manufacturing,* Institute for Defense Analyses, March 2012

in common with Silicon Valley start-ups as with the classic image of a factory[10]." This technology is called additive manufacturing, or as it is more commonly known, 3-D printing. Additive manufacturing was developed by the Massachusetts Institute of Technology and supported by grants from the Office of Naval Research and the National Science Foundation before being adopted by private industry. Additive manufacturing involves what looks like spray-painting a metal object into existence. These 3-D printers lay down very thin layers of stainless-steel powder and fuse them with a liquid binder until a part–like a torque converter, heat exchanger, or propeller blade– is built layer by layer. This process is appealing because it produces parts in shapes that would be impossible or overly expensive through traditional manufacturing processes. Additive manufacturing is expected to displace some jobs. For example, a foundry no longer needs workers carting patterns around a warehouse because patterns are no longer needed. Molds can be printed and cores stored on a thumb drive. Additive manufacturing will create a set of higher-skilled positions needed to work with the new technology.

Several states are creating industrial policy to support advanced manufacturing and some are involving community colleges. In North Carolina, community colleges are linked with specific companies like Siemens. As a preliminary effort to promote linking of government, academia, and industry, President Obama has called for such efforts to spread nationally. He has proposed new manufacturing tax breaks, more robust research and development spending and vocational training for workers.

Source: www.3DInnovations.com

[10] Foroohar, Rana. Made in the U.S.A., *Time*, April 22, 2013

Executive Interview Findings

In April 2013, executive interviews were conducted with industry and education representatives to gain perspective about the impact of advanced manufacturing. According to respondents, ***automotive***, ***aerospace***, ***defense***, ***medical devices***, and ***green technology*** are the primary industries within the advanced manufacturing sector. Employers indicated the top three trends in advanced manufacturing are: (1) the move towards 'lights out production' (fully automated facilities with non-manned machines and few personnel in the buildings); (2) the adoption of 'additive manufacturing' (3-D printing to provide same-day conceptualization to development); and (3) the use of 'higher speed machining' (faster-paced, cost-effective, precision machinery). Employers also indicated the most critical component of education for community colleges to address is the use of machinery that is consistent with current technology in the workforce. This includes the use of multi-axis machinery, simulators, and 3-D printing machines.

According to employers, advanced manufacturing requires fewer employees to produce more goods, yet the employees are required to have a high technical skill level. Because there is already an identified disparity of advanced manufacturing employees, employers indicated an increased need for community colleges to provide a skilled workforce. However, employers identified a perceived gap in current education offerings and actual skill requirements. Employers revealed that job applicants from community colleges frequently do not meet employer expectations and have high attrition rates. Employers indicated the need for employees that are '100% job ready', possess good work habits, and understand the entire manufacturing process outside their particular discipline or skill set in order to improve efficiency in the company.

Employers also identified a 'crisis' related to the shortage of skilled advanced manufacturing workers. As of April 2013, California's advanced manufacturing firms did not have enough skilled workers to fill open positions. California's high unemployment rate and the anticipated retirement rate of Baby Boomers may create a significant skill gap without community colleges offering education in advanced manufacturing. According to interviewees, even though advanced manufacturing's reliance on automation requires less workers, within five years there will still be a skilled employee gap because the volume of skilled workers is not currently available and the need will continue to grow. Employers also identified that advanced manufacturing employees must be highly logical, as well as able to take a big-picture view of the systems they work with.

Advanced Manufacturing Employer Survey

From June through August 2013, the Centers of Excellence, with assistance from Davis Research, collected workforce information regarding occupations in advanced manufacturing through an employer survey. Survey responses were collected by phone and online. Employers were asked to provide information about skill requirements, hiring challenges, as well as current and projected workforce needs for the eight occupations selected. A total of 392 employers responded to the survey.

Twenty-three individual industries were identified in the advanced manufacturing sector. Employers were asked to select a specialization that best describes their company. The specialization with the largest number of responses across all three regions was the Aircraft/Aerospace industry (17%). The specialization with the largest number of responses in both Orange County and the Central Valley was Fabrication of Metal Products (17% and 13%, respectively).

Table 5: Survey Participants' Industry Specialization

Industry Specialization	Overall	Los Angeles County	Orange County	Central Valley
Aircraft/Aerospace	17.1%	23.6%	15.1%	4.0%
Apparel, Finished products from Fabrics & Similar materials	2.0%	2.1%	0.0%	5.3%
Automotive	2.8%	1.6%	4.0%	4.0%
Chemicals and allied products	2.3%	2.6%	2.4%	1.3%
Electronic equipment & components, ex computer equip.	9.7%	9.4%	11.9%	6.7%
Fabricate metal products, ex machinery/transport equipment	16.1%	16.8%	16.7%	13.3%
Food/Edible goods	3.3%	2.6%	0.8%	9.3%
Furniture	1.8%	0.5%	4.0%	1.3%
Fixtures/Fittings	1.3%	1.6%	0.8%	1.3%
Games and toys	0.3%	0.5%	0.0%	0.0%
Industrial/commercial machinery and computer equipment	2.8%	3.7%	1.6%	2.7%
Jewelry	0.8%	1.0%	0.8%	0.0%
Lumber and wood products, except furniture	1.3%	1.6%	1.6%	0.0%
Measure/Analyze/Control Instruments	2.3%	2.6%	3.2%	0.0%
Paper and allied products	1.5%	1.0%	2.4%	1.3%
Petroleum and miscellaneous plastic products	1.8%	1.0%	2.4%	2.7%
Primary metal industries	1.0%	1.0%	0.0%	2.7%
Printing, publishing and allied industries	1.0%	1.0%	0.8%	1.3%
Signs and advertising specialties	4.3%	2.6%	3.2%	10.7%
Sporting and athletic goods	0.5%	0.0%	0.8%	1.3%
Stone, clay, glass, and concrete products	2.0%	0.5%	0.8%	8.0%
Textile mill products	1.3%	0.0%	3.2%	1.3%
Transportation equipment	2.0%	1.6%	3.2%	1.3%
Other	20.7%	20.9%	20.6%	20.0%

Machines and Equipment Used

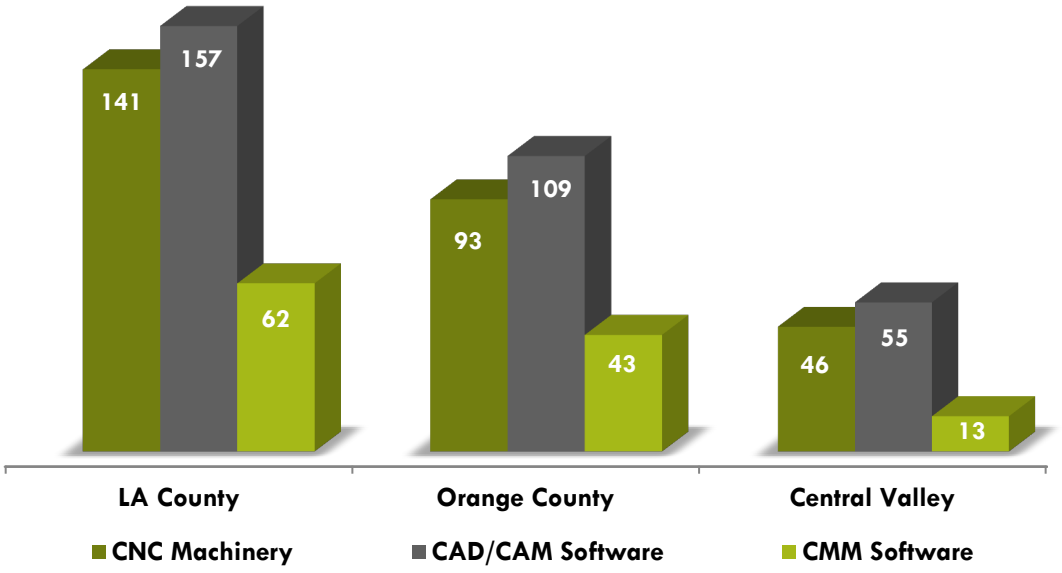
Employers identified specific types of machinery and equipment used at their respective facilities. The overall most-used machinery is multi-axis machines, with 54% of employers indicating this equipment is used at their facility. Also included in the top five identified equipment technologies were: Robotics (14% of companies), Lasers (19%), 3-D Printing (12%), and Automated Soldering Equipment (7%). The table below highlights machinery and equipment identified by employers in each region.

Table 6: High Tech Machines/Equipment Used by Manufacturing Companies

Region	Types of High Tech Machines/Equipment									
	Multi- Axis Machines	Robotics	Lasers	3-D Printing	Automated Soldering Equipment	Electron Beam Welding	Spin Forming	Spin Welding	Water Jet	Other
LA County	55.0%	17.3%	18.8%	12.6%	8.4%	2.6%	2.6%	1.6%	7.3%	39.3%
Orange County	54.0%	8.7%	19.0%	11.9%	5.6%	1.6%	1.6%	2.4%	4.0%	43.7%
Central Valley	50.7%	14.7%	21.3%	10.7%	4.0%	0%	6.7%	1.3%	6.7%	50.7%
Total	**53.8%**	**14.0%**	**19.4%**	**12.0%**	**6.6%**	**1.8%**	**3.1%**	**1.8%**	**6.1%**	**42.9%**

Manufacturing companies require employees to have a knowledge of and ability to use specific machinery and computer software. Over all regions, employers indicated that CAD/CAM software is the most used software at their companies (82% indicated frequent use). A large number of employers (71%) also indicated CNC Machinery software is a frequently used technology.

Figure 2: Most-Used Advanced Manufacturing Machinery and Software



Required Education by Occupation

For six of the eight identified advanced manufacturing occupations, some college/trade school was marked as the most desired educational requirement. Because the majority of occupations listed require at least some college/trade school, California Community Colleges are in a position to build partnerships with local employers to provide education and training for the advanced manufacturing industry.

In Orange County, 76% of employers indicated an education requirement of some college/trade school for CAD/CAM Designers. The Central Valley had the highest percentage of responses for the high school or less and 4-year degree categories (24% and 20%, respectively).

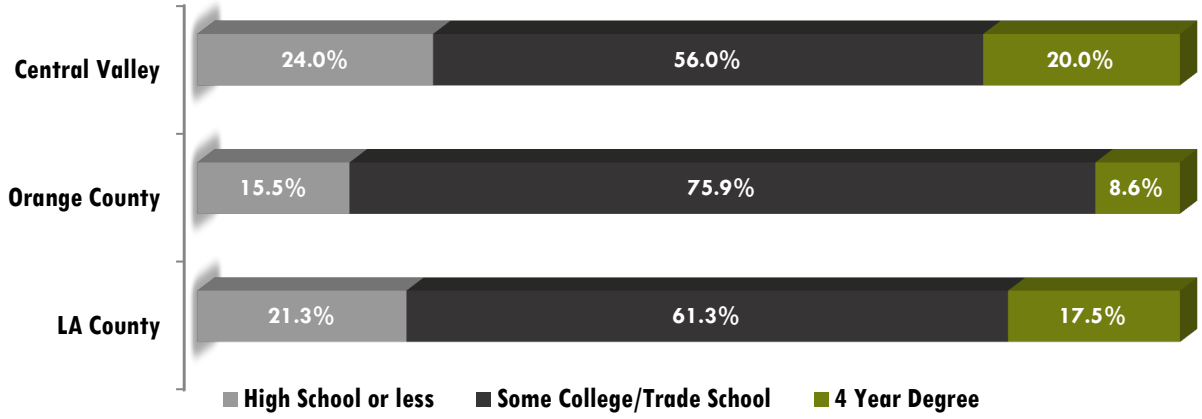
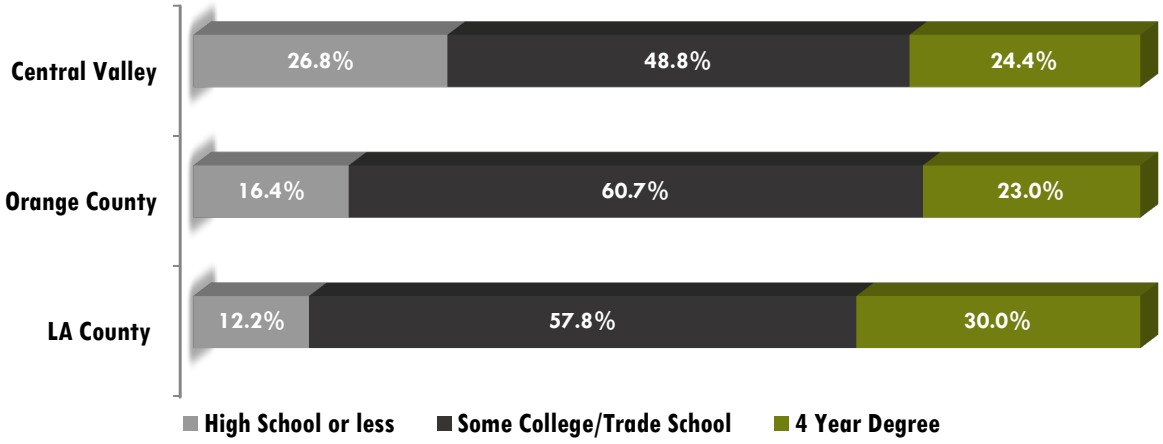


Figure 3: CAD/CAM Designer Education Requirements

In the Central Valley, a proportionately higher percentage of employers (27%) identified an education requirement of high school or less for CAD/CAM programmers. Orange County had the highest percentage (61%) of some college/trade school as a requirement, while LA County had the highest percentage (30%) of 4-year degree as a requirement.

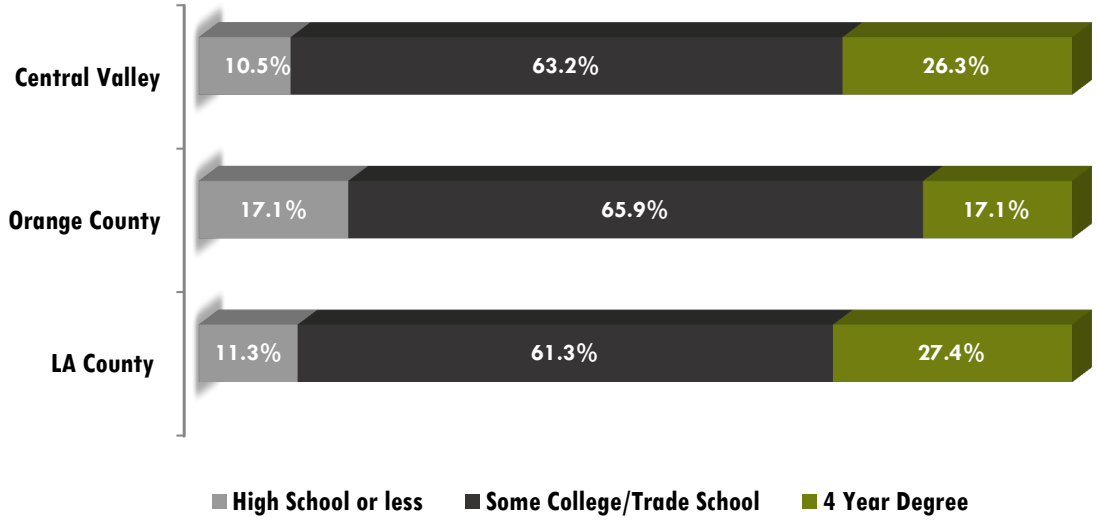
Figure 4: CAD/CAM Programmer Education Requirements



Orange County employers had the highest percentage of responses indicating an educational requirement of high school or less, as well as for some college/trade school for CAD/CAM Engineering Technicians (17% and

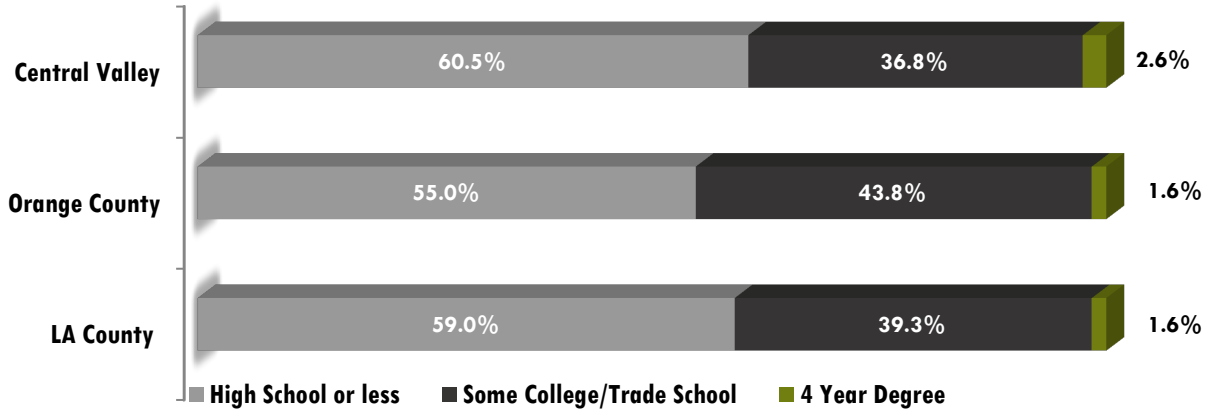
66%, respectively). Los Angeles County had the highest percentage (27%) of responses for the 4-year degree requirement.

Figure 5: CAD/CAM Engineering Technician Education Requirements



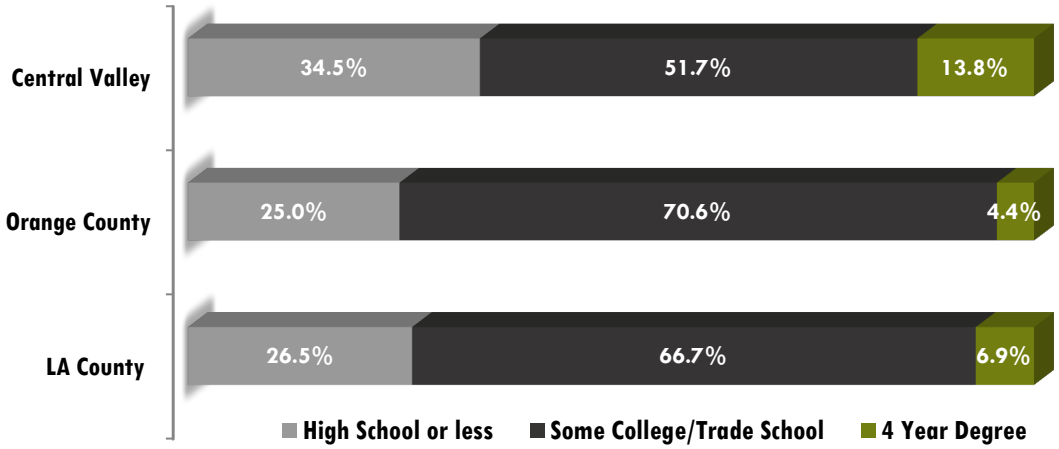
Overall, employers indicated an education requirement of high school or less for CNC Machinists/Operators. Each region also had a relatively similar percentage of employers indicate some college/trade school as an education requirement for this occupation. Additionally, very few employers (less than 3% in each region) indicated a 4-year degree was necessary for employment as a CNC Machinist/Operator.

Figure 6: CNC Machinist/Operator Education Requirements



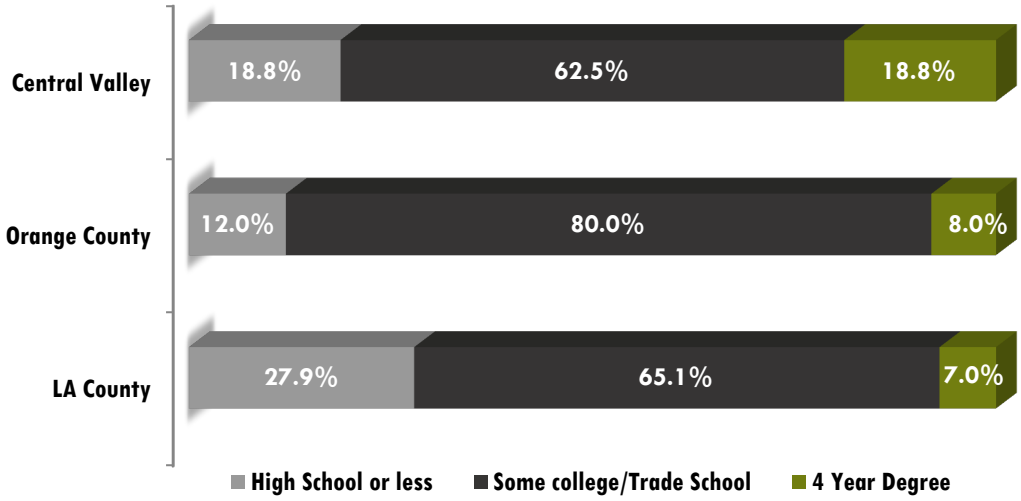
A majority of employers indicated some college/trade school as the preferred level of education for CNC Programmers. However, more than a quarter of employers in all regions also indicated that an education level of high school or less is acceptable for this occupation. A relatively low percentage of employers required a 4-year degree for this occupation, with Central Valley employers reporting the highest percentage (14%).

Figure 7: CNC Programmer Education Requirements



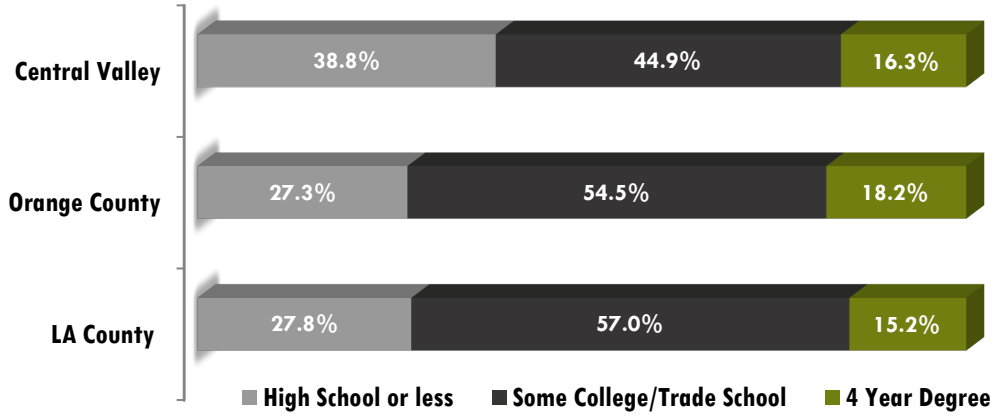
Overall, employers indicated an education requirement of some college/trade school for CNC Engineering Technicians. 28% of Los Angeles County employers indicated a requirement of high school or less, which was higher than the other regions studied. Most employers surveyed prefer some college/trade school for CNC Engineering Technicians.

Figure 8: CNC Engineering Technician Education Requirements



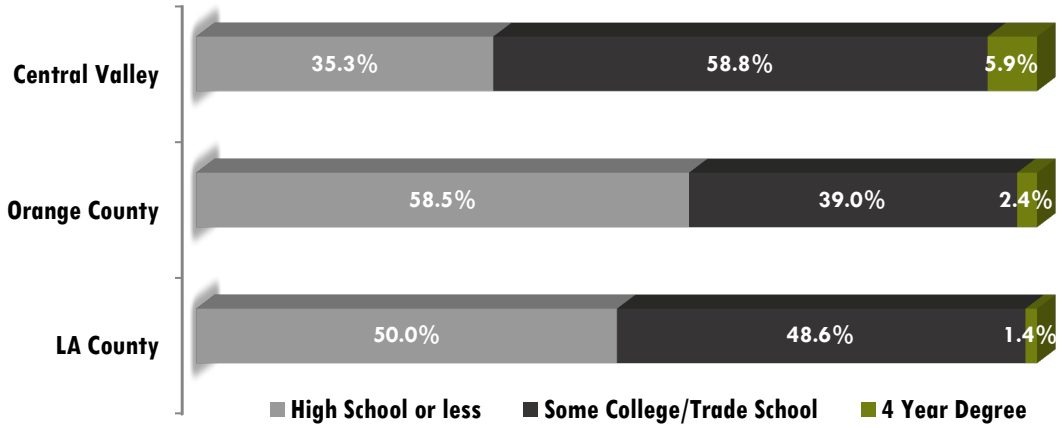
Education requirements for Quality Control Inspectors/Supervisors are similar across all three regions, with many employer responses indicating a preference for some college/trade school. Central Valley employers indicated the highest percentage (39%) for a high school or less education, while Orange County employers indicated the highest percentage (18%) for a 4-year degree.

Figure 9: Quality Control Inspector/Supervisor Education Requirements



A high percentage (59%) of employers in Orange County indicated high school or less as the primary education requirement for Tool/Die Makers. Central Valley employers indicated the highest percentage (59%) of some college/trade school. Los Angeles County had the lowest percentage (1%) of responses requiring a 4-year degree.

Figure 10: Tool/Die Maker Education Requirements



In summary, the survey revealed that the majority of employers require some college/trade school for 6 of the 8 occupations studied: CAD/CAM Designers, CAD/CAM Programmers, CAD/CAM Engineering Technicians, CNC Programmers, CNC Engineering Technicians and Quality Control Inspectors/Supervisors. Only CNC Machinists/Operators and Tool/Die Makers can more often be hired with a high school diploma or less. However, additional training makes applicants more employable, since many employers do require some college/trade school.

Advanced Manufacturing Job Growth

In the next five years, the 392 manufacturing companies surveyed indicated that they expect to add a total of 1,796 jobs (359 average openings annually) for the 8 occupations studied. CNC Machinist/Operator is the occupation with the largest number of current jobs, as well as projected new jobs (1,878 total). Each of the 8 occupations have positive growth projections over the next five years, with an average growth rate of 47%.

Table 7: Advanced Manufacturing Job Growth

Occupation	Current # of Employees	5-Year Job Growth	% Growth Rate
CNC Machinist Operator	1,225	653	53.3%
CAD/CAM Programmer	550	90	16.4%
Tool/Die Maker	452	149	32.9%
Quality Control Inspector/Supervisor	609	357	58.6%
CAD/CAM Engineering Technician	146	90	61.6%
CAD/CAM Designer	434	242	55.8%
CNC Programmer	319	186	58.3%
CNC Engineering Technician	53	29	54.7%
Total	**3,788**	**1,796**	**47.4%**

There is a large range of projected job openings by region, with Los Angeles County projected to experience the largest number of new jobs over the period (2,253 new jobs). The Central Valley and Orange County have the highest percentages of projected growth rate, with employers expecting 62% and 61% growth, respectively.

Table 8: Advanced Manufacturing Growth by Region

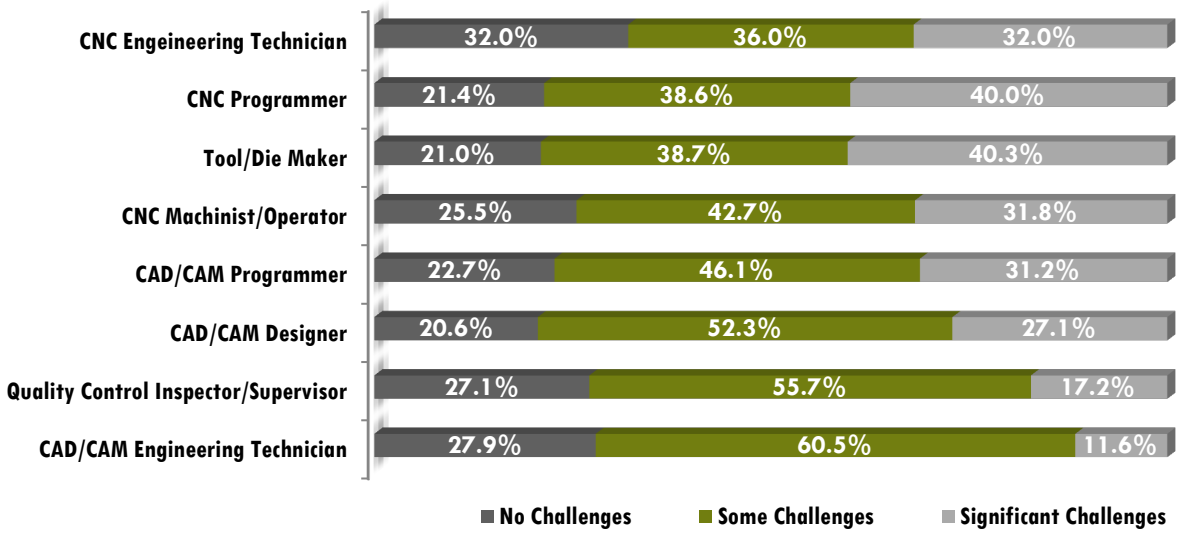
Occupation	Current # of Employees	5-Year Job Growth	% Growth Rate
Los Angeles County			
CNC Machinist Operator	693	286	41.3%
CAD/CAM Programmer	427	112	26.2%
Tool/Die Maker	319	79	24.8%
Quality Control Inspector/Supervisor	207	216	70.4%
CAD/CAM Engineering Technician	105	46	43.8%
CAD/CAM Designer	229	106	46.3%
CNC Programmer	156	78	50.0%
CNC Engineering Technician	17	22	129%
Los Angeles County Total	**2,253**	**945**	**41.9%**
Orange County			
CNC Machinist Operator	333	211	63.4%
CAD/CAM Programmer	88	50	56.8%
Tool/Die Maker	103	45	43.7%
Quality Control Inspector/Supervisor	157	79	50.3%
CAD/CAM Engineering Technician	30	32	106%
CAD/CAM Designer	123	80	65.0%
CNC Programmer	82	70	85.4%
CNC Engineering Technician	22	3	13.6%
Orange County Total	**938**	**570**	**60.8%**
Central Valley			
CNC Machinist Operator	188	152	80.1%
CAD/CAM Programmer	40	20	50.0%
Tool/Die Maker	38	24	63.2%
Quality Control Inspector/Supervisor	148	59	39.9%
CAD/CAM Engineering Technician	11	12	109%
CAD/CAM Designer	77	56	72.7%
CNC Programmer	74	40	54.1%
CNC Engineering Technician	15	4	26.7%
Central Valley Total	**591**	**367**	**62.1%**

*Totals may differ due to rounding

Employer Challenges

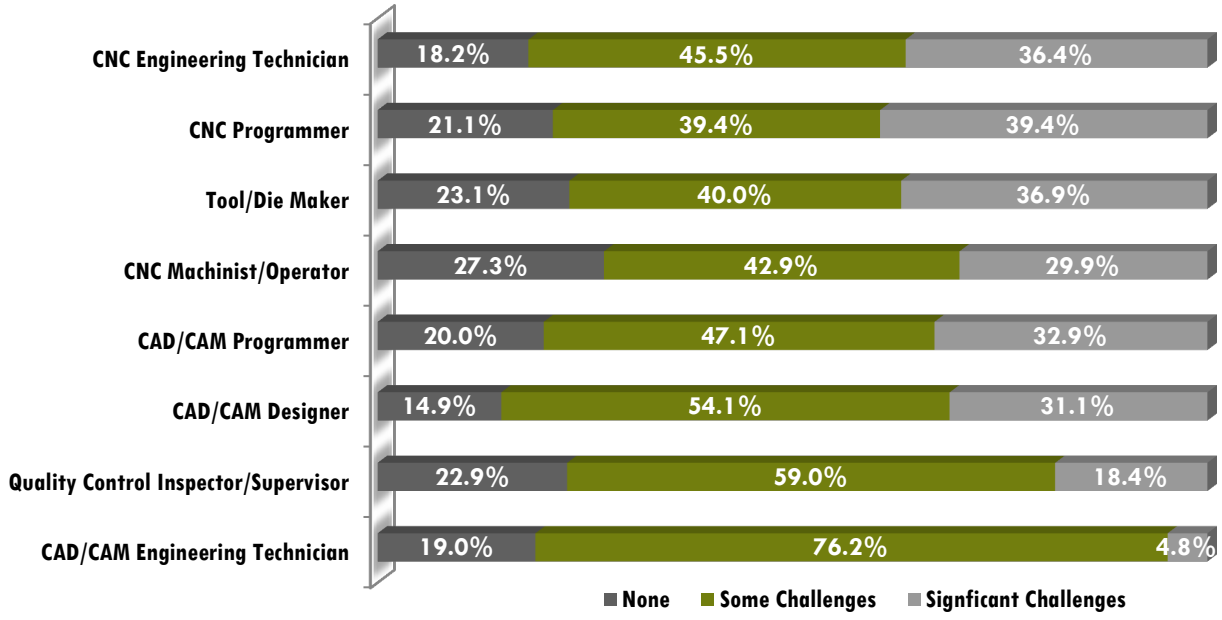
Employers were asked to identify challenges finding qualified employees to fill each of the eight occupations, distinguishing between, 'no challenges', 'some challenges' and 'significant challenges'. Employers reported challenges with all eight occupations, with CAD/CAM Designer being the occupation with the highest level of difficulty hiring.

Figure 11: Employer Challenges Finding Qualified Employees, Overall



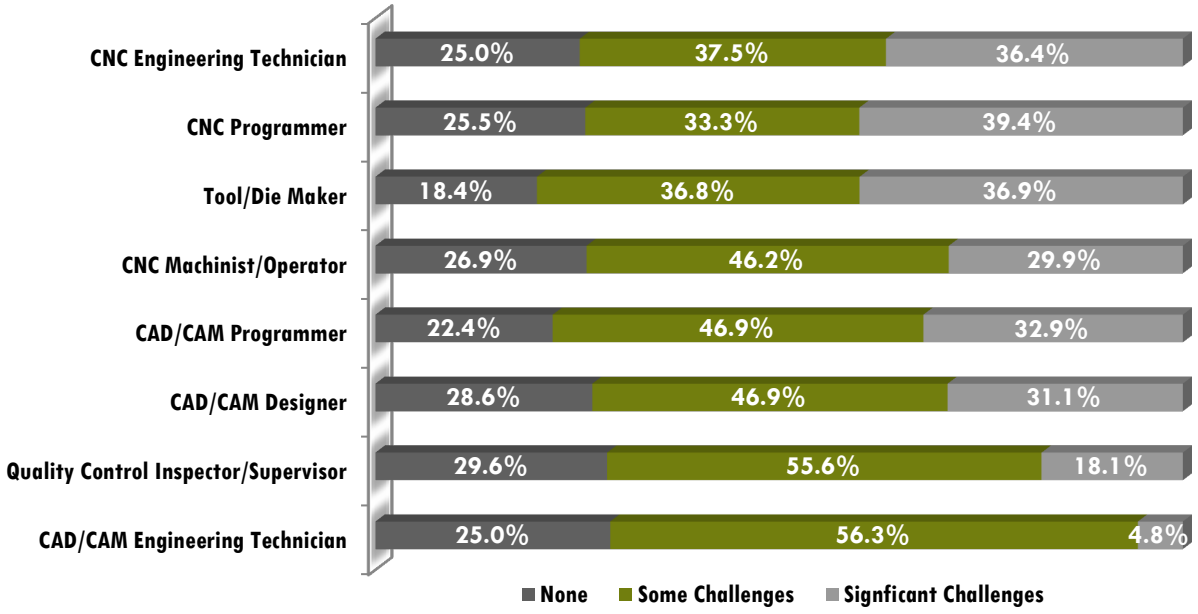
Los Angeles County employers reported a high level of difficulty finding qualified employees in all eight occupations, with more than seventy percent of employers reporting challenges. CNC Machinist/Operator is the occupation with the lowest percentage of hiring challenges, however 73% of employers still reported challenges hiring for this position.

Figure 12: Employer Challenges Finding Qualified Employees, Los Angeles County



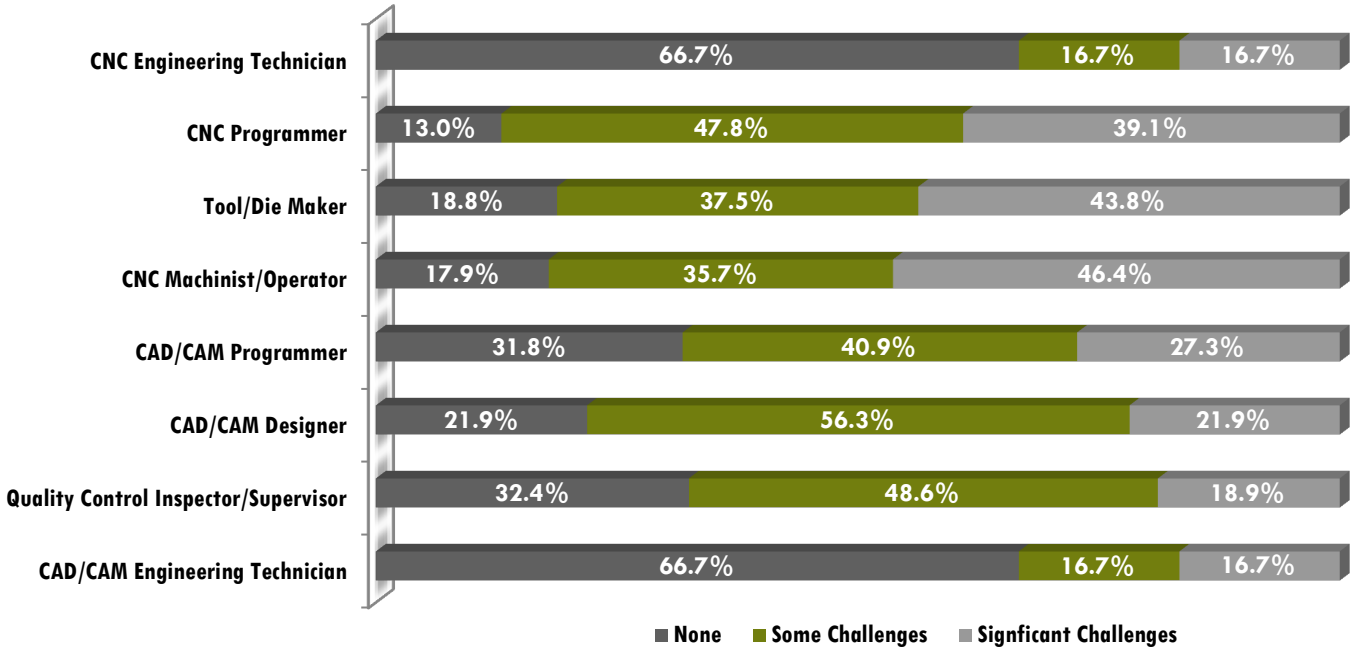
Orange County employers reported Tool/Die Makers as the occupation with the most overall challenges hiring (74% reported challenges). CNC Programmers had the highest percentage (39%) of employers report significant challenges, while Quality Control Inspectors/Supervisors had the lowest percentage of reported challenges.

Figure 13: Employer Challenges Finding Qualified Employees, Orange County



Central Valley employers reported a lower percentage of challenges hiring both CNC Engineering Technicians (66%) and CAD/CAM Engineering Technicians (66%) than the other two regions studied. Employers had a much harder time hiring CNC programmers in the Central Valley than the other regions studied, reporting hiring challenges 87% of the time.

Figure 14: Employer Challenges Finding Qualified Employees, Central Valley



Soft Skills

Employers were asked to identify the level of difficulty finding workers with the following "soft" skills: (1) Microsoft Office Programs; (2) Math Skills; (3) Teamwork/Collaboration; (4) Problem Solving Skills; (5) Oral Communication; and (6) Written Communication. The range of options employers were asked to choose from were Extremely Difficult, Somewhat Difficult, Not Very Difficult, or Not at All Difficult. For the following tables, Extremely Difficult and Somewhat Difficult are combined and reported as Difficult, and Not Very Difficult and Not at All Difficult are combined and reported as Not Difficult. More detailed information can be found in Appendix D.

The most difficult soft skill to find for every occupation with the exception of CAD/CAM Engineering Technician was problem solving. Employers also reported difficulty finding workers with satisfactory oral and written communication, as well as math skills. Teamwork/collaboration was cited as difficult to find about half the time. Microsoft Office skills were not noted as being hard to find for most occupations, except for CNC Machinist Operators and Tool/Die Makers.

Table 9: Employer Identified Soft Skills Gap

	Microsoft Office		Math Skills		Teamwork/ Collaboration		Problem Solving Skills		Oral Communication		Written Communication	
	Difficult	Not Difficult	Difficult	Not Difficult	Difficult	Not Difficult	Difficult	Not Difficult	Difficult	Not Difficult	Difficult	Not Difficult
CAD/CAM Designer	33.3%	66.7%	53.7%	46.3%	55.3%	44.7%	**75.6%**	24.4%	56.9%	43.1%	58.5%	41.5%
CAD/CAM Programmer	32.1%	67.9%	58.7%	41.3%	52.3%	47.7%	**76.1%**	23.9%	60.6%	39.4%	57.8%	42.2%
CAD/CAM Engineering Technician	25.8%	74.2%	51.6%	48.4%	45.2%	54.8%	**54.8%**	45.2%	64.5%	35.5%	71.0%	29.0%
CNC Machinist Operator	51.3%	48.0%	66.7%	33.3%	64.1%	48.7%	**76.1%**	23.9%	71.8%	28.2%	71.0%	29.0%
CNC Programmer	43.9%	56.1%	60.5%	39.5%	50.0%	50.0%	**72.8%**	27.2%	54.4%	45.6%	59.6%	40.4%
CNC Engineering Technician	35.3%	64.7%	76.5%	23.5%	64.7%	35.3%	**88.2%**	11.8%	70.6%	29.4%	82.4%	17.6%
Quality Control Inspector/Supervisor	39.4%	60.6%	65.4%	34.6%	57.5%	42.5%	**76.4%**	23.6%	59.1%	40.9%	65.4%	34.6%
Tool/Die Maker	55.8%	44.2%	66.3%	33.7%	51.6%	48.4%	**80.0%**	20.0%	56.8%	43.2%	58.9%	41.1%

Advanced Manufacturing Technical Skills

In addition to the identified soft skills, employers were also asked to identify technical skill requirements for each occupation. Employers were asked to differentiate between *required skills* and *preferred skills*. The technical skill required by most employers (68%) for CAD/CAM Designers was reading blueprints. More than half of employers reported CAD/CAM systems knowledge, GD&T knowledge, and the ability to read micrometers as 'must have' requirements for a CAD/CAM Designer.

Table 10: CAD/CAM Designer Technical Skill Requirements

Skill	Must have	Prefer to have	Not Required
Experience with multi-axis machines	22.6%	47.7%	29.7%
Understanding the A, B, and X, Y, Z axis on all machines	40.6%	39.4%	20.0%
3-D Modeling knowledge	40.6%	40.6%	18.7%
CAD/CAM Systems knowledge	57.4%	36.1%	6.5%
CNC Machines knowledge	31.6%	51.6%	16.8%
Reading blueprints	68.4%	24.5%	7.1%
ISO9000 Series knowledge/QMS/AS9100	14.8%	45.2%	40%
GD&T	52.3%	29.0%	18.7%
CNC programming	23.2%	46.5%	30.3%
Multi-axis programming	20.0%	41.9%	38.1%
CNC Machines (Sequencing)	24.5%	39.4%	36.1%
Adjusting machine controls (e.g. speed, feeds, etc.)	26.5%	39.4%	34.2%
Reading micrometers, calipers, and gauges	55.5%	29.0%	15.5%
Experience with ERP/SCN systems	9.0%	45.2%	45.8%
Experience with MRP software	11.0%	47.1%	41.9%
MMP knowledge/experience	10.3%	43.9%	45.8%

The technical skill with the highest percentage (95%) of employer response (preferred and required) for CAD/CAM Programmers was knowledge of CAD/CAM systems. The majority of employers indicated many of the identified skills as requirements, including understanding the axes on all machines, CAD/CAM systems knowledge, reading blueprints, CNC programming, adjusting machine controls, and reading micrometers, calipers and gauges.

Table 11: CAD/CAM Programmer Technical Skill Requirements

Skill	Must have	Prefer to have	Not Required
Experience with multi-axis machines	39.0%	47.5%	13.5%
Understanding the A, B, and X, Y, Z axis on all machines	66.0%	24.8%	9.2%
3-D Modeling knowledge	39.0%	42.6%	18.4%
CAD/CAM Systems knowledge	64.5%	30.5%	5.0%
CNC Machines knowledge	59.6%	33.3%	7.1%
Reading blueprints	77.3%	16.3%	6.4%
ISO9000 Series knowledge/QMS/AS9100	19.1%	43.3%	37.6%
GD&T	49.6%	36.2%	14.2%
CNC programming	68.8%	23.4%	7.8%
Multi-axis programming	49.6%	36.2%	14.2%
CNC Machines (Sequencing)	49.6%	39.0%	11.3%
Adjusting machine controls (e.g. speed, feeds, etc.)	51.8%	36.2%	12.1%
Reading micrometers, calipers, and gauges	66.0%	27.0%	7.1%
Experience with ERP/SCN systems	11.3%	48.9%	39.7%
Experience with MRP software	9.2%	51.1%	39.7%
MMP knowledge/experience	14.2%	46.1%	39.7%

Employers indicated reading blueprints as the most desired technical skill (93%) for CAD/CAM Engineering Technicians. CAD/CAM systems knowledge was most often required by employers (70%). The technical skill employers expressed the highest preference for was multi-axis programming (61%). Experience with ERP/SCN systems and MRP software were only required by 12% of the employers for this occupation.

Table 12: CAD/CAM Engineering Technician Technical Skill Requirements

Skill	Must have	Prefer to have	Not Required
Experience with multi-axis machines	32.6%	44.2%	23.3%
Understanding the A, B, and X, Y, Z axis on all machines	39.5%	39.5%	20.9%
3-D Modeling knowledge	34.9%	51.2%	14.0%
CAD/CAM Systems knowledge	69.8%	16.3%	14.0%
CNC Machines knowledge	39.5%	32.6%	27.9%
Reading blueprints	60.5%	32.6%	7.0%
ISO9000 Series knowledge/QMS/AS9100	11.6%	48.8%	39.5%
GD&T	37.2%	39.5%	23.3%
CNC programming	32.6%	39.5%	27.9%
Multi-axis programming	20.9%	60.5%	18.6%
CNC Machines (Sequencing)	30.2%	34.9%	34.9%
Adjusting machine controls (e.g. speed, feeds, etc.)	30.2%	32.6%	37.2%
Reading micrometers, calipers, and gauges	55.8%	30.2%	14.0%
Experience with ERP/SCN systems	4.7%	48.8%	46.5%
Experience with MRP software	7.0%	46.5%	46.5%
MMP knowledge/experience	11.6%	44.2%	44.2%

The technical skill with the highest overall percentage (96%) of employer response (required and preferred) for CNC Machinists/Operators was reading micrometers, calipers and gauges. Over 60% of employers reported CNC machines knowledge, reading blueprints, adjusting machine controls, and reading micrometers as 'must have' requirements for this occupation. Fifty percent of employers prefer to hire an employee with experience using multi-axis machines.

Table 13: CNC Machinist/Operator Technical Skill Requirements

Skill	Must have	Prefer to have	Not Required
Experience with multi-axis machines	32.5%	50.3%	17.2%
Understanding the A, B, and X, Y, Z axis on all machines	50.3%	38.9%	10.8%
3-D Modeling knowledge	10.2%	29.3%	60.5%
CAD/CAM Systems knowledge	0%	0%	0%
CNC Machines knowledge	61.1%	32.5%	6.4%
Reading blueprints	66.9%	24.8%	8.3%
ISO9000 Series knowledge/QMS/AS9100	0%	0%	0%
GD&T	36.3%	36.9%	26.8%
CNC programming	27.4%	49.0%	23.6%
Multi-axis programming	14.6%	47.8%	37.6%
CNC Machines (Sequencing)	58.6%	33.8%	7.6%
Adjusting machine controls (e.g. speed, feeds, etc.)	66.2%	27.4%	6.4%
Reading micrometers, calipers, and gauges	71.3%	24.2%	4.5%
Experience with ERP/SCN systems	6.4%	36.3%	57.3%
Experience with MRP software	4.5%	36.9%	58.6%
MMP knowledge/experience	6.4%	37.6%	56.1%

Employers indicated CNC machines knowledge as the most desired technical skill (97%) for CNC Programmers. Reading blueprints had the highest percentage (77%) of employer responses as a required technical skill. The technical skill employers expressed the highest preference for was MMP knowledge/experience (52%).

Table 14: CNC Programmer Technical Skill Requirements

Skill	Must have	Prefer to have	Not Required
Experience with multi-axis machines	44.1%	48.3%	7.6%
Understanding the A,B, and X, Y, Z axis on all machines	65.5%	29.7%	4.8%
3-D Modeling knowledge	25.5%	46.9%	27.6%
CAD/CAM Systems knowledge	55.2%	36.6%	8.3%
CNC Machines knowledge	74.5%	22.8%	2.8%
Reading blueprints	79.3%	16.6%	4.1%
ISO9000 Series knowledge/QMS/AS9100	14.5%	40.0%	45.5%
GD&T	49.0%	38.6%	12.4%
CNC programming	76.6%	20.0%	3.4%
Multi-axis programming	44.1%	45.5%	10.3%
CNC Machines (Sequencing)	60.7%	31.7%	7.6%
Adjusting machine controls (e.g. speed, feeds, etc.)	63.4%	30.3%	6.2%
Reading micrometers, calipers, and gauges	74.5%	21.4%	4.1%
Experience with ERP/SCN systems	17.2%	39.3%	43.4%
Experience with MRP software	13.8%	42.1%	44.1%
MMP knowledge/experience	10.3%	51.7%	37.9%

Reading micrometers was the 'must have' technical skill with the highest percentage (72%) of employer responses for CNC Engineering Technicians. Over 60% of employers reported CNC machine knowledge, reading blueprints, CNC machines sequencing, and adjusting machine controls as 'must have' requirements for this occupation. Additionally, 68% of employers prefer to hire an employee with MMP knowledge and experience.

Table 15: CNC Engineering Technician Technical Skill Requirements

Skill	Must have	Prefer to have	Not Required
Experience with multi-axis machines	48.0%	48.0%	4.0%
Understanding the A, B, and X, Y, Z axis on all machines	56.0%	36.0%	8.0%
3-D Modeling knowledge	16.0%	52.0%	32.0%
CAD/CAM Systems knowledge	48.0%	48.0%	4.0%
CNC Machines knowledge	60.0%	40.0%	0%
Reading blueprints	64.0%	36.0%	0%
ISO9000 Series knowledge/QMS/AS9100	16.0%	52.0%	32.0%
GD&T	48.0%	32.0%	20.0%
CNC programming	48.0%	52.0%	0%
Multi-axis programming	44.0%	52.0%	4.0%
CNC Machines (Sequencing)	60.0%	28.0%	12.0%
Adjusting machine controls (e.g. speed, feeds, etc.)	60.0%	36.0%	4.0%
Reading micrometers, calipers, and gauges	72.0%	24.0%	4.0%
Experience with ERP/SCN systems	4.0%	64.0%	32.0%
Experience with MRP software	8.0%	60.0%	32.0%
MMP knowledge/experience	12.0%	68.0%	20.0%

The technical skill with the highest percentage (82%) of employer response (required and preferred) for Quality Control Inspectors/Supervisors was reading micrometers, calipers and gauges. Employers reported reading

micrometers as the top 'must have' technical skill, and experience with ERP/SCN systems as the top 'prefer to have' skill, followed by experience with MRP software. 3-D modeling knowledge and MMP knowledge were the two technical skills neither required nor preferred by most employers surveyed.

Table 16: Quality Control Inspector/Supervisor Technical Skill Requirements

Skill	Must have	Prefer to have	Not Required
Experience with multi-axis machines	0%	0%	0%
Understanding the A, B, and X, Y, Z axis on all machines	18.4%	33.3%	48.3%
3-D Modeling knowledge	7.5%	29.9%	62.6%
CAD/CAM Systems knowledge	0%	0%	0%
CNC Machines knowledge	0%	0%	0%
Reading blueprints	51.7%	27.6%	20.7%
ISO9000 Series knowledge/QMS/AS9100	33.9%	36.2%	29.9%
GD&T	31.6%	32.2%	36.2%
CNC programming	0%	0%	0%
Multi-axis programming	0%	0%	0%
CNC Machines (Sequencing)	0%	0%	0%
Adjusting machine controls (e.g. speed, feeds, etc.)	21.8%	31.6%	46.6%
Reading micrometers, calipers, and gauges	60.9%	28.7%	10.3%
Experience with ERP/SCN systems	9.8%	40.8%	49.4%
Experience with MRP software	10.9%	40.2%	48.9%
MMP knowledge/experience	8.0%	33.9%	58.0%

The most desired technical skill with the highest percentage (93%) of employer response for Tool/Die Makers was reading blueprints. Employers also reported reading micrometers as the top 'must have' technical skill. Knowledge of CNC machines was the top 'prefer to have' skill with 45%. 3-D modeling knowledge and CAD/CAM systems knowledge were the top two technical skills employers deemed not required for the job.

Table 17: Tool/Die Maker Technical Skill Requirements

Skill	Must have	Prefer to have	Not Required
Experience with multi-axis machines	28.6%	41.2%	30.3%
Understanding the A, B, and X, Y, Z axis on all machines	42.9%	34.5%	22.7%
3-D Modeling knowledge	19.3%	37.0%	43.7%
CAD/CAM Systems knowledge	24.4%	41.2%	34.5%
CNC Machines knowledge	32.8%	45.4%	21.8%
Reading blueprints	78.2%	15.1%	6.7%
ISO9000 Series knowledge/QMS/AS9100	0%	0%	0%
GD&T	0%	0%	0%
CNC programming	0%	0%	0%
Multi-axis programming	0%	0%	0%
CNC Machines (Sequencing)	31.1%	43.7%	25.2%
Adjusting machine controls (e.g. speed, feeds, etc.)	48.7%	30.3%	21.0%
Reading micrometers, calipers, and gauges	78.2%	13.4%	8.4%
Experience with ERP/SCN systems	0%	0%	0%
Experience with MRP software	0%	0%	0%
MMP knowledge/experience	0%	0%	0%

Employer Difficulty Hiring Employees with Advanced Manufacturing Technical Skills

Employers were asked if they experience difficulty hiring employees with the identified advanced manufacturing technical skills for each of the occupations. For four of the eight occupations, employers reported the most difficulty hiring employees with 3-D Modeling knowledge. The technical skill hardest to find for CAD/CAM Designers was Multi-axis programming knowledge, while for CAD/CAM Engineering Technicians, GD&T was the most difficult skill to find. Employers also indicated the most difficult skill to hire for CNC Engineering Technicians is experience with multi-axis machines.

Table 18: Percent of Employers Reporting Difficulty Hiring Technical Skills

	CAD/CAM Designer	CAD/CAM Programmer	CAD/CAM Engineering Tech	CNC Machinist Operator	CNC Programmer	CNC Engineering Tech	Quality Control Inspector/ Supervisor	Tool/Die Maker
Experience with multi-axis machines	74%	74%	65%	80%	72%	88%	0%	75%
Understanding the A, B, and X, Y, Z axis on all machines	63%	63%	58%	70%	66%	82%	69%	71%
3-D Modeling knowledge	75%	79%	68%	89%	82%	77%	84%	84%
CAD/CAM Systems knowledge	63%	66%	48%	0%	69%	71%	0%	82%
CNC Machines knowledge	69%	60%	52%	71%	60%	65%	0%	71%
Reading blueprints	52%	44%	55%	64%	47%	59%	57%	53%
ISO9000 Series knowledge/QMS/AS9100	73%	71%	74%	0%	73%	53%	74%	0%
GD&T	70%	71%	81%	80%	68%	77%	69%	0%
CNC programming	70%	68%	52%	83%	67%	71%	0%	0%
Multi-axis programming	76%	76%	61%	89%	80%	77%	0%	0%
CNC Machines (Sequencing)	68%	62%	65%	76%	67%	77%	0%	66%
Adjusting machine controls (e.g. speed, feeds, etc.)	57%	47%	48%	64%	53%	59%	58%	61%
Reading micrometers, calipers, and gauges	41%	34%	36%	47%	33%	41%	43%	37%
Experience with ERP/SCN systems	67%	69%	58%	82%	74%	65%	78%	0%
Experience with MRP software	68%	69%	61%	84%	79%	77%	80%	0%
MMP knowledge/experience	72%	71%	52%	84%	76%	82%	78%	0%

Advanced Manufacturing Program Offerings

Interviews with community college representatives revealed that some community colleges are teaching 2-3 editions behind the current on-the-job advanced manufacturing software. One college reported using the 2011 version of AutoCAD, even though industry is using the 2014 version. This incongruence occurs when colleges do not have funding for the latest edition of AutoCAD software. In these cases, students will need to learn to use the newest software on the job after they get hired.

As the technology, machinery, and processes in advanced manufacturing continue to evolve, community colleges must also update program offerings, curriculum, and training equipment to meet the needs of industry. A preliminary review of available education programs revealed 42 different manufacturing related programs in the regions studied.[11] Appendix E contains a listing of the identified program titles. Community colleges indicated several current advanced manufacturing educational trends and practices to consider:

- Multi-axis machining: Multi-axis machining is one of the most important technologies in advanced manufacturing. Community colleges with programs in advanced manufacturing need to acquire these machines (purchase or preferably through donations) for students to learn to use them;
- Additive manufacturing: 3-D printing will continue to become more prevalent in industry due to its high efficiency. Additive manufacturing shares several principles with subtractive manufacturing, so many existing CAD/CAM skills are transferrable;
- Apps or digitized textbooks: Digital textbooks are a growing trend across all education disciplines, and provide a lower-cost alternative for students. Additionally, this trend allows students to keep up with latest software updates and industry trends;
- Industrial partners: In addition to using industry partners to help with curriculum updates, these partners can give access to machinery, provide field trip opportunities, contribute donations for equipment, and create internship opportunities;
- Para-professionals: The use of local industry experts to teach labs to provide students with real-world insight and application of the curriculum;
- Soft skills workshops: There is a growing acceptance that community college manufacturing programs need to address soft skills issues in the manufacturing sector through focused workshops for students.

Summary of Findings

Research conducted for this report indicates projected growth within the advanced manufacturing sector in the workforce and economy of the geographic areas studied. Furthermore, an increase of 1,797 new jobs over the next five years was projected from the 392 employers who participated in the survey. As automation and new technologies become standard across manufacturing companies, advanced manufacturing will continue to evolve and require employees to have advanced skills.

There are many community colleges throughout California with programs existing or in development to train for the occupations included in this report. However, it is unclear how current the curriculum and technology are within these programs. Employers identified multi-axis machines (54% of companies) and lasers (19%) as the most used machinery within their companies. Many colleges incorporate these machines into their curriculum, but it is important to note that employers also identified the use of robotics (14%) and 3-D printing (12%) as important to advanced manufacturing. Both of these technologies were identified as significant growth trends in advanced manufacturing during the literature review conducted for this research.

For six of the eight occupations studied, employers indicated college/trade school as the desired education requirement for employment. The other two occupations (CNC Machinist Operator and Tool/Die Maker) only require a high school degree or less. Employers indicated CAD/CAM Designers were the most challenging

[11] Integrated Postsecondary Education Data System (IPEDS), www.nces.ed.gov

positions to fill overall while Tool/Die Makers were the most challenging to hire. Additionally, employers indicated a significant deficiency in problem solving skills for employees in all 8 occupations studied.

Employers found the most difficulty hiring applicants with 3-D Modeling knowledge for all eight of the occupations studied. Skills also found difficult to find for each of the eight occupations were multi-axis programming and experience with multi-axis machines. Multi-axis machines were noted as a trend in advanced manufacturing by community college representatives; therefore, if community colleges incorporated these machines into the curriculum, the skills gap could possibly be minimized. Other emerging trends in the advanced manufacturing world, according to the community college representatives interviewed, were:

- Additive (3-D) manufacturing
- Apps and digital textbooks for students
- Partnerships between colleges and local industry
- Para-professionals teaching at the community college level
- Soft skills workshops to make community college students more competent candidates for job openings

References

Bureau of Labor Statistics, www.bls.gov

California Economic Summit proceedings, www.caeconomy.org

Forbes Magazine (May 2013)

Institute for Defense Analyses

Integrated Postsecondary Education Data System (IPEDS), www.nces.ed.gov

National Council for Advanced Manufacturing, www.ncfam.org

National Defense University, www.ndu.edu

O*Net Resource Center, www.onetonline.org

Time Magazine (April 2013)

Appendix A: How to Use this Report

This report is designed to provide current industry data to:

- Define potential strategic opportunities relative to an industry's emerging trends and workforce needs;
- Influence and inform local college program planning and resource development;
- Promote a future-oriented and market responsive way of thinking among stakeholders; and,
- Assist faculty, Economic Development and CTE administrators, and Community and Contract Education programs in connecting with industry partners.

The information in this report has been validated by employers and also includes a listing of what programs are already being offered by colleges to address those workforce needs. In some instances, the labor market information and industry validation will suggest that colleges might not want to begin or add programs, thereby avoiding needless replication and low enrollments.

About the Centers of Excellence
The Centers of Excellence (COE), in partnership with business and industry, deliver regional workforce research customized for community college decision making and resource development. This information has proven valuable to colleges in beginning, revising, or updating economic development and Career Technical Education (CTE) programs, strengthening grant applications, assisting in the accreditation process, and in supporting strategic planning efforts.

The Centers of Excellence Initiative is funded in part by the Chancellor's Office, California Community Colleges, Economic and Workforce Development Program. The total grant amount represents funding for multiple projects and written reports through the Central Region Center of Excellence. The Centers aspire to be the premier source of regional economic and workforce information and insight for California's community colleges.

More information about the Centers of Excellence is available at **www.coeccc.net**.

Important Disclaimer
All representations included in this report have been produced from primary research and/or secondary review of publicly and/or privately available data and/or research reports. Efforts have been made to qualify and validate the accuracy of the data and the reported findings; however, neither the Centers of Excellence, COE host District, nor California Community Colleges Chancellor's Office are responsible for applications or decisions made by recipient community colleges or their representatives based upon components or recommendations contained in this study.

Appendix B: Survey Methodology

About the Survey

In June through August 2013 the Centers of Excellence, with assistance from Davis Research, collected workforce information regarding occupations in advanced manufacturing through an employer survey. Survey responses were collected online and by phone.

Survey Methodology Summary

Technique	Online and phone survey of advanced manufacturing employers
Population	23,274 employers in Los Angeles County, Orange County, and Central Valley
Sample	392 employer respondents (4.90% margin of error)
Field dates	June-August 2013

About the Respondents

Three hundred ninety-two employers, representing a combined workforce of 3,788 advanced manufacturing employees in the identified counties, responded to the survey. The size of the firm and regional location were recorded where possible. Caution should be used in generalizing results to the entire population of employers to the degree that the sample may differ from the universe. Respondents were located in the following counties: Los Angeles County, Orange County, Amador County, Alpine County, Inyo County, Mono County, Tuolumne County, Mariposa County, Calaveras County, San Joaquin County, Stanislaus County, Merced County, Madera County, Fresno County, Kings County, Kern County, and Tulare County. The employers were carefully selected based on their relation to advanced manufacturing. All firms had some association with advanced manufacturing. NAICS (North American Industry Classification System) codes were used to compile the employer database.

Universe of Firms

The number of manufacturing firms in the identified regions was estimated by gathering public employer information and using proprietary employer databases (EMSI Equifax Database). Through the research conducted on the advanced manufacturing sector, a total of 23,274 manufacturing employers were identified as possibly using advanced manufacturing machinery in Los Angeles County, Orange County, and the Central Valley. Several thousand companies participated in screening interviews to identify advanced manufacturing companies. During the initial screening, 1,216 advanced manufacturing companies were identified and 1,184 agreed to participate in the full survey. The survey focused on a set of 8 occupations identified as important for the industry and relevant to community colleges. The survey included questions pertaining to current employment, 5-year occupational growth, and difficulty hiring for these occupations, as well as training offered to employees and interest in training/education programs. Of the 1,184 firms that agreed to participate in the full survey, 392 firms (33%) responded to the survey. The following is the distribution of the employer population in each county:

Manufacturing Firms by Region

Region	Number of Companies
Los Angeles County	10,886
Orange County	8,111
Central Valley	4,247
Not Specified	30
TOTAL	**23,274**

Source: EMSI, 2013

Occupation Data

Eight occupations related to the advanced manufacturing sector were identified as high growth and aligned with community college education programs. The combined employment in the identified counties for the eight occupations totals 3,788 jobs. The following table details the 2013 employment and growth expectation from the survey sample of employers.

2013 Employment Data and Projected 3-year Occupational Growth

Occupation	Current # of Employees	5-Year Job Growth	% Growth Rate
CNC Machinist Operator	1,225	653	53.3%
CAD/CAM Programmer	550	90	16.4%
Tool/Die Maker	452	149	32.9%
Quality Control Inspector/Supervisor	609	357	58.6%
CAD/CAM Engineering Technician	146	90	61.6%
CAD/CAM Designer	434	242	55.8%
CNC Programmer	319	186	58.3%
CNC Engineering Technician	53	29	54.7%
Total	**3,788**	**1,796**	**47.4%**

Employment numbers and growth rates were calculated using employer survey responses. Respondents were asked to report the number of individuals employed at their location for each of the eight occupations. Based upon these responses, the COE calculated the distribution of employment, mean employment, median employment, and total employment. Respondents then reported the number of individuals that would be employed in the eight advanced manufacturing occupations in five years. These responses resulted in occupational growth rates for the 5-year period. The average employment data for the sample and the number of firms in the universe were used to calculate the number of employees in each of the eight occupations. Percentage growth was applied to the current employment numbers, resulting in 5-year projected growth numbers.

For additional information on data methodology or to request a copy of the survey questions, please contact the Centers of Excellence at www.coeccc.net.

Appendix C: Occupation Profiles[12]

Computer-Controlled Machine Tool Operators, Metal and Plastic

Computer-Controlled Machine Tool Operators operate computer-controlled machines or robots to perform one or more machine functions on metal or places work pieces. The following list details the specific tasks required of this occupation:

- Measure dimensions of finished workpieces using precision measuring instruments, templates, and fixtures.
- Mount, install, align, and secure tools, attachments, fixtures, and workpieces on machines, using hand tools and precision measuring instruments.
- Stop machines to remove finished workpieces or to change tooling, setup, or workpiece placement, according to required machining sequences.
- Transfer commands from servers to CNC modules, using computer network links.
- Check to ensure that workpieces are properly lubricated and cooled during machine operation.
- Set up and operate computer-controlled machines or robots to perform one or more machine functions.
- Insert control instructions into machine control units to start operation.
- Review program specifications or blueprints to determine and set machine operations and sequencing, finished workpiece dimensions, or numerical control sequences.
- Listen to machines during operation to detect sounds such as those made by dull cutting tools or excessive vibration and adjust machines to compensate for problems.
- Remove and replace dull cutting tools.

Other Job Titles Associated with Computer-Controlled Machine Tool Operators:

- Computer Numerical Control (CNC) Lathe Operator
- **CNC Machine Operator**
- **CNC Machinist**
- CNC Mill Operator
- **CNC Operator**
- CNC Setup and Operator
- Machine Operator
- Machine Set-Up
- Operator
- Machinist

Tools and Technology Used in This Occupation

Tools Used	Technology Used
Calipers	Analytical or scientific software
Gauges or inspection figures	Computer aided design (CAD) software
Lathes	Computer aided manufacturing (CAM) software
Milling machines	Project management software
Turning machines	Spreadsheet software

Occupational Wage and National Employment Trends: In 2012, Computer-Controlled Machine Tool Operators had a national median hourly wage of $17.10 ($35,580 annually). Ten percent to 19% growth is the national projection over the next ten years for this occupation.

Education and Training: Either training in vocational schools, an associate's degree, or related on-the job training are required by those employing computer-controlled machine tool operators as well as most of the occupations related to it.

[12] Source O*Net, http://www.onetonline.org/; Bureau of Labor Statistics, http://www.bls.gov/ooh/

Computer Numerically Controlled (CNC) Machine Tool Programmers, Metal & Plastic

CNC Machine Tool Programmers develop programs to control machining or processing of metal or plastic parts by automatic machine tools, equipment, or systems. The following list details the specific tasks required of this occupation:

- Determine the sequence of machine operations, and select the proper cutting tools needed to machine workpieces into desired shapes.
- Revise programs to eliminate errors, and retest programs to check that problems have been solved.
- Analyze job orders, drawings, blueprints, specifications, printed circuit board pattern films, and design data to calculate dimensions, tool selection, machine speeds, and feed rates.
- Determine reference points, machine cutting paths, or hole locations, and compute angular and linear dimensions, radii, and curvatures.
- Observe machines on trial runs or conduct computer simulations to ensure that programs and machinery will function properly and produce items that meet specifications.
- Compare encoded tapes or computer printouts with original part specifications and blueprints to verify accuracy of instructions.
- Write programs in the language of a machine's controller and store programs on media such as punch tapes, magnetic tapes, or disks.
- Modify existing programs to enhance efficiency.
- Enter computer commands to store or retrieve parts patterns, graphic displays, or programs that transfer data to other media.

Other Job Titles Associated with Computer-Controlled Machine Tool Operators

- CNC Programmer
- Process Engineer
- Programmer
- Project Engineer
- Software Engineer
- Welding Engineer
- Computer-Aided Design/Computer-Aided Manufacturing Programmer (CAD/ CAM Programmer)

Knowledge and Skills Needed for This Occupation:

Knowledge	Skills
• Mathematics	• Programming
• Mechanical	• Complex problem solving
• Design	• Monitoring
• Engineering and technology	• Operation monitoring
• Production and processing	• Critical thinking
• Computers and electronics	• Active learning
• English language; Reading comprehension	• Judgment and decision making
• Education and training	• Systems analysis

Occupational Wage and National Employment Trends: In 2012, CNC Machine Tool Programmers had a national median hourly wage of $22.08 ($45,920 annually). Ten percent to 19% growth is the national projection over the next ten years for this occupation.

Education and Training: Either training in vocational schools, an associate's degree, or related on-the job training are required by those employing computer-controlled machine tool operators as well as most of the occupations related to it.

Mechanical Drafters

Mechanical Drafters prepare detailed working diagrams of machinery and mechanical devices, including dimensions, fastening methods, and other engineering information. The following list details the specific tasks required of this occupation:

- Develop detailed design drawings and ci for mechanical equipment, dies, tools, and controls, using CAD equipment.
- Lay out and draw schematic, orthographic, or angle views to depict functional relationships of components, assemblies, systems, and machines.
- Coordinate with and consult other workers to design, lay out, or detail components and systems and to resolve design or other problems.
- Check dimensions of materials to be used and assign numbers to the materials.
- Review and analyze specifications, sketches, drawings, ideas, and related data to assess factors affecting component designs and the procedures and instructions to be followed.
- Modify and revise designs to correct operating deficiencies or to reduce production problems.
- Compute mathematical formulas to develop and design detailed specifications for components or machinery using computer-assisted equipment.
- Position instructions and comments onto drawings.
- Lay out, draw, and reproduce illustrations for reference manuals and technical publications to describe operation and maintenance of mechanical systems.
- Design scale or full-size blueprints of specialty items such as furniture and automobile body or chassis components.

Other Job Titles Associated with Mechanical Drafters

- Mechanical Drafter
- Designer
- Drafter
- Design Drafter
- Mechanical Designer
- **Computer Aided Design Designer (CAD Designer)**
- CAD Operator
- CAD/CAM Specialist
- Project Designer
- Installation Drafter

Tools and Technology Used in This Occupation

Tools Used	Technology Used
• Curves • Plotter printers • Scales • Scanners • Triangles	• CAD software • Document management software • Graphics or photo imaging software • Optical character reader (OCR) or scanning software • Spreadsheet software

Occupational Wage and National Employment Trends: In 2012, Computer-Controlled Machine Tool Operators had a national median hourly wage of $24.21 ($50,360 annually). Ten percent to 19% growth is the national projection over the next ten years for this occupation.

Education and Training: Either training in vocational schools, an associate's degree, or related on-the job training are required by those employing computer-controlled machine tool operators as well as most of the occupations related to it.

Tool and Die Maker

Tool and Die Makers analyze specifications, lay out metal stock, set up, and operate machine tools, and fit and assemble parts to make and repair dies, cutting tools, jigs, fixtures, gauges, and machinists' hand tools. The following list details the specific tasks required of this occupation:

- Verify dimensions, alignments, and clearances of finished parts for conformance to specifications, using measuring instruments such as calipers, gauge blocks, micrometers, and dial indicators.
- Study blueprints, sketches, models, or specifications to plan sequences of operations for fabricating tools, dies, or assemblies.
- Set up and operate conventional or CNC machine tools such as lathes, milling machines, and grinders to cut, bore, grind, or otherwise shape parts to prescribed dimensions and finishes.
- Visualize and compute dimensions, sizes, shapes, and tolerances of assemblies, based on specifications.
- Inspect finished dies for smoothness, contour conformity, and defects.
- Fit and assemble parts to make, repair, or modify dies, jigs, gauges, and tools, using machine tools and hand tools.
- Conduct test runs with completed tools or dies to ensure that parts meet specifications, making adjustments as necessary.
- Select metals to be used from a range of metals and alloys, based on properties such as hardness and heat tolerance.
- File, grind, shim, and adjust different parts to properly fit them together.
- Lift, position, and secure machined parts on surface plates or worktables, using hoists, vises, v-blocks, or angle plates.

Other Job Titles Associated with Mechanical Drafters

- Aircraft Tool Maker
- Carbide Tool Die Maker
- **Die Maker**
- Jig and Fixture Builder
- Jig and Fixture Repairer
- Tool Repairer
- Tool and Die Machinist
- **Toolmaker**
- Trim Die Maker

Tools and Technology Used in This Occupation

Tools Used	Technology Used
• Calipers • Gauges or inspection fixtures • Power grinders • Squares • Workshop presses	• CAD software • CAM software • Materials requirements planning logistics and supply chain software • Project management software • Word processing software

Occupational Wage and National Employment Trends: In 2012, Computer-Controlled Machine Tool Operators had a national median hourly wage of $22.60 ($47,000 annually). The national projection over the next ten years is **-2%** to 2%.

Education and Training: Either training in vocational schools, an associate's degree, or related on-the job training are required by those employing computer-controlled machine tool operators as well as most of the occupations related to it.

Appendix D: Advanced Manufacturing Soft Skills

Microsoft Office				
	Extremely Difficult	Somewhat Difficult	Not Very Difficult	Not at All Difficult
CAD/CAM Designer	6.5%	26.8%	55.3%	11.4%
CAD/CAM Programmer	4.6%	27.5%	47.7%	20.2%
CAD/CAM Engineering Technician	9.7%	16.1%	48.4%	25.8%
CNC Machinist Operator	13.7%	37.6%	40.2%	8.5%
CNC Programmer	7.0%	36.8%	47.4%	8.8%
CNC Engineering Technician	5.9%	29.4%	58.8%	5.9%
Quality Control Inspector/Supervisor	3.9%	35.4%	50.4%	10.2%
Tool/Die Maker	9.5%	46.3%	32.6%	11.6%

Math Skills				
	Extremely Difficult	Somewhat Difficult	Not Very Difficult	Not at All Difficult
CAD/CAM Designer	14.6%	39.0%	38.2%	8.1%
CAD/CAM Programmer	15.6%	43.1%	33.9%	7.3%
CAD/CAM Engineering Technician	9.7%	41.9%	22.6%	25.8%
CNC Machinist Operator	19.7%	47.0%	28.2%	5.1%
CNC Programmer	12.3%	48.2%	34.2%	5.3%
CNC Engineering Technician	5.9%	70.6%	23.5%	0%
Quality Control Inspector/Supervisor	13.4%	52.0%	33.9%	0.8%
Tool/Die Maker	16.8%	49.5%	27.4%	6.3%

Teamwork/Collaboration				
	Extremely Difficult	Somewhat Difficult	Not Very Difficult	Not at All Difficult
CAD/CAM Designer	13.8%	41.5%	36.6%	8.1%
CAD/CAM Programmer	9.2%	43.1%	41.3%	6.4%
CAD/CAM Engineering Technician	19.4%	25.8%	35.5%	19.4%
CNC Machinist Operator	14.5%	49.6%	31.6%	4.3%
CNC Programmer	14.0%	36.0%	45.6%	4.4%
CNC Engineering Technician	17.6%	47.1%	29.4%	5.9%
Quality Control Inspector/Supervisor	10.2%	47.2%	27.8%	4.7%
Tool/Die Maker	12.6%	38.9%	44.2%	4.2%

Problem Solving Skills				
	Extremely Difficult	Somewhat Difficult	Not Very Difficult	Not at All Difficult
CAD/CAM Designer	29.3%	46.3%	20.3%	4.1%
CAD/CAM Programmer	24.8%	51.4%	19.3%	4.6%
CAD/CAM Engineering Technician	25.8%	29.0%	29.0%	16.1%
CNC Machinist Operator	31.6%	44.4%	18.8%	5.1%
CNC Programmer	25.4%	47.4%	22.8%	4.4%
CNC Engineering Technician	47.1%	41.2%	11.8%	0%
Quality Control Inspector/Supervisor	22.8%	53.5%	22.0%	1.6%
Tool/Die Maker	31.6%	48.4%	17.9%	2.1%

Oral Communication				
	Extremely Difficult	Somewhat Difficult	Not Very Difficult	Not at All Difficult
CAD/CAM Designer	11.4%	45.5%	35.0%	8.1%
CAD/CAM Programmer	6.4%	54.1%	30.3%	9.2%
CAD/CAM Engineering Technician	16.1%	48.4%	25.8%	9.7%
CNC Machinist Operator	17.1%	54.7%	25.6%	2.6%
CNC Programmer	10.5%	43.9%	42.1%	3.5%
CNC Engineering Technician	17.6%	52.9%	23.5%	5.9%
Quality Control Inspector/Supervisor	11.8%	47.2%	35.4%	5.5%
Tool/Die Maker	11.6%	45.3%	38.9%	4.2%

Written Communication				
	Extremely Difficult	Somewhat Difficult	Not Very Difficult	Not at All Difficult
CAD/CAM Designer	18.7%	38.8%	34.1%	7.3%
CAD/CAM Programmer	12.8%	45.0%	34.9%	7.3%
CAD/CAM Engineering Technician	19.4%	51.6%	16.1%	12.9%
CNC Machinist Operator	16.2%	57.3%	23.9%	2.6%
CNC Programmer	16.7%	43.0%	36.8%	3.5%
CNC Engineering Technician	17.6%	64.7%	17.6%	0%
Quality Control Inspector/Supervisor	16.5%	48.8%	33.1%	1.6%
Tool/Die Maker	21.1%	37.9%	35.8%	5.3%

Appendix E: Manufacturing Programs

A preliminary review of available education programs revealed 42 different manufacturing related programs in the regions studied.[13] While the current program offerings most likely have the capacity to fill current and projected employment demands, it is unclear to what extent the offerings meet industry technology, machinery, and process demands. Additional research is needed to conduct a detailed inventory of program offerings that identify technology, machinery, and processes within each program. Additionally, information reflecting program completion, demand, and challenges would provide colleges insight into the extent that program offerings are aligned with program demand.

Advanced Manufacturing Programs

CIP Code	Program Title	CIP Code	Program Title
01.1002	Food Technology and Processing	15.1201	Computer Engineering Technology/Technician
03.0509	Wood Science and Wood Products/Pulp and Paper Technology	15.1202	Computer Technology/Computer Systems Technology
14.1801	Materials Engineering	15.1203	Computer Hardware Technology/Technician
14.1901	Mechanical Engineering	15.1301	Drafting and Design Technology/Technician, General
14.2701	Systems Engineering	15.1302	CAD/CADD Drafting and/or Design Technology/Technician
14.2801	Textile Sciences and Engineering	15.1303	Architectural Drafting and/or Architectural CAD/CADD
14.3501	Industrial Engineering	15.1305	Electrical/Electronic Drafting and Electrical/Electronic CAD/CADD
14.3601	Manufacturing Engineering	15.1306	Mechanical Drafting and Mechanical Drafting CAD/CADD
14.4101	Electromechanical Engineering	15.1501	Engineering/Industrial Management
14.4201	Mechatronics, Robotics, and Automation Engineering	19.0902	Apparel and Textile Manufacturing
15.0399	Electrical and Electronic Engineering Technology/Technician	41.0303	Chemical Process Technology
15.0403	Electromechanical Technology/Electromechanical Engineering Technology	47.0105	Industrial Electronics Technology/Technician
15.0404	Instrumentation Technology/Technician	47.0303	Industrial Mechanics and Maintenance Technology
15.0607	Plastics and Polymer Engineering Technology/Technician	48.0501	Machine Tool Technology/Machinist
15.0613	Manufacturing Engineering Technology/Technician	48.0503	Machine Shop Technology/Assistant
15.0616	Semiconductor Manufacturing Technology	48.0506	Sheet Metal Technology/Sheet working
15.0699	Industrial Production Technologies/Technicians/Other	48.0508	Welding Technology/Welder
15.0702	Quality Control Technology/Technician	48.0510	Computer Numerically Controlled (CNC) Machinist Technology/CNC Machinist
15.0801	Aeronautical/Aerospace Engineering Technology/Technician	48.0702	Furniture Design and Manufacturing
15.0803	Automotive Engineering Technology/Technician	52.0203	Logistics, Materials, and Supply Chain Management
15.0805	Mechanical Engineering/Mechanical Technology/Technician	52.0205	Operations Management and Supervision

Note: Program offerings are reported to IPEDS using CIP Codes, not TOP Codes

[13] Integrated Postsecondary Education Data System (IPEDS), www.nces.ed.gov