THE IMPLICATIONS THAT CHANGE IN MANUFACTURING WILL HAVE ON EMPLOYMENT OF MICHIGAN WORKERS

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Planning, Design, and Construction - Doctor of Philosophy

2021

ABSTRACT

THE IMPLICATIONS THAT CHANGE IN MANUFACTURING WILL HAVE ON EMPLOYMENT OF MICHIGAN WORKERS

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Michigan is closely tied to its economic success as a manufacturing center and a hub for the global automotive industry. Over the years, automation and relocation has reduced the role of manufacturing as a source of employment and led to the decline of manufacturing communities in Michigan. The challenges of declining manufacturing communities and concern for access to employment by displaced workers and underrepresented groups prompts this analysis of career paths and education for advanced manufacturing. Research examined the potential for training and upskilling at community colleges, and the development of a labor pool equipped to serve in emerging and future manufacturing jobs in the United States and the State of Michigan.

To understand the career paths available and the experience of students, three analyses were conducted of students, instructors, and employers. The student survey of 190 students across five community colleges in southeast, central, and west Michigan was conducted in the summer and fall of 2020. The study found community colleges are providing Michigan workers with the technical skills needed for advanced manufacturing jobs but more work needs to be done. There is a divide between what the businesses wish community colleges were teaching and the rate it is being taught and what the budget constraints of the community colleges allow them to teach and how fast. Policy recommendations to close the divide is to formulate government policies that assist students in paying for their education to allow more to attend a community college and provide financial support for schools to invest in the latest equipment and technologies for training that employers demand. The technician study can be utilized as Michigan sets policies to get more students to meet its Sixty by 2030 goal where 60 percent of adult workers obtain a certificate or degree by 2030.

This dissertation is dedicated in honor of my maternal great-grandfather, Frank Smith Sr. and paternal grandfather, Dennis L. Green, Sr. who in the early 1920s and 1940s, respectively, as former Georgia residents began to work in the Detroit automotive plants to make a better way for their families. Their hard work and dedication set an example for their children, grandchildren, and great-grandchildren to follow as they have made careers from the blue-collar assembly line to white-collar middle management.

ACKNOWLEDGEMENTS

Special thanks go out to my dissertation committee members for their dedication and guidance in my research.

Dr. Mark Wilson , Major Professor, School of Planning, Design, and Construction

Dr. Laura Reese, Professor, School of Planning, Design, and Construction

Dr. George Berghorn, Professor, School of Planning, Design, and Construction

Dr. Mark Skidmore, Morris Chair in State and Local Government Finance and Policy; Professor, Department of Economics

Dr. David Ranney, Professor Emeritus in Urban and Planning Policy at the University of Illinois at Chicago. In his economic development class in 1997, he challenged my viewpoint that globalization of the automotive industry would have a detrimental impact on Detroit. He, however, thought globalization would be the best thing to create jobs. This piqued my interest to analyze the topic to this day as an insurmountable amount of job losses have occurred. Thus, has led to the development of this study.

Dr. Rachel Weber, Professor and Director of Graduate Studies in Urban and Planning Policy at the University of Illinois at Chicago. As my major professor over my master's thesis, she helped me develop my research skills that were utilized in this study and will be in future research projects.

A heartfelt thank you goes out to the Institutional Review Boards at Oakland Community College, Washtenaw Community College, Macomb Community College, Grand Rapids Community College and Lansing Community College. A great debt of gratitude is owed to them for approving their students and instructors to participate in this study.

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CHAPTER 1: INTRODUCTION

1.0 Introduction

Michigan is closely tied to its economic success as a manufacturing center and a hub for the global automotive industry. Over the years, automation and relocation has reduced the role of manufacturing as a source of employment and led to the decline of manufacturing communities in Michigan. The challenges of declining manufacturing communities and concern for access to employment by dislocated workers and underrepresented groups prompts this analysis of career paths and education for advanced manufacturing. Advanced manufacturing includes automated production and research and development of new technologies. This research surveyed community college students and instructors, as well as interviewed advanced manufacturing employers in southeast, central, and west Michigan to learn about readiness to adapt to the changing technological needs of manufacturing and its employment requirements.

1.1 Main Issues

Between now and 2050, many manufacturing jobs in the United States will be subject to automation and created by artificial intelligence and machine learning to perform repetitive tasks found in industries like automotive manufacturing (Holzer, 2019). Holzer (2019) estimated that 10 percent of jobs will be completely automatable over the next few decades and 30 to 40 percent partially automated. Dziczek et al. (2017) state that more automotive positions will be technologically inclined and require a STEM background. Being skilled in lightweighting, designing, analyzing, and building automotive tools, dies, molds, jigs, and fixtures to form the array of new and advanced materials that are being deployed in current and future vehicles will be an asset. There are different schools of thought on how this will affect the workers. Levy and Murname (2013) believe the relationship between automation and labor can be a complement or substitute. It is believed that the number of jobs can actually grow because the costs of

producing new products like automobiles so fast will cause prices to fall rapidly, enabling middle and low-income customers to buy them for the first time reducing the labor needed to produce them and in turn driving up the demand for workers in the industry. On the other hand, automation can replace or substitute some groups of workers, while creating new demand or complementing other workers. Holzer (2019) gives the example of robots replacing workers on manufacturing assembly lines while creating jobs for engineers or technicians.

Furthermore, international trade agreements by the federal government will impact the labor force for decades to come. More imports as well as offshoring of production of goods and services by U.S. firms have weakened labor demand in the U.S (Holzer, 2019). Holzer states that our older workforce and significantly less-educated minority workers might face greater difficulties adapting than a younger more educated one. In addition, there will be periodic shortages of skilled workers in growing occupations and industries, while other workers may be dislocated and underemployed. Finally, the Covid-19 pandemic has been a disruptive force in the economy and labor market that cannot yet be fully evaluated.

Over the years in Michigan, automation and international trade doubled the blow to manufacturing workers and led to the decline of manufacturing communities in Michigan where automotive plants once stood. Holzer states that reforms should expand student attainment of "21st Century Skills" that will make them more complimentary with and less substitutable by new automation. Also, reforms should create systems of "lifelong learning" where workers who have experienced (or are at risk of) technological displacement can more easily obtain new skills that better compliment automation in the workplace.

This study will assess the possibility of community colleges providing training to unskilled and dislocated workers that will complement new technologies in advanced manufacturing. Further, the study will look

at training that can be transferred to other growing sectors in Michigan such as pharmaceutical, aerospace, and biomedical manufacturing and research and development. Research hypothesizes that community college training is an effective way to prepare Michigan workers for the changes manufacturing will have on employment. The struggles of unskilled and dislocated workers are being addressed in manufacturing states such as Pennsylvania, Massachusetts, Ohio, Tennessee, Texas, Illinois, and Indiana and will be used as models for this study.

1.2 Background

A country's ability to produce products from raw materials into quality goods gives a country an advantage over others. Freelance writer Andrew Lisa (2019) describes the ingenuity of inventors, engineers, builders, and titans of industry like Henry Ford as key players in the history of manufacturing. The automotive industry was a major economic engine for this country during the 20th century. Families came to Michigan from all corners of the United States to work on Ford Motor Company's assembly line in the early 1900's (Maynard, 2003). It was possible for workers to save enough money to buy a home and to purchase cars manufactured by these companies. Family members of these workers remained loyal to the respective automotive employer and purchased their cars, too (Popeley, 2016). This kept the industry flourishing and fueled the nation to where automotive manufacturing was the foundation that set wages for other industries after it became unionized (Durban and Krisher, 2010). A union autoworker was able to provide a quality standard of living for their families for decades to come.

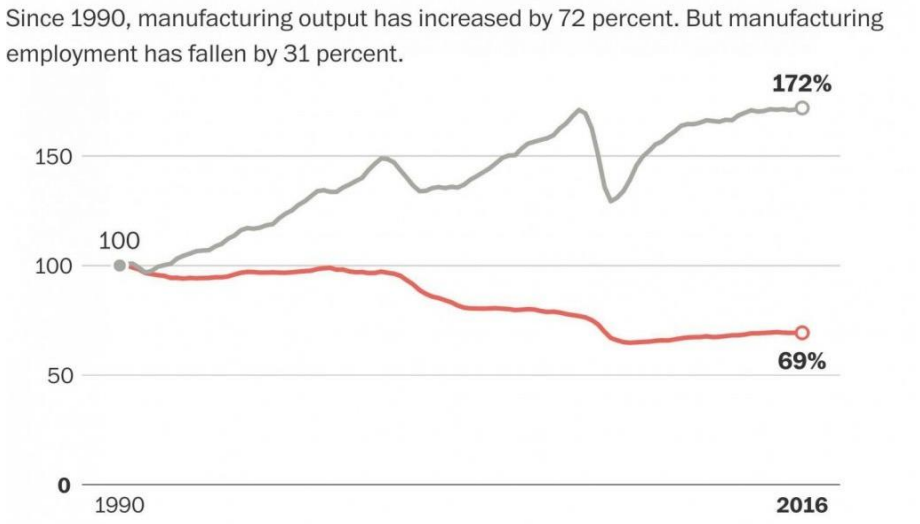
When times are good, the automotive industry is prosperous. At its peak a scant 40 years ago, Detroit-built vehicles accounted for more than 9 out of 10 automobile sales in the U.S (Maynard, 2003). Nearly a million people in the U.S. worked in automobile plants, and every manufacturing job created by Detroit generated five more, at automotive parts suppliers scattered across the country, at steel mills in

Pittsburgh, Cleveland, Detroit, and Chicago, and at coal mines in West Virginia and in the Deep South (Maynard, 2003). Workers were able to infuse disposable income into the ecosystem and small businesses like grocery stores and cleaners were established to meet their needs. This is how communities came to be a part of the American dream of owning a home and sending children to a nearby public school for a valuable education.

There are a number of studies on the automotive industry chiefly done by economists and automotive analysts. Klier and Rubenstein and the University of Michigan Center for Automotive Research examined how the Detroit Three (GM, Ford & Stellantis) lost its market share in the 1990s and what the future of the industry holds. Following the sequence of research, this industry went through ups and downs and all manufacturing companies, American and international, made the needed adjustments to the market. This includes government intervention by way of free trade agreements and tariffs. Trade agreements such as the North American Free Trade Agreement in 1994 also contributed to the decline of manufacturing workers by opening up global markets and investing less capital (Dziczek et al., 2018) .

As time went on, U.S. manufacturing employment declined while production increased because of automation to get rid of human errors. Figure 1 shows how manufacturing output rose by 72 percent even as employment fell by 31 percent from 1990 – 2016 (Vyomika, 2018).

Figure 1: The Employment of Less Workers for Manufacturing Output

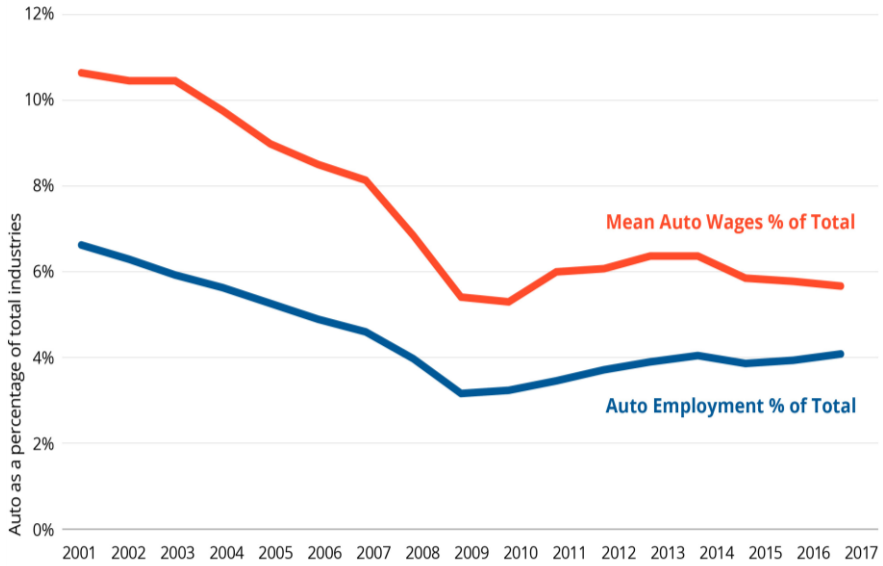


Source: Vyomika, 2018, taken from BLS FRED

Michigan, like other midwestern manufacturing states has been impacted negatively by the decline in U.S. manufacturing. Hohman and Slasinski (2019) found that one out of 25 jobs in Michigan is in automotive manufacturing. They do not minimize the importance of education but show how it has diminished in the state compared to yesteryear. The industry hit the lowest at 3 percent of total industries in 2008 – 2009 during the Great Recession, which had 4,835,000 workers. In September 2009, the number of people employed in Michigan was 4,095,000, down 14,000 from the previous month, while the labor force decreased by 10,000. The statewide total number of unemployed increased by 4,000 to 740,000 (State of Michigan Department of Treasury, 2009). In 2017, automotive employment rose to 4 percent of the total state's workforce while automotive wages were at 7 percent, much lower than other Michigan industry

wages. Hohman and Slasinski state that it is not that Michigan is producing fewer vehicles, it is that fewer people make them. In fact, vehicle production is nearly the same as it was 20 years ago. Figure 2 shows the state's decline in automotive manufacturing employment from 2001 – 2017.

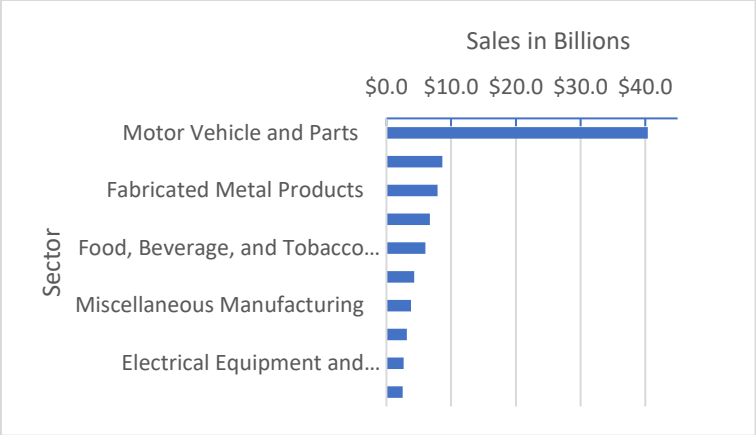
Figure 2: Auto and Auto Part Employment and Wages as a Percent of Michigan's Total



Source: Hohman and Slasinski, 2019 taken from BLS and Mackinaw Policy Center

Michigan has several manufacturing sectors: furniture and related products; electrical equipment and appliances, primary metal; plastics and rubber products; food, beverage, and tobacco products; chemical products; and the dominant motor vehicle and parts. Michigan is singularly dependent on motor vehicle and parts manufacturing which totaled over $40 billion in 2017 (National Association of Manufacturers, 2019). Figure 3 on the next page shows the top 10 manufacturing sectors in Michigan.

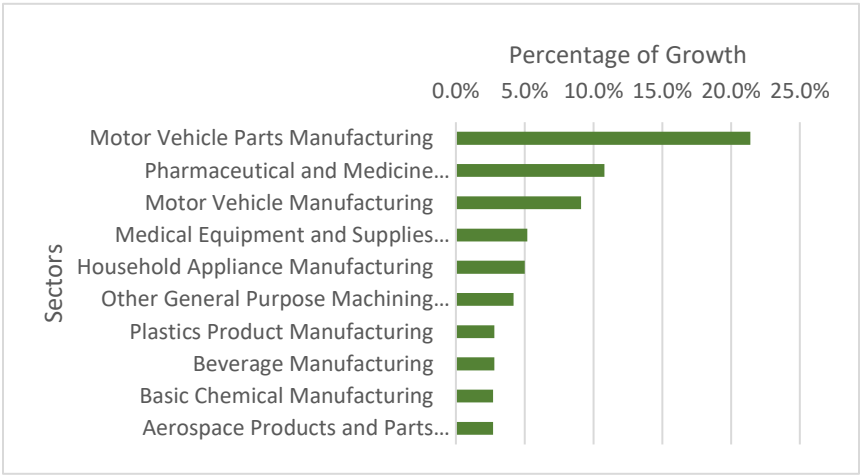
Figure 3: Top 10 Michigan Manufacturing Sectors, 2017



Source: National Association of Manufacturers, 2019

Michigan has other manufacturing sectors that have growth potential and will be discussed in this study. Figure 4 shows that the pharmaceutical and medicine manufacturing sector has grown by 10.8 percent in 2018; medical equipment and supplies manufacturing by 5.2 percent; and aerospace products and parts manufacturing by 2.7 percent.

Figure 4: Top 10 Major Michigan Manufacturing Job Growth Sectors, 2018



Source: 2019 Michigan Manufacturing Facts

As Michigan manufacturers add more automated technologies such as robotics and artificial intelligence and the Detroit Three look to capture the autonomous vehicle (AV) and electronic vehicle (EV) market in

the next five years, what will happen to employment of the less skilled manufacturing worker? If there is a skill deficiency in Michigan workers for this new technology, will this result in more jobs being shipped overseas to more educated countries with cheaper labor costs? Will the state's manufacturing employment decrease further? What effect will this have on Michigan manufacturing communities that house these plants?

Given the employment experience of the automotive industry in Michigan and the United States, there is concern by employers, workers and policymakers about labor force preparedness for future manufacturing needs. One avenue for talent development is through post-secondary education, such as community colleges. Can community colleges play a role in advanced manufacturing training and upskilling of workers?

With a STEM education, community college students will be skilled for future automotive and other manufacturing sector jobs. As the automotive industry invests money in producing AVs and EVs, community colleges can play an important role in preparing students for high-demand jobs. Carson et al. (2019) state that employers are having trouble finding the right workers. Currently 390,000 manufacturing jobs in the U.S. remain unfilled because they require workers trained in high-skilled manufacturing methods. They cite Justin Guinn's, a content analyst at Software Advice, explanation that "the prevalence of computer-controlled machinery now demands manufacturing workers possess a combination of math skills, intuition, stamina, and often a college degree" (Carson et al., pg. 4). Post-secondary community colleges have long played a role in upskilling workers to meet the needs of local employers. Carson and collaborators point out that there is a wide variation in the approaches the institutions take. Some community colleges in the U.S. are run on a statewide system, allowing more coordination across campuses and giving students access to state resources. Other community colleges

are less coordinated but have the freedom for local institutions to partner directly with local employers to meet that employer's needs.

1.2.1 Central Research Question

Central Research Question: Can community colleges provide Michigan workers with the technical skills needed for advanced manufacturing jobs?

To understand the needs and interests of advanced manufacturing, surveys comprising community college students and instructors and interviews with advanced manufacturing employers were conducted. The surveys evaluated whether students at five community colleges throughout Michigan have the skills to represent a qualified talent pool for technologically advanced manufacturing. An apprenticeship and job placement through a community college will be ways for traditional and nontraditional students to gain entry into high demand jobs. Traditional students are defined as high school students who enroll in a community college shortly after graduation. Nontraditional students are defined as older students (beyond high school age) who are unemployed, underemployed, and veterans that are returning to or starting a post-secondary institution later in life. Instructors were surveyed to determine their process for designing a curriculum and to determine the extent of their knowledge of the subject they are teaching. Employers were asked the skill sets that they look for in new hires and their outlook on advanced manufacturing.

1.2.2 Problem Statements

Structural change means that as an economy evolves, the nature of production changes both what is produced and how it is produced. For Michigan's top manufacturing industry, the automotive sector, there is greater emphasis on plastics and composite materials, as well as software and electronics. To make today's vehicles, different labor skills are needed compared to the past. The result is that vehicles are very different than forty years ago, and the skills and labor needed are also different. While this may result in more advanced vehicles, it can hurt traditional manufacturing occupations whose skills are no longer needed.

Problem #1: Michigan's labor pool may not be skilled enough to meet the technological demands required of the fourth Industrial Revolution in automation. This new revolution is a fusion of advances in artificial intelligence (AI), robotics, the Internet of Things (IoT), 3D printing, genetic engineering, quantum computing, and other technology (McGinnis, 2018). A loss of traditional manufacturing jobs will ensue and the lack of a skilled labor pool in Michigan may cause production to be moved to other states or countries as more technically skilled jobs are created. The loss of jobs will hurt dislocated workers and the cities they live in. These cities are already in distress because an automotive plant may be one of their largest employers like the case of Highland Park, Michigan. Thus, a more comprehensive study is needed to assess Michigan's talent pool and its skill set to be competitive globally to meet the demands of a changing market. Ideally, their skills will be transferrable to other manufacturing sectors should one sector like automotive decline.

Problem #2: Can community colleges provide a path for students to gain skills in demand for manufacturing of the future? The definition of skilled is having training (classroom and apprenticeship) to fill the technological requirements to make products such as AVs and EVs and new lightweight materials

for the exterior and interior. The future is the next five years (2019 – 2024). The study will research various technician positions being brought on-line to advance the industry.

1.3 Research Goals and Objectives

The goals and objectives address the problem statement. Goal #1 is to identify manufacturing jobs of the future. The objective is to link unskilled and dislocated workers in manufacturing communities to training at community colleges for positions that are vacant and in high demand. Goal #2 is to determine if the skills being obtained can be transferred to other sectors in advanced manufacturing outside of the automotive industry and research and development in all areas.

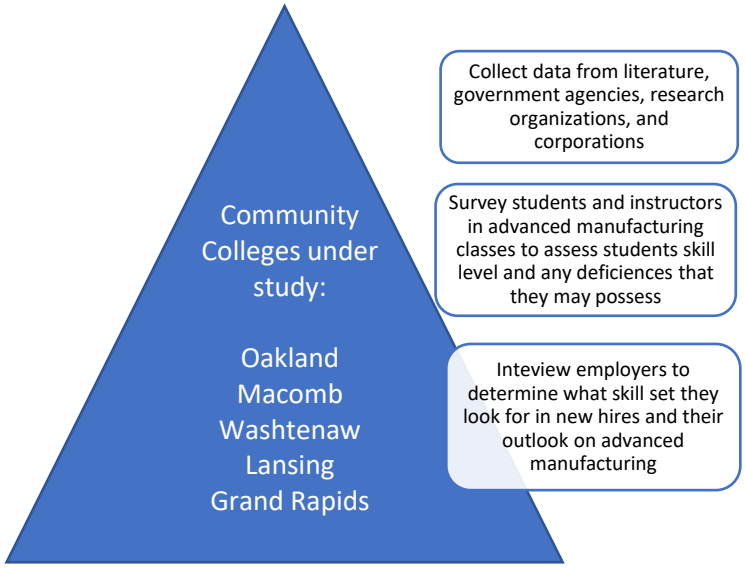
1.4 Research Hypothesis

Community colleges are two-year schools that provide post-secondary education. Usually traditional and non-traditional students attend community colleges because they are more affordable than a four-year institution. The research hypothesis is that community college training is an effective way to prepare Michigan workers for the changes manufacturing will have on employment. It will be tested in the study.

An overview of data collection and analysis is presented in Figure 5 on the next page, showing the five community colleges under study, the method to collect data from literature, government agencies, research organizations, and manufacturing corporations. Students and instructors in advanced manufacturing classes were surveyed and manufacturing employers were interviewed to assess students' skill level and any deficiencies that they may possess.

1.5 Process of Data Collection and Analysis

Figure 5: Diagram of Study Subjects and Plan for Data Collections and Analysis



Evidence gathering to test the hypothesis came from an evaluation of each school's curricula. Each community college's DACUM process was asked in the instructor survey. DACUM (developing a curriculum) is a process when a focus group is used to capture the major duties and related tasks included in an occupation, as well as, the necessary knowledge, skills, and traits, also known as job tasks analysis (Eastern Kentucky University, 2019). Usually, a panel of six to eight high-performing incumbent workers analyze their own job duties and tasks over a two-day period. A facilitator gets the workers to employ a storyboarding technique. The final product is an occupational profile presented in a chart format to include tasks sequenced and ranked according to criticality; most time consuming; new worker training needs; and veteran worker training needs. These panels are assembled at each community college/university under study and are analyzed as part of this research.

Community college students were surveyed for the skills that have been identified for advanced manufacturing such as mechatronics and robotics in the automotive industry and whether they were being trained on the latest equipment. These skills should be transferrable to any other advanced

manufacturing sector. The technician study evaluates whether there is a pipeline from STEM preparation in high school to admission into a community college training program to result in being placed in an advanced manufacturing position after graduation.

1.6 Contents and Organization

The dissertation is presented in nine chapters as follows:

Chapter 1: Introduction

This chapter addresses the main issues, background, central research question, problem statements, research goals and objectives, research hypothesis, and the content and organization of this dissertation.

Chapter2: Theoretical Background and Literature Review

The theoretical framework focuses on two sets of theories. The first set of literature explores the framework of theories on the change in the American manufacturing industry due to technology and its future human capital needs as a result. The second set of literature looks at community colleges as a pathway to future manufacturing jobs for unskilled and dislocated workers.

Chapter 3: Case Study: The Role of Community Colleges in Workforce Development

Community colleges play an important role in education and training in Michigan, and this chapter provides a profile of their scale and scope in the state. In addition, there is focus on five community colleges in selected Michigan counties to participate in this study to assess their training in advanced manufacturing. The educational level of the county residents is highlighted. Further, the demographics of the student population at all participating community colleges and in the advanced manufacturing academic programs are identified.

Chapter 4: The Research Design and Methodology

Informed by the literature on manufacturing employment and community college training, this chapter outlines the approach to data collection used to support the research hypothesis. Evidence to test the hypothesis was collected from surveys of community college students and instructors and interviews with advanced manufacturing employers. The methodology taken to survey and collect data is discussed and the reliability and validity of the data is tested. Finally, an analysis plan lays out the measures that will evaluate the variables in the next chapter.

Chapter 5: Analysis and Findings from Student Survey

The study contains responses from a student survey to assess the advanced manufacturing training and skill level of the participants. The results of the student survey are presented and assessed, allowing evaluation of the core hypothesis as to whether community college training is an effective way to prepare Michigan workers for the changes manufacturing will have on employment.

Chapter 6: Analysis and Findings from Instructor Survey

The study contains responses from an instructor survey that assesses their knowledge of the course they are teaching and what they are doing to address deficiencies in students. The results of the survey were analyzed qualitatively and quantitatively to assess community college training.

Chapter 7: Analysis and Findings from Employer Interviews

The study contains responses from employer interviews. The results of the interviews were analyzed quantitatively to determine the skill set that they look for in new hires and if they influence the curriculum of their respective community college.

Chapter 8: Policy Recommendations

The implications that change in manufacturing will have on employment of Michigan workers is considered in light of possible policy remedies. The research questions and hypothesis are also answered. Policies recommendations are offered as solutions to get more workers trained at community colleges.

Chapter 9: Conclusions

The motivation for this study was concern both for career development that maintains traditional manufacturing communities in Michigan and also provides a career ladder for economic success for individuals and communities bypassed by recent economic trends. The dissertation research focused on ways to get unskilled and dislocated workers equipped to handle the change that is occurring in Michigan's largest employment sector, manufacturing.

CHAPTER 2: THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1 Introduction

This chapter reviews how the changing needs of manufacturing in the United States and Michigan have led to significant changes in demand for labor while also marginalizing some workers. Recognizing how manufacturing in the future will need different skill sets that may exclude disadvantaged members of the community, the review continues by analyzing the emerging skills needed and the role of community colleges in providing career opportunities.

2.2 The Changing American Manufacturing Industry

American manufacturing has long been a central route for economic opportunity and success that allowed a middle-class way of life for millions of people. Starting in the 1990's, changes in manufacturing such as automation, deskilling, and offshore production changed the organization of the industry and also its labor needs. The reorganization of manufacturing hurt many communities and led to the naming of the Midwest as the Rust Belt due its abandoned and underused industrial infrastructure.

2.2.1 The Automotive Sector

One of the most significant sectors of U.S. manufacturing is the automotive industry, that is a $327.1 billion part of the economy that employs 17.9 million workers in the United States (Amadeo, 2019). In particular, this industry is central to the economy and even identity of Michigan which has been the global hub for production and automotive firms for a century.

Klier (2009) methodically explains how it was imports from foreign markets in the 1950s that started the trend toward small cars. His research analyzes the time periods when Detroit responded to this switch in product from foreign imports and foreign manufacturing on American soil and the downturns in the

industry altogether from the oil embargo and rise in gasoline prices to exorbitant legacy costs in 2008. The decline took place in three distinct phases: the mid-1950s to 1980, 1980 to 1996, and 1996 to 2008.

With the oil embargo in the 1970s, the automotive industry began to be cyclical in nature (McIntosh, 2017). The U.S. was dependent on foreign oil that came from the Organization of the Petroleum Exporting Countries (OPEC) founded in 1960 by Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela. The United States used about 17 million barrels of oil each day, but only produced 11 million barrels. Most of the oil needed came from Venezuela. After the Six-Day War of 1967 that included Egypt, Syria, and Jordan that lost land to Israel, OPEC cut off oil supply in retaliation (History.com, 2018). Prices soared and American car owners regretted owning gas guzzlers. Smaller cars were more desired and were imported by foreign competitors. As the years passed, more foreign cars were sold in the United States.

Richardson (1994, pg. 5) describes the economic environment in the 1980's as dominated by the dramatic decline and sluggish recovery of the U.S. balance of trade. He credits the trade balance to the sharp early and mid-1980s breaks in monetary, fiscal, and foreign exchange policies and by the shifting ideologies that prompted them. In addition, there were perceived changes in the structure of U.S. trade: apparent losses of competitive advantage in manufactures, especially high-technology manufactures (construction machinery and home appliances); inadequate and dubious gains of competitive advantage in business services; increasing specialization on narrow product varieties; and outsourcing. Lastly, the end of the period was marked by the reacceleration of foreign direct investment in the United States, especially through takeovers. For example, a British firm could acquire a U.S. firm with funds borrowed in the United States; a Japanese firm could acquire a U.S. firm via an exchange of stock with an already existing subsidiary. In either case, there would be an increase in the share of the U.S. economy controlled by foreign firms, but no inflow of capital (Graham and Krugman, 1993). The Japanese car companies: Honda

built its first car at Marysville, Ohio, in 1982. Nissans were built in Smyrna, Tennessee in 1983. Toyotas were actually sold in the U.S. in 1957 but it was not until 1982 that the U.S. headquarters opened in Torrance, California (Toyota Today, 2017). Mazda entered the market earlier in 1970 and in 1978 and Ford took a 25 percent share in the company (History.com, 2010).

In the 1990s, there was the practice of government intervention on behalf of firms in the automotive market for companies to become more global. In 1990, Mexican President Carlos Salinas de Gortari and U.S. President George H.W. Bush announced that they were signing a free trade agreement (FTA) between their two countries. One year later, Canada joined this union. The marrying of all three countries led to the North American Free Trade Agreement (NAFTA) in 1994. There was concern immediately that Mexico could destroy domestic industries due to its lower wages. Proponents of NAFTA dismissed these fears and instead emphasized the benefits of free trade in terms of efficiency, productivity, and greater variety of products for consumers (Blecker and Esquivel, 2010).

Blecker and Esquivel analyze the expectations and the realities about NAFTA's economic impact on Mexico when it comes to economic convergence, trade, investment, employment, wages, and income distribution. They conclude that U.S. manufacturing employment did decrease by approximately 3 million but not until after 2001, seven years after NAFTA was established. Another 2 million jobs decreased during the 2008-2009 recession. Mexico hoped NAFTA would increase the average wages of all workers contributing to a higher standard of living and a decrease in outward migration, but this did not occur, especially in the tradable goods industry. Blecker and Esquivel determined that NAFTA failed to fulfill the promise of closing the Mexico-U.S. development gap due to the lack of deeper forms of regional integration or cooperation between Mexico and the United States. Mexico also failed to implement economic reforms in areas such as rule of law, competition, financial sector, and infrastructure.

Villarreal and Ferguson (2014) consider the fact that NAFTA phased out all U.S. tariff imports from Mexico and Mexican tariffs on U.S. and Canadian products if they met the Rules of Origin requirements of 62.5% North American content for automobiles, light trucks, engines and transmissions; and 60% for other vehicles and automotive parts. Some tariffs were eliminated immediately, while others were phased out in periods of 5 to 10 years. Prior to NAFTA, the U.S. assessed the following tariffs on imports from Mexico: 2.5% on automobiles, 25% on light duty trucks, and a trade-weighted average of 3.1% for automotive parts. Mexican tariffs on U.S. and Canadian automotive products were as follows: 20% on automobiles and light trucks, and 10-20% on automotive parts. The authors discovered that Canadian advocates saw NAFTA as a way for the country to alleviate the long-term labor productivity gap between the U.S. and Canada, which was attributed to the low value of the Canadian dollar. But low expenditures in research and development and on information technology make Canada noncompetitive in the long run. They note that a plus was investment in terms of stock and flow of investment from the U.S. into Canada. It represents nearly 51.5% of total stock of foreign direct investment in Canada from global investors reaching $351.5 billion in 2012, up from a stock of $69.9 billion in 1993.

There are two views on whether NAFTA was successful. Villarreal and Ferguson (2014) found that economists and business leaders think NAFTA created jobs in the U.S. To the contrary, labor groups attribute the outsourcing and lower wages negatively impacting the U.S. economy and job dislocations in Mexico to NAFTA. They offer points for Congress to utilize for future agreements: strengthen institutions to protect the environment and worker rights; establish a border infrastructure plan; increase regulatory cooperation; promote research and development to enhance global competitiveness; make border crossing more efficient; and lessen income differentials within the region.

Klier and his colleague Rubenstein (2017), analyze the effect that NAFTA had on Mexico, and offer a more positive account of the agreement. Klier and Rubenstein found that during the more than two decades under NAFTA, Mexico's light vehicle production more than tripled-from 1.1 million units in 1994 to nearly 3.5 million units in 2016. Moreover, Mexico's light vehicle exports increased from 579,000 to 2.8 million units during the same period. By 2016, motor vehicle assembly and parts employed 735,472 workers in Mexico. Mexico is the low-wage country among NAFTA partners. Over the period 2007-14, on average, wages in motor vehicle assembly represented around one-fifth of those in the United States and wages in the production of motor vehicle parts about one-eighth. They cite one 2016 news article on trade trends after a recent growth spurt; the automotive sector now represents 25 percent of Mexico's manufacturing exports and over 3 percent of the country's gross domestic product. The country's gains could be strengthened even more as a larger exporter to South America because of the clustering of assembly plants in central Mexico.

Klier and Rubenstein (2013) looked at the restructuring of the automotive industry during the downturn in the industry from 2008-2009. The Detroit Three had to restructure through a bankruptcy, the largest in U.S. history. Combined U.S. sales for Chrysler (now Stellantis), Ford, and GM declined from 8.4 million in 2007 to 6.4 million in 2008 and 4.6 million in 2009, and their combined market share fell from 52 percent in 2007 to 48 percent and 44 percent in the next two years. Market share was lost by American cars to new foreign brands principally by the Japanese and Germans, which provided better gas mileage, affordability and attractive design features (Davis, 2019). The Detroit Three carmakers suffered the most during the recession because their viability was dependent on selling large volumes of light trucks, a segment of the market that declined relatively rapidly during the recession, and as mentioned before labor costs.

Klier and Rubenstein (2013) note that during the structured bankruptcy under the Obama Administration, the viable assets-properties, contracts, personnel, and other assets necessary to move forward as a viable operation – were allocated to a "new" carmaker. The "old" carmaker kept the "toxic" assets destined for liquidation or write-off, as permitted under the bankruptcy laws. Results of the bankruptcy were reduced labor costs and reduced production capacity. This stemmed from the transfer of retiree health care liabilities from the carmakers to the Voluntary Employees' Beneficiary Association (VEBA), a tax-exempt trust used by its members and eligible dependents to pay for eligible medical expenses. The plan is funded by the carmakers and employees do not contribute. Further, a much lower Tier 2 wage rate for new hires was instituted. As a result, by 2011, average hourly labor costs for Ford were $58, GM ($56), and Chrysler ($52). These salaries were more competitive with foreign competitors, Toyota ($55) and Honda ($50). The 2011 labor contracts continued to hold the position of fixed labor costs and grew by less than 1% annually through 2015. Capacity utilization is a key driver of profitability for carmakers. Typical capital utilization is employment of several thousand and production of more than 200,000 units per year. Between 1972 and 2007, it averaged 77.6%. During the recession, capacity utilization was approximately 50%. As production decreased, so did capacity utilization. After bankruptcy, in 2010 and 2011, it was approximately 70%, much higher than in the past at similar output levels.

Dziczek et al. (2018) examined the proposed elements in the renegotiations of the NAFTA agreement under former president, Donald Trump, and Congress. President Trump ran for office on the promise to renegotiate this agreement because he felt that foreign competitors have an unfair advantage in the importing and exporting of vehicles and automotive parts in the U.S. Changes to the automotive Rules of Origin were on the table to raise the threshold for the Regional Value Content (RVC) and add a requirement on the share of NAFTA steel and aluminum in certain parts, and add a requirement that at

least 30 percent of a vehicle's content be produced in a country where labor earns more than the median North American wage for automotive manufacturing.

In their analysis, Dziczek et al. (2018) thought it was important to highlight that the U.S. cannot self-supply. There is more demand for light vehicles in the U.S. than the U.S. producers can supply. In 2017, U.S. production totaled 11 million units, and sales were 17.3 million units. Also, in 2017, 56 percent of light vehicles sold in the U.S. were produced in U.S. assembly plants; most of these vehicles were produced by U.S.-based firms, but more than 25 percent of vehicles sold in the U.S. were made in the U.S. by foreign automakers. Every global producing automotive region relies on low-cost content to be competitive. If U.S. automakers do not rely on Mexico, they will find other sources for low-cost automotive parts. Thirty-one countries each imported more than $100 million in automotive parts to the U.S.

Dziczek et al. (2018) clearly believe that high NAFTA content requirements could result in less U.S. automotive and parts manufacturing because if the cost of meeting the Rules of Origin exceeds the Most Favored Nation tariff plus any transportation and logistics costs, then production will move outside of North America to lower-cost regions. Roughly 20 percent of 2017 U.S. parts imports from Canada and Mexico do not use the NAFTA trade preference. The same applies to U.S. exports. High contents requirements raise the cost of U.S. vehicle and parts production and negatively impact exports. The U.S. exports 22 percent of the total vehicles made in the country to our NAFTA trading partners and others. Of that 22 percent, 70 percent goes to Canada and Mexico. Raising production costs will limit the ability of U.S. built vehicles to compete in the global marketplace and will negatively impact U.S. production and employment. Dzicek et al. (2018) estimate the current U.S. proposal could result in Most Favored Nation tariffs adding $470 to $2,200 to the cost of these specific vehicles. If the manufacturers pass the entire cost of the tariff to consumers, it will result in a loss of 60,000 to 150,00 in U.S. light vehicle sales.

2.3 Technological Change Impacting Manufacturing

Automation has constantly changed over the years by improving manufacturing processes and products in all sectors. It helps in reducing production time and brings new products to market. The McKinsey Global Institute believes highly skilled workers will benefit employment wise from technological advances while lower-skilled workers might not (Manyia, 2017). To be highly skilled in manufacturing, especially in the automotive sector, the ability to interface with computers, materials and processes, and technological advances will be in demand.

New automotive technology can be divided into three parts: Intelligent Mobility Technology; Materials and Manufacturing Processes; and Light Duty Vehicle Propulsion (Smith et al, 2017). Vehicle automation or intelligent mobility technology will advance from developments in the last 5 to 10 years from automated park assist, adaptive cruise control, and automated emergency braking to fully automated (i.e., SAE Level 5) vehicles. SAE International is a global association of engineers and technical experts in the aerospace, automotive and commercial-vehicle industries that have defined six levels of automation for on-road motor vehicles. Also, vehicle connectivity covers telematics (GPS systems, OnStar, and hand-free mobile calling) and infotainment (type of media, usually television, that combines information and entertainment) to vehicle-to-vehicle and vehicle-to-infrastructure communications for safety. Smith et al. point out that tech companies and startups are interrupting traditional supply chains by developing software, chipsets, and sensors for automated vehicles. The study will take this into consideration when evaluating the number of jobs that could result to meet the demand. Faster developments of enabling technologies could speed up the market availability of full automation but consumers lack of acceptance could delay it. Enabling technologies are human-machine interface, driver monitoring, object recognition, artificial intelligence, sensors (miniaturization and cost reduction), cloud computing, cybersecurity, and 3D high-definition maps.

New materials and manufacturing technologies will test hot stamping as opposed to cold stamping to increase the ductility of the steel material which helps in forming complex shapes without cracking. Smith et. al found that automakers are looking for materials with higher strength-to-weight ratio to reduce weight, while improving performance. It is expected that the U.S. fleet will achieve a five percent curb weight reduction by 2025 through greater use of aluminum in the closures and body structure. Additive manufacturing, also called 3D printing, is a technology that could change the tool and die business but is not yet suited for mass production because of cost or cycle time. It is used for rapid production of prototype parts. "A single 3D-printed product does not have to account for the tolerances of individual components made on different machines at different facilities" (Miller and Sofio, 2017, pg. 3). Moreover, joining technologies, such as adhesives and advanced fasteners, will be important in achieving mixed-material architecture to join any combination of dissimilar materials. Essentially, automakers will be looking to eliminate weight that will hinder performance as more improvements to the vehicles are added. For example, 200 to 300 pounds per vehicle added to a vehicle for automated driving features need to be offset elsewhere. Engineers and plant workers need to be retrained to work with these new materials and processes.

For decades, light duty vehicle propulsion has been dominated by the internal combustion engine and is expected to remain through 2025. This engine requires gasoline. Smith et al. (2014) found that industry experts believe electrification of light-duty vehicle propulsion is key. Yet consumer acceptance has remained uncertain. There are hybrid electric vehicles (HEV, requiring gas with battery); plugin hybrid electric vehicles (PHEV); battery electric vehicles (BEV), and fuel cell electric vehicles (FCEV). For HEVs, the cost of two propulsion systems will continue to hinder cost competitiveness. The same holds true for PHEVs which has an added cost for a larger battery. Both electrical systems are expected to be part of the market through at least 2030. Experts believe if costs of BEVs are reduced, the 200-mile plus range

with faster charge capabilities could become an important part of advanced propulsion. It is hoped that more consumer acceptance will occur from cost reductions, combined with improved chemistries and more effective thermal management to increase battery capabilities and less charging time.

New materials and manufacturing skills also apply in life sciences research and development. 3D bioprinting is the manufacturing and prototyping of devices, organs, and solid drug products in various shapes, geometric designs, and spatial dimensions of the active and inactive ingredients. Scientists have discovered the printing of kidneys, livers, and skin. During the drug development process new techniques enable biochemical, genetic and historic analysis to be instrumental in toxicology and disease modelling (Skills Alliance, 2018). Research is also underway to combine certain medications into one "polypill" using 3D designs and 3D printing processes for those who take multiple medications daily. Overall cost of production and products are reduced because of this technology and skilled labor (Skills Alliance, 2018).

2.4 Technical Skills

Workforce Intelligence Network (2017) composed a report from job postings on the skills needed for future connected and automated vehicles. These skills are applicable to other manufacturing sectors as well and are categorized in: design & testing, vehicle manufacturing, IT design, quality control, and data management & cybersecurity.

Design & Testing and Value Manufacturing occupations require skills with an engineering background. One should know specific computer languages. WIN found employers of Design & Testing and value manufacturing occupations typically want well-rounded workers with the ability to research, communicate, and solve problems with teams on projects. IT Design occupations require extremely specialized, industry-specific skills and languages such as JAVA, software development, C++, and LINUX.

Employers want IT workers to also have employability skills like communication skills, writing, troubleshooting/problem solving, research, and project management.

Quality Control require a wide array of technical skills, like inspection, software development, and computer skills. WIN found job postings listing required knowledge or experience in LINUX, Cisco, and Microsoft Office. Employers are also seeking foundational skills like communication skills and planning. Data Management & Cybersecurity occupations require an engineering background and knowledge of specific computer languages. Employers of Data Management & Cybersecurity occupations want well-rounded workers with the ability to research, communicate, and solve problems with teams on projects. Many cybersecurity workers must also possess a Federal-level security clearance due to the sensitive nature of their work.

2.5 The Future of the Automotive Industry

Dziczek et al. (2017) found that North American, European, Israeli, and Japanese companies are leading the development of automated vehicles, but Chinese companies are quickly on the rise and will be just as competitive. Tech companies and startups are disrupting traditional supply chains by developing software, chipsets, and sensors for automated vehicles. Aside from making cars, more automakers are developing driving automation technologies in-house to assure their companies remain relevant and profitable where software, data, and connectivity are more valuable than the mechanical elements of the car.

To avoid another downtuwn in the automotive market being caused by manufacturers misreading consumers' demands, it is important to analyze whether consumers are embracing this new technology. Bailo et al. (2018) composed a report that addresses the challenges automakers and suppliers face; the

tension between consumer demand and regulatory mandates on electrified powertrains; the impact of connected and automated vehicles on personal vehicle ownership and mobility; and the implication for the nation's engineering and technological leadership in the world.

In their study, Bailo et al. (2018) discovered that most automakers and suppliers agree that the "three revolutions" of automated, shared, and electric vehicles will be transformative but will take decades to be fully realized. The internal combustion engine (ICE) has been the dominant power source for a light-duty car for over a century. They cite the fact that 17.2 million light vehicle sales occurred in 2017, and over 98 percent of the vehicles sold in the U.S. had an ICE. To improve technology, automakers are investing heavily in advanced propulsion and vehicle electrification.

According to a consumer "engine preference" survey for selected countries, the data suggest globally that consumers are interested in hybrid-electric vehicles (HEV) and battery-electric vehicles (BEV). There were 18 percent of such consumers in the U.S., 30 percent in Germany, 25 percent in France, and 56 percent in China. The current market share of BEVs and HEVs is 3.3 percent in the U.S. (2017), 0.7 percent in Germany (2016), 1.5 percent in France (2016); and 1.4 percent in China (2016). However, there is a disconnect between consumers' stated intent and their actions. The reasons for not buying a BEV or plug-in electric vehicle could be purchase price, technology limitations, or other performance challenges that current electrics may not be capable of meeting.

GM has recently announced that that it aspires to 100% of its portfolio, including full-size pickups and SUVs, fully electric by 2040 (LaReau, 2021). GM will offer zero-emissions vehicles with varying prices and has collaborated with suppliers and the Environmental Defense Fund to build charging infrastructure and

promote consumer acceptance. The company has pledged that high-paying jobs of today will be present in the future.

2.5.1 Human Capital Needs

Research was conducted as early as 2007, before the Great Recession, about the changing human capital needs in the automotive industry. Dziczek et al. of the Center for Automotive Research (CAR) (2008) found there were no longer any "unskilled" positions in a modern automotive assembly or parts facility. The Michigan workforce was comprised of 27.5 percent skilled trades in 2007. The percent of workers in the trades was projected to drop to just 16.0 percent nationally and 16.4 percent in Michigan. All the companies in the study have extensive corporate training infrastructure and standardized training curricula for production workers. Initial training consists of roughly 40 hours of classroom training with 40 hours of on-the-job training at the Detroit Three to three months of training to master both the basic concepts as well as full job rotation at one of the international firms. The types of training offered include health and safety, quality, environmental compliance, company procedures, ethics, and company and facility orientation.

For skilled trades, a journeyperson's card or eight years in the trade would be considered favorable. Then the candidate is given an apprenticeship. In general, apprentices receive 8,000 hours of on-the-job training including specialized in-house training with hands-on experience coupled with 650-700 hours of classroom instruction, usually offered in cooperation with a local community college (Dziczek et al., 2008). Back then, the market was becoming more sophisticated in the electrical trades. It called for mechatronic engineering, a combination of mechanical, electronic and software engineering for vehicle design and engineering. The use of electrical engineers will also increase as electronic content greatly increases in the vehicle and knowledge of specific powertrain technologies will also become critical. Future engineers

will be well-versed in computer design and CAE technologies before arriving at the firm for employment. Engineers will be hired from other companies, on referral, and straight out of educational institutions. They will need a four-year degree. Further, even automotive service technicians at dealerships will require an associate's degree (Dzicek et al, 2008).

Fast forward to 2017, CAR's researcher, Dziczek et al. (2017) confirmed past research that more automotive positions needed will be technologically inclined and require a STEM background. Being skilled in lightweighting, designing, analyzing, and building automotive tools, dies, molds, jigs, and fixtures to form the array of new and advanced materials that are being deployed in current and future vehicles, will be key for incumbent workers and future apprentices. Automotive skill trade occupations include electricians, welders, millwrights, pipefitters, machine repair, computer numerical control machinists, mold makers, and tool and die workers. These occupations require an apprenticeship – classroom and on-the-job training – of at least two years. In addition, 3D printing is an advanced tool and die technology and for rapid production of prototype parts but is not yet suited for mass production in terms of cost or cycle time.

The U.S. Bureau of Labor Statistics reported the National Industry – Specific Occupational and Employment and Wage Estimates in May 2019. Motor Vehicle Manufacturing is classified NAICS 336100 and considered part of NAICS 336000 – Transportation Equipment Manufacturing. Production occupations such as assemblers and fabricators make up 74.35 percent of the occupations in the sector. The median hourly wage is $23.76. The architecture and engineering occupations make up most of the skilled positions in motor vehicle manufacturing for a total of 25,520 workers. These are mechanical engineering technicians, electrical and electronics engineering technicians, and industrial engineering technicians. The median hourly wage $41.62.

According to the U.S. Bureau of Labor Statistics, today the motor vehicles and parts manufacturing sector comprises of 995,900 U.S. workers in November 2019 to 926,500 workers in November 2020, a decrease of 69,400. Michigan's employment decreased from 38,200 to 37,700 during the same period, a decrease of 500. Workers are continuously being dislocated while wages increased by 52 cents during the same period. Their average hourly earnings as of November 2020 is $24.57.

The Bureau's Occupational Outlook Handbook for 2020 expects mechanical engineering technicians to grow in 2019 – 2029 by 3 percent or 1,400 workers from 43,500 in 2019. They help mechanical engineers design, develop, test, and manufacture mechanical devices. The median pay is $27.40 per hour (2019$). Electrical and electronics engineering technicians are expected to grow in 2019 – 2029 by 2 percent or 1,900 workers from 125,800 in 2019. Electrical and electronics engineering technicians help engineers design and develop electrical and electronic equipment. The median pay is $31.38 per hour (2019$). Industrial engineering technicians are expected to grow in 2019 – 2029 by 1 percent or 1,000 workers from 68,500. Industrial engineering technicians assist industrial engineers in creating systems that integrate workers, machines, materials, information, and energy to make a product or provide a service. The median pay is $27.19 per hour (2019$).

2.5.2 STEM (Science, Technology, Engineering, and Math) Educational Background

To meet the demand of more technically advanced automotive positions, a review of the state of STEM in public education was undertaken. Weis et al. (2015) determined that policymakers emphasize that inequalities in STEM limit the nation's economic competitiveness as well as future employment prospects for next-generation workers, especially in the case of women and low-income minority students. Inclusive STEM-focused high schools, high schools that are nonselective and self-identify as a "STEM school" or as a school with a distinct STEM program, were studied in Buffalo and Denver. Their "high school opportunity

structure" was examined. This structure is defined as the institutional arrangements – including math and science emphases or tracks, course offerings, and course requirements – that organize high school – based trajectories to successful education for futures in STEM. The authors cite the findings from other studies that suggest high school opportunities can improve students' chances of pursuing STEM by encouraging rigorous math and science course-taking that fosters higher-level skills and confidence with this subject matter. It is thought that high school course-taking is a better predictor of STEM degree attainment in college than individual background factors such as race, parental education, or income.

In looking at Buffalo and Denver in this study, it was found that neither city was successful in transforming their STEM education into meaningful improvements for the students. In Denver, large increases in math and science courses occurred but these good intentions were met with other requirements for schooling, requirements for graduation, accountability demands, and students' weak academic performance that worked against plans to offer, enroll, and staff more STEM courses. In Buffalo, efforts were met by failure also. For instance, one school, a well-designed high-level math/science program in bio-pharmacy was disbanded after five years while two lower-level programs in health occupations and forensics expanded. Advanced math proved difficult for students, even for those in the top 20 percent of the class. Consequently, at both schools, advanced math and science course offerings and course content were either eliminated or substantially scaled back.

Carmichael (2017) conducted analyses of state-by-state polices of STEM education for K-12 public schools for her Dissertation research. In response to the federal Race to the Top competition (2010) under the Obama Administration, states' departments of education were encouraged to have innovative STEM programs to qualify for federal funds. Only the states of Delaware and Tennessee were awarded for their programs after the initial Phase 1 in March 2010. Both states had STEM education as part of their

applications and received 100 percent toward each state's answer in the grant application. Tennessee is another state besides Michigan that has automotive plants. The state used part of its funding to found the Tennessee Innovation Network in 2011. It is run by Battelle Memorial Institute of Ohio and the University of Tennessee. The mission of the Network is to increase student interest, participation, and achievement in STEM; expand student access to effective STEM teachers and leaders; reduce the state's STEM talent and skills gap; and build community awareness and support for STEM. The Network is broken into six regional networks of K-12 schools; colleges, and universities, and businesses called Innovation Hubs. It is the belief of the Network that their goals help prepare students for a global economy.

Carmichael mentions Michigan's STEM Partnership in her research. The state's program represents four disciplines (Science, Technology, Engineering and Math), and therefore refers to an education initiative that addresses quality and participation in these disciplines out of economic, political, and educational concerns. The four disciplines are combined into a cohesive learning paradigm based on real-world applications. In 2015, the Michigan Board of Education supported the Michigan STEM Partnership with grant money and support. The Board's goals were to target populations of organizations conducting student-focused, project-based programs and competitions, either in the classroom or extracurricular in science, technology, engineering, and mathematics subjects such as, but not limited to, robotics, coding, and design-build-test projects for schools with achievement gaps from Pre-k through college level.

Is there a shortage of STEM educated students for the workforce? Salzman (2013) gives a different answer by saying no. He follows the chronological timeline of when IT workers were in demand in his report. In February 2011, Steve Jobs of Microsoft told President Obama that Apple would have located 700,000 manufacturing jobs in the U.S. instead of China if only the company had been able to find enough U.S. engineers. But Salzman found no evidence that the company tried to recruit the needed engineers. It

was more about the cost of an American worker. It would cost the company about $42,000 (in 2011$) for a U.S. worker compared to $4,800 per year for a worker in China. He also gives the example that Hewlett Packard planned to lay off 15,000 workers by that year's end because they had too many tech workers. These companies represent the general trend, in industry after industry, of locating STEM-intensive activities offshore while downsizing their U.S. labor pool.

Failing to find current shortages, Salzman wanted to know if it was true that U.S. students do not perform well on international tests. He and his colleague concluded that this claim is baseless because, 1) average scores of the students tested (mostly middle-schoolers) do not indicate the performance of the actual population that finds its way into STEM occupations; 2) the performance of the upper portions of the U.S. student distribution is world-class, and this segment is larger than most of the relevant populations in the oft-touted high performing countries, such as Singapore, South Korea, Finland, or any of the central or eastern European countries formerly part of the Soviet Union; 3) the average test scores of the countries that are of most concern as economic competitors would be dismal if a more representative sample of their students tested, as is the case in the United States. China and India have very large illiterate populations that would lead to devastatingly low averages; 4) there is no credible evidence that scores on these tests have any relevance for the outcome of interest: science and engineering performance, innovation, and economic competitiveness. Salzman's colleague found that the students not earning a STEM occupation went into fields that paid more than STEM occupations. Thus, a STEM career, does not seem to offer pay advantages for high-performing students.

Classes taught at the best STEM high schools in the country and Michigan have been researched on their advanced placement curriculum. In the Advanced Manufacturing, Mechatronics, and Quality Consortium report, Negoita (2013) and her colleagues found that skills associated with STEM occupations are cognitive

and non-cognitive. Cognitive knowledge consists of math, chemistry, and other scientific and engineering fields; and STEM skills, such as complex problem solving, technology design, and programming; and STEM abilities, including deductive and inductive reasoning, mathematical reasoning, and facility with numbers. The non-cognitive competencies associated with STEM are preferences for investigative and independent work. Further, a high school graduate that took a career and technical education after school program at a community college or university will be favorably viewed.

2.6 Community Colleges

Community colleges, sometimes defined as junior colleges, are two-year schools that provide affordable postsecondary education as a pathway to a four-year degree, workforce development and skills training, and a range of noncredit programs such as English as a second language. According to the American Association of Community Colleges, enrollment at 941 U.S. community colleges peaked in 2010 at 7,284,638 students and has declined for the third-consecutive year by 3.2 percent in 2018 and 1.4 percent in 2019 (Juszkiewicz, 2020). The results of how much the pandemic has affected enrollment is yet to be determined.

Between fall 2018 – fall 2019, the highest increase of enrollment in a major at a U.S. community college is 16 percent in Science Technologies/Technician; 1.4 percent in Construction Trades; and 0.6 percent in Psychology (Juszkiewicz, 2020). Engineering enrollment declined 8.2 percent and Computer and Information Sciences and Support Services declined 5.8 percent (Juszkiewicz, 2020). The Michigan Community College Association Fast Facts stated in 2019 that there were 28 public community colleges. Enrollment comprised of 365,232 students. There were 7,852 that received certificates, 21,480 received associate degrees, and 49 received bachelor degrees. The average age of the students was 25.7 and consisted of 56.16 percent women and 43.84 percent men. Whites made up 64.55 percent; Blacks 17.05

percent; Hispanics 4.11 percent; Asian-Americans 2.19 percent; Native Americans .73 percent, and Native Hawaiians/Pacific Islanders 0.12 percent. Michigan community colleges are funded with 20 percent state funds; 35.1 percent property taxes; 43.2 percent tuition; and 1.7 percent other.

2.7 Community Colleges as a Pathway to Future Manufacturing Jobs

Enrollment in community colleges can be a career pathway to future manufacturing jobs. A foundational education can be attained for technical skills. This education should be in the form of an apprenticeship for the student to obtain hands-on training with classroom learning, especially when it comes to operating new equipment such as a robotic programmable logic controller.

Fein (2012) describes the career pathway model as post-secondary education and training organized as a series of manageable steps leading to higher credentials and employment opportunities in growing occupations. The model effectively engages, retains, and facilitates learning of a diverse population, integrates promising instructional strategies, supports, and connects employers. It assumes interventions are comprehensive and intensive to address effectively the learning and life challenges adult students may face. Partnerships are made with providers such as community-based organizations, community colleges and other post-secondary training providers, human services and workforce agencies, and employers and their representatives.

Community colleges that have apprenticeships have proven to be instrumental in the students' training. Wyman (2014, pg. 113) believes that "apprenticeships remain a fundamental, proven method of training individuals in what are likely high-skilled occupational areas, with hand-on learning processes that are directly supervised by skilled mentors". Skills obtained from apprenticeships can lead to rewarding careers in advanced manufacturing. He concludes that hardworking people who enter this field and build

their skills year by year will not be stuck in jobs with limited prospects; they can progress to solid middle-class lifestyles and beyond.

Selwitz et. al (2017) explains that community colleges serve a vital function in STEM education training for high-skilled technical careers and providing employers with the labor necessary to be thriving businesses. Community college training provides foundational education for entry-level careers in scientific, technological, engineering, or mathematical skills. This also gives the student the knowledge to pursue a four-year degree. Community colleges are less expensive than a university and thus are more attractive to low-income students. The authors found in their research that community colleges are better suited than universities to provide the needs of dislocated workers. They must prepare students in critical thinking and real-world problem-solving skills to be more marketable to employers. The authors expect the instructors to stay well-informed on advancing and emerging technologies in addition to course knowledge.

2.8 Community Colleges and Their Role in State Workforce Development and Education Boards

Workforce development and education boards and community colleges in Pennsylvania, Massachusetts, Ohio, Tennessee, Texas, Illinois, and Indiana have made great strides in training and upskilling traditional and nontraditional students. This section will also discuss the role of community colleges in Michigan.

Michigan's Governor Whitmer has made education a cornerstone of her tenure. Her administration has established the Sixty by 2030 initiative (State of Michigan, 2020). The goal is to have 60 percent of all working adults with a credential or degree by 2030. This will be achieved through the following programs: Futures for Frontliners for essential workers; Skills to Work has free online courses that prepare for College Board's College-Level Examination Program tests; and Going Pro in Michigan for Professional Trade

careers (State of Michigan, 2020). Opportunity scholarships will pay for education at a community college (State of Michigan, 2020). Opportunity scholarships are "last dollar scholarships" that are awarded to needy students after other grants and awards have been applied. The money will come from the U.S. Cares Act that was passed by Congress to battle the COVID-19 pandemic (State of Michigan, 2020).

2.8.1 Pennsylvania

Ginsberg (2015) states that the Community College of Philadelphia (CCP) has responded to the federal government's challenge of 30 percent more associate degree holders by 2020. Her extensive research has linked this degree to better job prospects and quality of life, especially for low-income individuals. In Ginsberg's study of CCP, three groups of community colleges nationwide that share key characteristics with the school were compared. One group consisted of colleges that serve large cities. The second group is institutions with substantial numbers of minority students receiving financial aid. The third group is community colleges located in regions with a high concentration of colleges and universities. Ginsberg's study concluded that the majority of the student population was enrolled in liberal arts and other programs intended for transfer to a four-year institution, as opposed to technical and career-specific majors that lead to jobs.

Further, CCP struggled to provide the job training that some employers require. The low enrollment in technical and career-specific majors can be explained by the fact that 70 percent of new CCP students had to take remedial classes, a percentage not uncommon at comparable colleges. Technical careers require a high degree of math. In addition, the six-year graduation rate for associate degrees at CCP was just 17.5 percent, slightly below the average of the comparable schools. However, African American students are slightly more likely to graduate from CCP than from similar schools. When it comes to evaluating CCP's workforce development efforts, Ginsberg found that Philadelphia firms reduced their use of the college's

corporate and contract training offering to a larger extent than did firms at other Pennsylvania colleges. To reverse the course, CCP planned to make college free for hundreds of Philadelphia high school graduates every year and to hire more advisors, lessening the choice of electives in its academic curricula, and making workforce development a priority.

2.8.2 Massachusetts

In 2015, the Massachusetts Department of Higher Education (MDHE) composed an advanced manufacturing workforce plan. It first initiated a workforce plan for the healthcare sector to address the nursing field. Being a manufacturing state, MDHE devised a plan to inform the Board of Higher Education about the current and future trends that impact the skills gap. Two topics were identified: 1) assess the current manufacturing education pathways that span vocational education schools and community colleges and gauge the output of this pipeline to assess the supply and demand talent gap; 2) look beyond the role of the production manufacturing worker and to accelerating advances in materials, technologies and supply chain processes that require a workforce with new and different knowledge, skills, and abilities.

The MDHE came up with the following recommendations in the plan: 1) analyze regional and sector workforce gaps through regional data; 2) assess the alignment of the public higher education system and each of the regional manufacturing partnerships of high school and community college academic pathway programs for manufacturing; 3) incorporate advanced manufacturing career awareness initiatives with the community college STEM Starter Academy initiative that recruits high school and adult students, including underrepresented populations, to pursue STEM programs and careers, statewide. It is hoped that student retention and success in certificate and degree programs and job placement will be achieved; 4) promote increased collaboration across community colleges, state universities, and the University of

Massachusetts to get information out that will inform curriculum enhancements, industry collaboration and faculty development to improve the workforce readiness and competitive position.

2.8.3 Ohio

Sommo et al. (2018) evaluated three community colleges in Ohio. The three community colleges - Cincinnati State Technical and Community College, Cuyahoga Community College, and Lorain County Community College – joined forces to create a strategy to tackle low graduation rates. The strategy became known as the Accelerated Study in Associate Programs (ASAP). It was patterned after the City University of New York model. ASAP required students to enroll full-time in the fall and spring. Summer school attendance was highly recommended also. Students were encouraged to take remedial courses immediately. Structured advising occurred twice a month in the first semester and financial incentives were provided to students who remained in the program. Students in remedial courses were required to attend at least three hours of tutoring per month. Program students were granted waivers for the portion of tuition and fees not covered by financial aid packages. They also received financial assistance to cover the costs of textbooks at the campus bookstore (at least $300 during each of the fall and spring semesters and half during the summer). There was also a monthly incentive of a $50 gift card for the purchase of groceries or gas. This led to 45 percent receiving three or more payments in each semester. The program was measured by its effect on two groups: the program group and control group. The program group's graduation rate more than doubled to 19 percent with a degree or credential after two years compared with 8 percent of the control group.

2.8.4 Tennessee

In general, low graduation rates are prevalent in Tennessee. Tennessee has two skills improvement programs that assist traditional and nontraditional students: Tennessee Promise and Tennessee

Reconnect. Tennessee Promise makes college tuition free for traditional students attending associate, certificate or diploma programs, while Tennessee Reconnect gives free college tuition for students enrolling strictly in Tennessee Colleges of Applied Technology (TCAT). Lawmakers passed the Tennessee Promise program in 2015 to instill that high school students had the ability to attend a community college with no direct cost of tuition or fees (indirect costs such as books and school supplies). Hightower (2019) is very critical of the state's efforts. First, the promise program was born out of the "Drive to 55" initiative. Its goal is to get 55 percent of working-age adults a postsecondary degree or certificate by 2025. The Tennessee Promise is a plan to meet this goal. It is a last-dollar scholarship meaning it is a financial aid award given to students after other scholarships and grants have been applied according to their Free Application for Federal Student Aid (FAFSA) report. Nevertheless, it is not means-tested and wealthy students qualify and can go technical schools and certificate programs in addition to community colleges tuition free.

Once a student enrolls in a community college as part of the Tennessee Program, they must maintain a 2.0 grade point average and complete eight hours of community service every semester. Hightower found that Tennessee community colleges had an almost 25 percent increase in enrollment the first year in 2015. However, he is critical of the program because it does not solve the education deficit, negatively impacts graduation rates, ignores diversity, and does not tackle the financial burden on lower-income families. Hightower found research that says a student attending a community college is not likely to transfer to a four-year institution. Also, he believes the last-dollar scholarship is money better spent if it went towards free transportation, intensive advising, career services, special seminars, and other supportive services. There was a 1 percent decrease from 2015 to 2014 of black students at Tennessee community colleges. Hightower emphasizes that community colleges should improve and encourage access of minority

students. From statistics in the Tennessee Promise Annual Report 2017 and Pell Grant data, Hightower gleaned that there was a decrease in the poorest students attending a community college.

Carruthers and Welch (2019) found that 81 percent of students in TCAT schools completed their programs compared to 28% of students in the state's community colleges. The state's majority of students, nontraditional enrollees, were more likely to attend TCAT schools. However, the cost of a TCAT was substantially more in 2017-18 at $14,908. This higher tuition than a community college does not deter students because it is believed that TCATs are very successful at connecting students to jobs. The tuition can be subsidized as a last-dollar scholarship through FAFSA or federal Trade Adjustment Assistance or Workforce Innovation and Opportunity Act grants. The Trade Adjustment Assistance program supports retraining of workers who lost their job due to trade. The Workforce Innovation and Opportunity Ace also supports displaced workers.

Carruthers and Welch's analysis on how both type of students fared in both Tennessee programs shows that 55 percent of Promise students in the 2015 entering cohort completed a degree at some point before the end of fall 2017, which was slightly more than the 53 percent of Reconnect students and 46 percent of other students. This can be explained by the amount of contact hours a student had. Contact hours are hours spent directly engaged in coursework. Of the 2,932 Promise students under study, they had 1,227 contact hours in contrast to 1,531 Reconnect students with 979 contact hours.

2.8.5 Texas

Amarillo College in Texas, a midsize community college, created a No Excuses Poverty Initiative in 2010. Students at the community college are mostly Latino, low-income, and first in their family to attend college. The initiative was formed to promote college attainment as a way to escape poverty. It is

comprehensive and involves on-campus wraparound services from the Advocacy and Resource Center (ARC) in the form of a food pantry or emergency grant, case management, academic support, curriculum development, and college-wide hiring and evaluation processes. ARC also offers assistance for childcare, transportation in the form of bus passes, textbooks, and tuition. There is a No Excuses Fund as a last-dollar scholarship that helps with tuition costs. Goldrick-Rab and Cady (2018) took a mixed-method approach to evaluate student outcomes. From an online survey, out of the 400 student respondents, 54 percent had experienced food insecurity in the previous 30 days, 59 percent were housing insecure and included those struggling to pay for utilities. Just as important, 6 percent of students were homeless in the previous 30 days and 11 percent had experienced homelessness in the past 12 months. The overall effectiveness of the initiative will be assessed later but there are retention rate numbers available. Over a three-year period, fall to spring retention was 67.5 percent for all Amarillo College students vs. 73 percent for students receiving services from ARC or the No Excuses Fund. The fall-to-fall retention, 46.8 percent was for all Amarillo College students vs. 48 percent for students receiving services from ARC or the No Excuses Fund.

2.8.6 Illinois

Under former Illinois Governor Bruce Rauner, the state tried to focus on apprenticeships to create new opportunities for youth, adults, and employers. A report by Young Invincibles (2018) states that 53 percent of jobs in Illinois require more training than a high school diploma but less than a college degree while only 42 percent of the workforce is qualified. They cite that once an apprenticeship ends, 91 percent of apprentices retain employment at a median salary of $50,000. Illinois allocated $1.3 million to expand apprenticeships to increase the number of women, people of color, youth, low-income individuals and others in manufacturing, health care, transportation, distribution, and logistics. Young Invincibles provided the following recommendations for Illinois to meet its apprenticeship goals: 1) use strategies

that include continuous monitoring, create inclusion committees, and provide incentives like tax credits for hiring underrepresented populations; 2) enable accountability by requiring programs to publicly release disaggregated data on who participates in apprenticeships at the state and program level and keep track of discrimination cases at the worksite; 3) form implementation committees consisting of community groups, contractors, unions, and underrepresented populations on large projects to ensure projects meet inclusion goals; and 4) give incentives like reserving state grants or penalties in the form of public funds withheld to encourage diversity in apprenticeships.

2.8.7 Indiana

Indiana dealt with displaced workers when Navistar Engine Plant and Foundry in Indianapolis eliminated jobs after they lost business due to import competition in 2009. As a primary customer of Ford Motor Company, the plant produced metal castings for diesel engines. Nearly 2,000 workers were eligible for retraining opportunities through the federally funded Trade Adjustment Assistance (TAA). Workers receive 104 weeks of paid training if they are "20 years of age and older who lost or left jobs because their plant or company closed or moved, there was insufficient work for them to do, or their position or shift was abolished" (Walker, 2013, pg. 3). Walker details the long arduous process in applying for the funds, getting accepted, and excelling in the program.

Community colleges were to provide hands-on training in manufacturing. Walker mentions that workers had to test out of basic math and reading at a ninth grade, three-month level. In order to accommodate the workers who did not meet this test, remedial classes were held at a local union hall. Also, this is where workers were assisted in filling out the cumbersome paperwork to qualify for the funding. Walker found longer processing times by 102 days as opposed to 40 days projected because TAA coordinators were overwhelmed with the volume of applications. Participants found the TAA coordinators helpful but

became frustrated by a requirement that forced them to contact at least three employers in a field they wanted to enter and interview them. The participants had no knowledge of what to ask to move forward in a new career or position. In addition, the participant had to write an essay on why they should be allowed to get TAA assistance and how they were going to support themselves until school was completed.

The community colleges held classes at the union hall but had to change locations because the union hall was sold. Walker cites this causing uncertainty about the program because workers were not sure where they were going to meet. No textbooks were provided, computers were limited, and instructors who were not knowledgeable of some subjects were used such as a math instructor teaching Intro to Manufacturing. Some workers regretted being in the manufacturing program after it was over and saw little prospect in obtaining advanced manufacturing work elsewhere other than being called back to Navistar's foundry, which had a contract with foreign markets. Overall, they felt better time and money would have been spent in applying for acceptance into an accredited institution of higher learning and completing a degree. The reason given that this was not an option is because the time frame to complete a degree would have taken longer thus delaying their reentry into the workforce and they did not have the educational background to meet admission requirements.

In summary, the experience in several states shows that the career pathway programs proven to be successful were ones that have strong workforce development boards and community colleges on the same accord. This allows federal and state dollars that are allocated for training initiatives to directly impact dislocated workers' ability to obtain new skills that are in high demand. Funding should also be spent on supportive services that enable students to overcome barriers that may prevent them from completing their training.

2.9 Students Experience at a Community College

There has been little research on the experience of students at community colleges. This prompted Dr. Paul Umbauch, a professor at North Carolina State University, and Meagan Vallejo, Director of Operations to develop the RISC survey. The survey revealed the obstacles and challenges that students face. The RISC Survey was administered by Umbauch and Vallejo in 2015 and 2017. It is based on recent surveys of 10 community colleges that used the RISC Survey to understand more about how they can help their students succeed.

They found:

- Community college students have many personal challenges that present obstacles such as balancing work and school, paying expenses, meeting demands of family and friends, and health and disabilities.
- Students also report school obstacles such as online classes, parking on campus, developmental courses, faculty, doing college-level work, and registering for courses.
- While students face challenges, they overwhelmingly report a positive community college experience. Ninety-five percent were very likely or somewhat likely to recommend their college to a friend. Ninety-six percent believe their community college education was worth what they paid or worth more than what they paid. Most believe their college helped them meet their educational goals.

These responses were asked in the student survey to see if the students under study had the same experience.

2.10 Summary

The literature highlights the implications of changing manufacturing demand for labor to both people and places, and the potential for training through community colleges to offer career paths for disadvantaged and marginalized workers. Some literature gives the upside to being skilled as far as wages and long-term employment counter to others that found that some unskilled wage earners exceed earnings of the skilled trades. Furthermore, several public high schools across the country may not be adequately teaching STEM education to prepare students for the global economy. Likewise, post-secondary schools may not be keeping up with the latest technology such as robotics training. Further, there may even be an oversupply of qualified engineers. Yet there are job advertisements and news reports everyday that say there are high-demand manufacturing jobs going unfilled because of not enough skilled people (Robinson, 2019). Also, it is expected that through attrition of employees of the automakers and parts suppliers, more positions will remain unfilled.

CHAPTER 3: CASE STUDY: THE ROLE of COMMUNITY COLLEGES IN WORKFORCE DEVELOPMENT

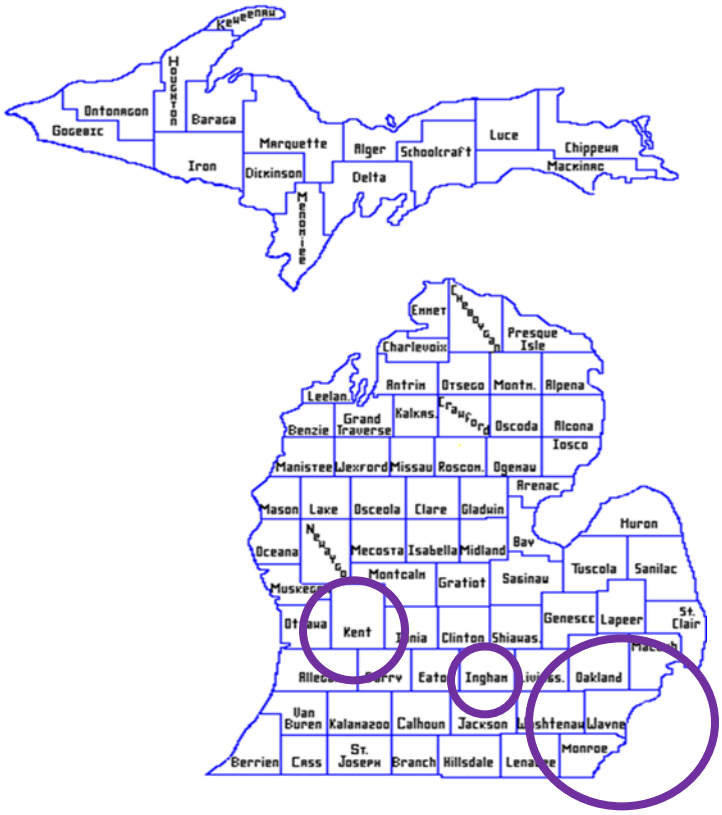
3.1 Introduction

The literature review established how changes in manufacturing demand for labor may be mitigated through training, and the role that community colleges may play in this process. To understand the experience of the colleges and students, a case study was conducted of five community colleges in southeast, central, and west Michigan focusing on preparation of students to work in advanced manufacturing. Students were surveyed to assess their skill level. The case study also included an instructor survey to get their assessment of students' skills and deficiencies and what improvements need to be made to their academic program. Manufacturing employers were interviewed to find out what skills they look for in new hires and whether they offer apprenticeships to compliment the student's training. Lastly, the employers were asked their outlook on manufacturing in Michigan.

3.2 Counties of the Community Colleges

The community colleges chosen to study are located in counties that are home to manufacturing plants and their partners' plants or testing sites, and pharmaceutical, aerospace, and biomedical companies. Sixty percent of suppliers are headquartered in Michigan (Detroit Regional Chamber, 2021). The community colleges are in the jurisdictions of Oakland County, Macomb County, Washtenaw County, Ingham County, and Kent County shown in Figure 6 on the next page.

Figure 6: Map of Michigan Counties



Source: Michigan County Outline, maps.com (2020)

Oakland County contains many of the more advanced research and production facilities for the auto industry and is home to GM's Lake Orion plant that has been allocated the electric Bolt, Cruise AV test vehicles, and other electric vehicles (Mays, 2019). It also houses original equipment manufacturers Detroit Three parts suppliers such as the #1 ranked by sales, Delphi Corporation in Troy. Delphi produces steering, chassis, energy and thermal management, interiors, and electronic components (Autonews.com, 2018).

Macomb County has Fiat Chrysler's Warren Truck plant that will make the HEV (hybrid electric vehicle) Jeep Wagoneer, Grand Wagoneer, and continue to assembly the Ram 1500 classic and move to fully electric models (Wall, 2019). The county is also home to GM's Technical Center that developed the Digital

Vehicle Platform, the electrical architecture to control the vehicle's systems and connect the car to data in the cloud and information from traffic lights and highways. It falls in line with GM's goal of zero fatalities, zero emissions, and zero congestion (Phelan, 2019).

Washtenaw County houses the American Center for Mobility in Ypsilanti. The global center is a 500-acre test facility for autonomous vehicles that allows private companies, government, standard bodies, and academia the ability to test lane detection, mobile apps to inspect poor roads and new methods of detecting pedestrians for driving safety (Afana, 2019; ACM). Furthermore, several pharmaceutical companies have research centers in Ann Arbor such as Advaita, a bioinformatics software company that has an AI platform able to predict a drug to rid the country of COVID-19 (Advaitabio.com, 2020). The company's research is used by universities across the U.S. and Michigan. With a skilled labor pool, these pharmaceutical and research companies can move manufacturing to Michigan from overseas.

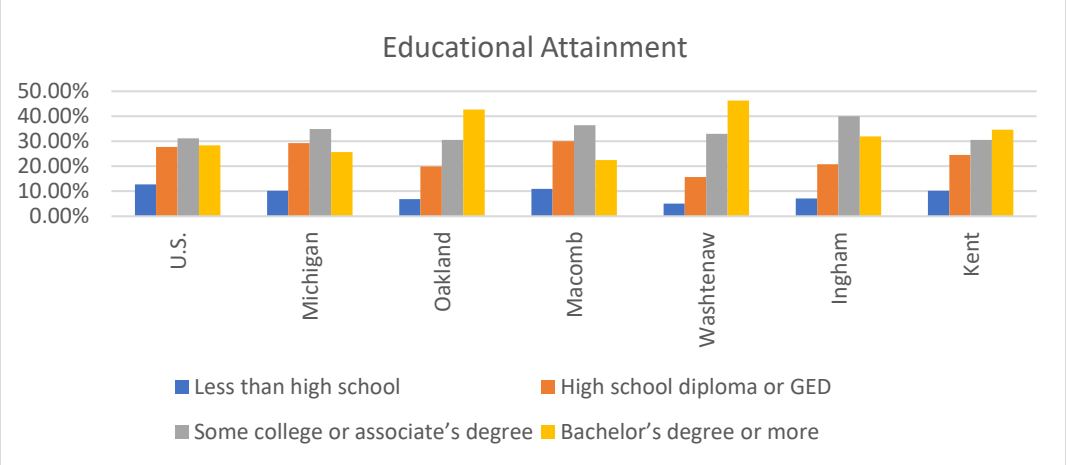
Ingham County has two GM plants. Lansing Delta Township builds the Buick Enclave and Chevrolet Traverse SUV. This facility is one of the company's most modern and LEED certified because its engineers developed the "Ergo Chair" that consists of a robotic arm to carry a worker into the vehicle at the ideal position to perform vehicle assembly (LaReau, 2019). The other plant, Lansing Grand River builds Cadillacs, the recently announced leading brand of the company's electric vehicles (Hawkins, 2019). Both facilities will be considered for future AV and EV production. There is also a Pepsico bottling plant in Lansing that employs approximately 100 people to diversify the economy into the food, beverage, and tobacco manufacturing sector.

Kent County located in the western part of the state, has 15 percent of manufacturing jobs in the region. The region leads in metals, plastics, biopharmaceuticals, medical devices, production technology,

automotive, office furniture and food processing manufacturing (The Right Place, 2015). It is home to Aspen Surgical, a medical device manufacturing company, Kellogg's cereal processing plant, and Steelcase, a furniture manufacturer.

To get a sense of the level of training that needs to occur, the educational attainment of the adult population for each county is shown in Figure 7. The adult population is 18 – 65 and over.

Figure 7: Education Attainment Includes Comparison of the United States and State of Michigan



Source: American Fact Finder, 2017

Oakland County, once known as one of the wealthiest counties in the U.S., has the most educated adult population in Michigan with some college, associate's and bachelor's degrees or higher. However, Figure 3 shows as a percentage of its total adult population, Washtenaw County is the most educated county with a bachelor's degree or higher at 46.24 percent as evidenced by the research and development companies located in Ann Arbor mentioned earlier and the highly regarded University of Michigan school and hospital. The educational attainment of the adult population with bachelor degrees or more in the U.S. is 28.35 percent overall and can explain why the Detroit Three look to other countries' workforces when it comes to developing advanced technology, given China and India supply almost half of (46.4

percent) the global 6.4 million Science and Engineering bachelor's degrees (CSIS: Science and Engineering Indicators Report, 2016). The two countries are projected to collectively account for two-thirds of the increase in global science and engineering graduates through 2030. Michigan's percentage of adult population that has some college or an associate's degree is slightly higher at 34.86 percent than the U.S. percentage at 31.15 percent. The table and graph demonstrate the need for more adults to be retrained and upskilled at a community college (Workforce Intelligent Network for Southeast Michigan, 2017). Kent County's education is more evenly distributed among high school through bachelor's or more degrees than the other counties.

The community colleges with advanced manufacturing and related programs that will be analyzed are: Oakland Community College, Macomb Community College, Washtenaw Community College, Lansing Community College in Ingham County and Grand Rapids Community in Kent County.

3.3 Selected Community Colleges

3.3.1 Oakland Community College (OCC)

OCC has five building campuses and a virtual campus. It has a student population of 15,121 local, national, and international students (2019 Annual Report). There are 885 faculty members. The school touts its 50 percent transfer rate to a four-year institution. Seventy-one percent of the students attend the school on a part-time basis. The majority of students are white, female, and between the ages of 18-24. The tuition cost for in-district students is $94.50 per credit hour and for out-of-district (international and non-Michigan residents) students is $183.00 per credit hour.

OCC has agreements with over 30 high schools to accept their students for a dual program that allows them to earn free community college credits while still in high school. Students in Birmingham and Detroit Public Schools are eligible. These career and technical education students can enroll in introductory business administration, computer programming, engineering technology and advanced manufacturing courses. Classes are taken at the high school or the school district's technical education center. An advantage in this program is after high school, students have saved money and time and can move into higher level courses.

According to the school's website, advanced manufacturing is located on the campus of Auburn Hills and falls under the Engineering, Manufacturing, and Industrial Technology program. OCC received a grant for robotics from the National Science Association in 2018. Students find jobs in fields ranging from automotive services and robotics to construction management and heating and cooling. The study will focus on the robotics/automated systems; welding and fabrication technology; computer-aided design and engineering technology – vehicle design option; machine tool technology; and Computer Information Systems sections. Students can obtain a certificate or an associate's degree as a robotics technician to work in a factory or automation facility. A certificate in Robotics/Automation Systems Technology – Programmable Controllers can be earned after 12 credit hours. The Robotics/Automation Systems Technology certificate is designed to be completed after 34 credit hours. An associate of applied science degree can be earned after 62 credit hours.

The welding program only offers a certificate to become a welding technician and preparation for the examination of the American Welding Society SENSE Level 1 (entry-level) certification. It can be completed after 3 semesters and 39 course credits. OCC gives high school graduates the ability to get credits for welding classes taken at a career and technical education program (CTE).

Computer-aided design and engineering technology – vehicle design options give a student an entry way into the principles and concepts of vehicle underbody and upper-body design, creation of assembly structures, advanced modeling techniques, building parametric models, data organization, and advanced surface development. An associate of applied science can be earned with 62 – 64 credit hours. OCC may give credit in this program to students that were in a career and technical education (CTE) program in high school. The college encourages graduates to transfer to Eastern Michigan University, University of Michigan – Flint, or Siena Heights University for a four-year degree in Engineering Technology.

The Machine Technology program instructs the students on manually operated and computer-driven metal cutting machinery such as the CNC machine. Also, the interfacing of automated equipment with computer aided design and computer aided manufacturing systems are taught. As factories become more automated, the study views the required introduction to robotics course as a favorable transfer to a mechanical engineering program at a four-year institution after earning 63 credit hours for an associate of applied science degree.

Computer Information Systems is located at the Orchard Ridge Campus. There is a Software Engineering option that fits in mobility. The student will learn the computer skills to design, create, and test software. A certificate with 34 credit hours and an associate of applied science degree with 62 credit hours can be earned as a precursor to a four-year degree required for most jobs.

Cybersecurity is offered for students that want to plan and carry out security measures to protect an organization's computer networks and systems. Networking and network security skills are offered

using server, infrastructure and perimeter technologies working in Linux operating systems, Cisco infrastructure and perimeter devices, and Microsoft operating systems. A certificate with 36 credit hours and an associate of applied science degree with 61 – 62 credit hours can be earned as a precursor to a four-year degree required for most jobs.

OCC provides students with online access to outside supportive human services in Oakland County. For food and nutrition agencies like the Grace Center of Hope and for housing the Salvation Army is listed. The agencies' guidelines and contact information are provided to help the student determine if they qualify for a particular program.

Tuition grant assistance is available from the federal, state, and college. The Federal Pell Grant is awarded to students with "exceptional" financial need in an amount up to $6,195 for the academic year. Secondly, the Federal Supplemental Educational Opportunity Grant is available for exceptional needy students also with preference given to those that qualify for the Pell Grant. One can receive an amount up to $1,600 for the academic year. The student must fill out the Free Application for Federal Student Aid (FAFSA) to begin the assessment of the grant amount. Further, there is a Tuition Incentive Program through the state that pays in-district tuition, registration, and student service fees for up to 12 credit hours per semester or 24 credit hours per academic year. There is also the state-sponsored Michigan Competitive Scholarship Fund for needy students that have academic potential based on a national ACT composite score of 23 or more. A student will receive up to the amount of financial need or the amount of tuition, whichever is less. Through OCC's Board of Trustees, the Trustee's Award is offered to in-district students without an associate's degree in the amount up to $1,400 per academic year.

OCC is a participating member with the Detroit Scholarship Fund that gives Detroit high school graduates a chance to have their tuition and fees paid based on the FAFSA. It does not cover books, transportation, and computers. OCC offers free onsite career counseling with advisors to guide their career pathway. In addition, OCC has a partnership with an online global career development platform, Career Cruising, in Canada. The website describes the platform as a way to prepare all students for success in school, career, and life. A password for the online service is provided by an OCC counselor. Enrolled students have access to resume review, a library with open jobs, and career and workforce development programs for adult learners.

3.3.2. Macomb Community College (MCC)

MCC has three campuses as well as online learning. There are 21,946 students enrolled in a degree credit program (2018 By-the-Numbers Report). It has 85 percent of in-district residents, 13 percent non-district residents, and 2 percent other (affiliate, veterans, etc.). Seventy percent of the students are part-time. The majority of the students are white, female, and 18-24 years old. Fifty-three percent of the degree seeking students wish to transfer to a four-year institution such as Oakland University, Wayne State University, Michigan State University, and Walsh College. The tuition for Macomb residents, including veterans or members of the Armed Services and their families, is $102 per credit hour; in-state (outside of Macomb County) is $190.00 per credit hour; and out-of-state is $242 per credit hour.

The Early College of Macomb program allows high school juniors to enroll in a three-year program starting with the 11th grade through the 13th year. Macomb County public and non-public school students' books, fees, and tuition are free. The school district is billed for these fees for public school students and the state is billed for non-public school students. The student is responsible for any fees that exceed the

authorized payment limit. The student can choose one of six career pathways: animation, business, mechatronics, medical assistant, hotel management, and renewable energy.

The Engineering, Technology, and Design Department offers Electronic Engineering Technology; Information Technology; Manufacturing Engineering Technology; Automated Systems Technology - Mechatronics; Automotive Technology – Vehicle Development; and Pre-Engineering at the South Campus. A certificate of completion can be earned in Electronic Engineering Technology – Basic Electronics with 22 credit hours. A certificate of achievement in Electronic Engineering Technology can be earned with 47 credit hours. An associate of applied science degree in Electronic Engineering Technology can be earned with 62 credit hours.

The Information Technology program offers certificates in completion and achievement in Java & Mobile Programming with 22 credit hours, C++ Programming with 23 credit hours, and Information Technology Programming with 32 credit hours. An associate in applied science in Information Technology Programming can be earned with 64 credit hours.

The Manufacturing Engineering Technology prepares students to become technologists to provide support for routine engineering operations in product design, development, and manufacturing. An associate in applied science can be obtained after 62 credit hours.

The Automated Systems Technology – Mechatronics certificate of achievement is earned with 46 credit hours. The associate of applied science degree in Automated Systems Technology – Mechatronics is earned with 62 credit hours. A certificate of completion in Pre-Engineering can be earned with 29 credit hours. An associate of science degree in Pre-Engineering can be earned with 62 credit hours.

The Automotive Technology – Vehicle Development program gives students the ability to develop the technical skills, knowledge and abilities to assist engineers in the development of electro-mechanical systems for the next generation of safe, efficient, and intelligent vehicles. An associate of applied science in Automotive Technology – Vehicle Development can be earned with 66 credit hours.

The Pre-Engineering program gives students an insight into the math, science, and basic engineering principles for a 4-year degree. With a certificate after 29 credit hours or an associate of applied science degree after 62 credit hours, a student can become an electrical and electronics engineering technician, engineering technician, mechanical engineering technician, or machinery mechanic.

MCC has a new program as of fall 2019 at the West Campus. Information Technology – Cloud Computing prepares students in Cloud Infrastructure as a service (IaaS), Platform as a Service (PaaS) and development of cloud native applications. A student can get an entry-level job as a data architect to work on data systems such as GM's OnStar in vehicles and in analytics to maximize uptime, improve first-time quality, and optimize machine productivity and predict customer's habits. A certificate of achievement can be obtained after earning 48 credit hours and an associate of applied science degree after 63 credit hours.

Also, in the Information Technology department is Cybersecurity. A student can earn a certificate of completion as a Networking Specialist with an Information Assurance, Skill Specific Certificate after 18 credit hours. A certificate of achievement as a Networking Specialist – Networking Security Professional can be obtained after 49 credit hours and an associate of applied science after 64 credit hours. The program prepares students for the following certifications: Security+, Certified Ethical Hacker (CEH), and the Systems Certified Practitioner (SSCP).

MCC is unique in that the school has a Center for Advanced Automotive Technology that has been funded by a grant from the National Science Foundation. It is a partnership between MCC and Wayne State University and connects academia, government, and industry to provide education resources in advanced automotive technology. The center gives conferences on ways to replace aging populations in the positions of automotive technicians, engineering technologists, and engineers. It is recommended that children at the pre-K age be introduced to STEAM (science, technology, engineering, arts, and math) to get them interested in technology.

Also, touted at MCC is the Applied Technology and Apprenticeship program that combines on-the-job training with classroom and lab instruction. There are also employer-sponsored apprenticeships where an employer teams up with MCC for the school to train their employee on specific skills to carry out their job duties. After completion of the apprenticeship program, a student will receive both a U.S. Department of Labor certificate and an MCC certificate. The student can seek more education by earning the apprentice certificate and an Associate of Applied Science Degree in Applied Technology. Students can transfer their industry training for a bachelor's degree or to higher technical programs at Eastern Michigan University, Ferris State University, Lawrence Technological University, and Wayne State University.

MCC provides students with online access to outside supportive human services in Macomb County. Organizations that have affordable childcare options and that dispense diapers and formula are listed in a directory. Students who receive public assistance will likely qualify. The college offers the Pell Grant, state Tuition Incentive Program and Michigan Competitive Scholarship Fund for needy students that have academic potential based on the national ACT. Tuition assistance is also available in the form of a grant based on financial need, Macomb residency, and enrollment of at least six credit hours. MCC is a

participating member with the Detroit Scholarship Fund that gives Detroit high school graduates a chance to have their tuition and fees paid based on the FAFSA.

MCC offers free onsite career counseling with advisors to guide their career pathway and through the online global career development platform, Career Cruising, in Canada. The college also hosts First Fridays Field Trips that give students the opportunity to visit an employer and tour their facility.

3.3.3 Washtenaw Community College (WCC)

WCC has one campus in Ann Arbor, online learning, and three extension sites that are in Brighton, Ypsilanti, and Hartland. There are 12,264 enrolled students, with 166 full-time and 536 part-time faculty members (National Center for Education Statistics, Fall 2018). The percentage of full and part-time students is relatively the same amount. There are 53.2 percent of female students and 46.8 percent of males that are enrolled part-time, while 48.9 percent of female students and 51.1 percent of males are enrolled full-time (Consumer Information Report, 2017). The majority of the student body is white, 24 years of age and under (National Center for Education Statistics, Fall 2018). The retention rate that measures the percentage of first-time students who return to the institution to continue their studies the next fall is 70 percent for full-time students and 50 percent for part-time students. Yet the overall graduation rate is 17 percent for students who began their studies in 2015. Ninety-seven percent of the students are in-state residents. The tuition rate for in-district students (resident of Washtenaw County) is $95 per credit hour; $164 per credit hour for out-of-district; $227 per credit hour for out-of-state; and $268 per credit hour for international residents.

WCC has multiple dual enrollment programs for high school students. If students begin this program as early as the 9th grade, they can earn up to 18 credits by the time they graduate. Most schools pay for

public school students' tuition, fees, and books, while the state pays for non-public school students' expenses and books.

WCC also has a career and technical education program where classes are free and can be taken at the student's high school if it is part of the Tech Prep partnership with the community college. A student can choose from several fields such as accounting, business, computer information systems, robotics or mechatronics, and welding.

Washtenaw Technical Middle College, a four-year high school on WCC's Ann Arbor's campus, is highly regarded and enrollment is done on a lottery system. Ypsilanti Community Schools STEMM Middle College is a five-year program located in Ypsilanti Community School high school. Students begin their STEM journey in the early grades and by the 11th grade, they transition to college classes at WCC. Students get the opportunity to be on two-award winning FIRST Robotics teams.

Neighboring Livingston County Early College gives students in Brighton, Fowlerville, Hartland, Howell, and Pickney high schools the opportunity to earn a technical certificate or associate degree. They have four courses to choose from: cybersecurity, computer networking, construction technology, or construction management. A student begins to take the college level courses at WCC in the 11th grade through a fifth year of high school free of charge.

WCC's website states students obtain advanced manufacturing skills in the Advanced Manufacturing Systems division. A student can earn an advanced certificate with 16 credits in machine tool programming and industrial electronics technology, and with 24 credits in welding and fabrications advanced applications. In the machine tool programming curriculum students will learn advanced computer

numerical control programming. The industrial electronics technology courses teach students advanced techniques to apply and control electric motors, use structured techniques to program programmable logic controllers (PLCs), and an industrial computer found on assembly lines or robotic devices, according to the National Electric Code. The program prepares students to pass the State of Michigan Journeyman Electrician Licensing Exam.

An associate in applied science can be obtained in Engineering-Technologist Manufacturing, Mechatronics, and Welding Technology. With an engineering-technologist manufacturing degree, students will be able to operate various types of automated design/machine tool equipment. They will become an entry-level engineering technologist or technician. The mechatronics degree will prepare a student to become an entry-level automated equipment technician. The welding degree consists of courses in welding, cutting and fabrication safety, theory and fundamentals, and then more advanced techniques such as weld quality, inspection testing and repair techniques, and automated welding, and cutting systems and operations. WCC has articulation agreements with Eastern Michigan University, Wayne State University, for students to transfer to earn a Bachelor of Science degree.

WCC has Information Technology under the Business Division and gives students the opportunity to earn one of several certificates and an associate in applied science degree. The certificates are: Applied Data Science, Computer Systems Technology, Foundations of Information Systems, Linux/Unix Systems, and Principles of Cybersecurity ranging from as little as 10 – 20 credit hours. An Advanced Certificate can be obtained in: C++ Programming; Computer Networking Academy; Computer Networking Operating Systems; Program in Java; and Web Database Programming Professional ranging from just 12 credit hours. There is an associate in science degree for Programming in Java; Programming in C++; General Studies; Computer Systems and Networking; and Cybersecurity with 60 credit hours. The study will focus on

certificates in applied data science, program in Java, C++ programming, and the associate of science degrees in Java and C++ programming. The information systems and programming curriculum prepares students for professions in computer information systems and programming for a foundation in robotics, systems, and software development. The applied data science courses prepare students for a data analytics position, which is in demand for manufacturing processes.

WCC has an Advanced Transportation Center (ATC) on its main campus and trains future and existing workers. According to its website, advanced transportation is where the point of advanced manufacturing and information technology intersect. The college and five Midwestern universities have formed a consortium to research connected and automated vehicles at the U.S. Center for Connected and Automated Vehicles. The consortium is made up of the University of Michigan, Purdue University, the University of Illinois at Urbana-Champaign, University of Akron, and Central State University. It is charged with researching safety, congestion, connected vehicles, connected infrastructure, and autonomous vehicles. For WCC's part, the areas of study are: intelligent transportation systems that include connected vehicle technologies; advanced automotive service and repair, and lightweight materials/manufacturing that includes the aforementioned programs. Some of the classes can be taken online.

WCC students receive human services help from an on-site student resource center. A Student Emergency Fund has been established for childcare; tuition; books; bus tokens; avoiding utility shutoffs, unexpected car repairs; and rent assistance. A student must have completed a semester and be in good academic standing and meet the income guidelines. The resource center has an on-site emergency food pantry for food and hygiene products. WCC has an onsite childcare facility for children 18 months through 5 years old. This college has the programs comparable to the ones in the Literature Review that appear to be successful in helping students complete their studies.

The college offers the Federal Pell Grant, Federal Supplemental Educational Opportunity Grant, and Federal Carl Perkins Grant. The Carl Perkins Grant pays for tuition, books, and childcare costs for financial needy students in certain occupational majors. There are also eight categories that a student must identify with: single parent; person with disability; someone preparing for a non-traditional field; someone from an economically disadvantaged family; someone out of workforce; a youth aged out of the foster care system; English learner; and someone who is homeless. The state Tuition Incentive Program and Michigan Competitive Scholarship Fund is also offered. Tuition assistance is also available in the form of a grant based on financial need, Michigan residence, and enrollment of at least six credit hours.

WCC offers onsite career counseling with advisors and through several online platforms to self-assess their interest and personality traits: Career Cruising, My Next Move, Inside Jobs, The Keirsey Character Sorter I and II. The college has also highlighted several academic programs that students can use to find out more information of their career path such as Accounting and Business.

3.3.4 Lansing Community College (LCC)

LCC has two campuses and two centers that are in East Lansing and Livingston County. There are 17,503 enrolled students (2017-18 LCC Facts). It also has 1,566 faculty members. The 2016 Annual Report states that the majority of the students were white, female and between the ages of 18-21 years old (2016 Annual Report). From fall 2017-fall 2018, the retention rate was 62 percent. The graduation rate during this academic year was 18 percent with 28 percent transferring to a four-year institution.

LCC's website explains that the school makes efforts to ready high school students for college through three initiatives. The High School Diploma Completion Initiative gives a student between the ages of 16 and 19 the opportunity to earn college credits while in high school. The courses are part of the LCC

curricula and are taken on campus. The Early College initiative is a three-year STEM based program where up to 60 credits towards an associate's degree can be earned. Free tuition, textbooks, and CATA bus tickets are given to the students. Lastly, the Coalition for College and Career Readiness initiative addresses the skill gaps identified between high school and first year of college by projects of five action teams.

Unlike other community colleges, tuition costs are based on the course's billable hours, instead of credit hours. A billable hour is the amount of time that a student spends in direct contact with an instructor or with laboratory equipment. College district residents are residents that have lived four or more months in one of 15 school districts listed on LCC's website. East Lansing is included as one of the school districts. The tuition is $108 per billable hour. For in-state students who live in Michigan but not in one of the 15 school districts, the cost is $216 per billable hour. Out-of-state students that live outside of Michigan must pay $324 per billable hour and for international students, the cost is $378 per billable hour. The courses needed are expressed in credit hours with the number of billable hours.

According to LCC's website, the Center for Manufacturing Excellence is located on the West Campus in Delta Township. The center has programs in Computer Aided Design, Precision Machining, Robotics & Automation, and Welding. There are two certificate programs: certificate of completion and certificate of achievement. If further education is desired, an associate of applied science is granted. Under the computer aided design curriculum, a student can learn the use of engineering design graphics, parametric modeling, computer numerical control programming, 3D printing, and additive manufacturing. An example of the skills taught is when Industry 4.0 is applied inside the CAD system to stage products for metrology inspection, metallurgy, geometric dimensioning and tolerancing, tools for production, and engineering changes. A student will be skilled for an entry-level position in manufacturing after earning 40 credit hours for a certificate of achievement. A certificate of completion in Computer Aided Design

can be gained with 22 credits/31.5 billing hours and will introduce manufacturing principles and automation design. After earning 69 credits/94.5 billing hours, an individual can obtain an associate degree in applied science in Computer-Aid Design to build virtual representations of products by employing 3D parametric Solid Modeling found in the automotive industry.

The Precision Machining department teaches CNC Machine Technology, Industrial Manufacturing Engineering Technology, Machine Tool Technology, Electrical Technology, and Manufacturing Engineering Technology. A student can earn a certificate of completion in CNC machine technology after 21 credits/31 billing hours and a certificate of achievement after 35 credits/52 billing hours. A certificate of achievement in machine tool technology is obtained after earning 31-34 credits/42.5 – 51 billing hours. An associate in applied science in manufacturing engineering technology and industrial manufacturing engineering technology is awarded after earning 60 credits/83 billing and 63-64 credits/81-82 billing hours, respectively. All the programs give the student the technical skills for CNC machine programming and operation, computer aided manufacturing design/programming and metal processes. Again, as the industry transitions into more automated processes, more education will have to be obtained to remain employed in the industry.

Under Robotics and Automation, an individual can earn a certificate of completion in Robotics and Automated Technology to obtain an entry-level position to write and edit programs on industrial robots and maintain fluid power systems with 16 credits/22.5 billing hours. A certificate of completion to become an industrial maintenance technician is achieved with 31 credits/42 billing hours. This certificate is designed for a pre-apprentice or apprentice and an employee of an industrial business. Students will learn the ability to troubleshoot, test, and repair modern-day equipment having a diverse technological design.

Further, LCC offers a certificate of achievement in Mechanical Systems to obtain an entry-level position to adjust, maintain, replace, and repair equipment and machines after 32 credits/43.5 billing hours. Also, one can gain a certificate of achievement in Robotics and Automated Technology for industrial and manufacturing sectors with 31 credits/42 billing hours. Students can earn an associate of applied science degree in Mechanical Systems with 63 credits/85.5 billing hours to become a maintenance technician to be able to diagnose hydraulic problems, perform preventative maintenance procedures, and be able to work well with others. In addition, an associate degree in Mechatronics – Multi-Skilled Maintenance Technology can be obtained with 62 credits/83 billing hours to become a mechatronics technician. The graduate will have knowledge of electrical, electronic, computer, mechanical, fluid power, robotic and programmable logic controller systems.

In the Welding Technology curriculum, students can earn one of two certificates. The certificate of achievement of Welding Technology can be obtained with 31 credits/45.5 billing hours for expertise in metal arc welding (MIG), gas tungsten arc welding (TIG), shielded metal arc welding (SMAW), brazing and ox-fuel cutting, and plasma cutting for entry-level positions. The certificate of completion in Welding Technology requires 18 credits/27 billing hours. An associate degree in welding technology can be obtained with 60-61 credits/81-83.5 billing hours.

The Computer Programmer/Analyst and Cybersecurity programs are also located at the West Campus. A certificate of completion can be earned after 19 credits/19 billing hours and an associate of science degree after 64-67 credits/65-69 billing hours. A computer software tester certificate of achievement can be earned after 33 credits/33 billing hours to create software programs or applications and search for defects in these applications. An associate of business degree in Computer Networking and Cybersecurity can be earned after 66-68 credits/67-71 billing hours. LCC has an Engineering/Physics

program in the Science Department at the main Lansing campus. An associate of science degree can be earned after 60 – 62 credits/65-68 billing hours.

Lastly, LCC has a University Center, which is an on-campus partnership with Central Michigan University, Ferris State University, Northwood University, Siena Heights University, and University of Michigan-Flint. These universities offer junior and senior level and some master's degree courses in Allied Health and Administration, Business Administration, Criminal Justice, Elementary Education, Career & Technical Education, Accounting, Communication, Applied Science, and Psychology.

LCC provides supportive services through its Adult Resource Center. The Center grants partial payment for childcare based on the FAFSA. The requirement for funds is that children must be in an outside licensed day care during the time the student is attending a class. There is a Financial Aid Book Voucher up to $600 for students that receive a refund for aid greater than tuition and fees.

The Center also oversees the Special Population Grant for tuition assistance for designated classes: single parent; enrollee in occupational program that has been underrepresented by his/her gender; English learners; disabled physically and mentally student; economically disadvantaged student, including foster children, homeless students; youth in or out of the foster care system; and an underemployed or unemployed student. The amount for the academic year is based on the FAFSA.

LCC offers the Federal Pell Grant and the Federal Supplemental Educational Opportunity Grant. Career and Employment Services offers one-on-one advising on how the student can create a resume and cover letter; prepare for interviews; search for internships and jobs.

3.3.5 Grand Rapids Community College (GRCC)

GRCC has a campus in the city on the lakeshore and four satellite sites in Grandville, Rockford, Lowell, and Caledonia. There are 13,825 enrolled students (2018 Fall Enrollment Report). The 2018 Fall Enrollment Report cites the majority of the students were white, female, and the average age of 23.8 years old. The one-year retention rate for beginning, degree-seeking freshmen from fall 2017 returning for fall 2018 was 53.5 percent. As of August 31, 2017, the graduation rate was 19 percent and 25% had transferred to higher learning institutions (GRCC Student Outcomes Grad/Transfer Report, 6/10/2019).

GRCC has developed a Strategic Plan 2018 – 2021 to address teaching and learning; completion and transfer; equity; community impact; and infrastructure and sustainability (GRCC New Strategic Plan, July 2018). Indicators to measure success have been established and outlined in the plan. The effort to address completion and transfer will be tackled through the Academic Pathways Model, which evaluates admissions, advising, orientation, program review, curriculum development, transfer, classroom instruction, tutoring, financial aid, student progress tracking, and high school outreach.

GRCC has a dual/concurrent enrollment program. Tuition and fees are paid by the participating high school for public students and the state for non-public students. A student must maintain a 2.5 or higher to continue in the program.

GRCC also has a middle college program. It is a 13th year high school program that gives a student the opportunity to earn an associate's degree. GRCC has a partnership with Wyoming, Cedar Springs, East Kenwood, and Ottawa Hills high schools for an associate of arts degree; Kent Intermediate School District for an associate of applied arts and sciences – mechanical design degree; and the Ottawa Area

Intermediate School District and local business partners with a certificate of industrial maintenance or tooling and manufacturing degree.

The 2020-21 tuition cost is $117 per contact hour for a resident, $247 per contact hour for non-resident; and $371 per contact hour for out-of-state students. GRCC defines a contact hour as 60 minutes of student instruction that the student is scheduled to come into contact with an instructor or tutorial or laboratory equipment. Thus, the calculation of the number of contact hours of a course is divided by the minutes spent in class by 60.

The Manufacturing Program is housed in the Wisner-Bottrall Applied Technology Center in Grand Rapids. It consists of three departments: Tool and Manufacturing; Plastics; and Welding. A student can earn a machine tool certificate of completion after 17 credit hours. A certificate of achievement in tooling and manufacturing technology can be earned after 27 credit hours. A student can learn machine tool operations, computer numerical control (CNC) programming, computer aided design or computer aided manufacturing (CAD/CAM).

An associate of applied arts and sciences in plastics-polymer engineering technology in preparation to transfer to Ferris State University's bachelor of science degree in plastics engineering technology after 73 credit hours is offered. A student can also earn an AAAS degree in plastics-polymer engineering technology in preparation to transfer to Ferris' bachelor of science degree in manufacturing engineering technology after 69 credit hours. Skills taught are utilized in developing healthcare devices, automotive parts, household goods, sports equipment, furniture, toys, and machinery parts.

A welding skills certificate can be earned after 16 credit hours. An associate of applied arts and sciences can be earned after 60 credit hours. The welding student is trained to connect metal parts in automobiles, spacecraft, ships, appliances, construction equipment, etc.

GRCC has an Advanced Manufacturing Partnership program brings together students with West Michigan manufacturers. Companies pay for full tuition while the student works for that company. It began in 2012 and continued through 2017 until student interest decreased and resumed in fall 2018 with nine students. According to the school's website, a new cohort will not start in 2020.

Under Computer Information Systems, a student can enroll in computer programming, pre-computer information systems, and pre-information systems (cybersecurity). An associate of applied arts and sciences in computer programming can be earned after 60 credit hours. The school stresses that students should prepare to continue in a four-year program.

As a pre-cursor to a bachelor's degree in computer information systems, a student can earn an associate of arts in pre-computer information systems after 60 credit hours. The student is awarded the opportunity to learn database management, networking, software design, and systems analysis courses that are equivalent to those in the freshman and sophomore years at four-year institutions.

The pre-information security program prepares students for the CompTIA Security+, Linux+, Cisco CCNA Security, and the EC-Council's Certified Ethical Hacker (CEH) credential prior to transferring to a four-year institution. An associate of arts can be earned after 60 credit hours.

GRCC has a food pantry onsite that allows eligible students the ability to get non-perishable food and hygiene items such as soap. There are also six snack pantries throughout the campus. A student is required to complete an intake form every academic year to have pantry access twice a month.

The college offers the Federal Pell Grant and the Federal Supplemental Educational Opportunity Grant. The state Tuition Incentive Program and Michigan Competitive Scholarship Fund are also offered. There is also the Children of Veterans Tuition Grant for up to $2,800 per academic year to children of Michigan veterans who are totally and permanently disabled, missing in action, deceased because of a service-related injury or illness.

GRCC offers onsite career counseling with advisors and through some online platforms, Focus 2 and Career Coach, to self-assess their interest and personality traits and posted jobs.

Table 1: Summary of Community College Programs in Advanced Manufacturing (2019-2020)

OCC-CA, CC, AAS; LCC-CC, CA	a	Robotics & Automated Systems Technology (positions: robotics technician, robotics engineer) Median Salary: $77,309 for robotics engineer	This program is designed to prepare students for career opportunities in the robotics and automation fields
MCC-CA, AAS; LCC-AAS; WCC-AAS	b	Mechatronics (positions: robotic programmer, robotic technician, robotics engineer, controls technician, maintenance technician, electro-mechanical technician, automated equipment technician, mechatronics technician, mechanical engineering technician) Median Salary: $48,343 for Mechanical Engineer Technician	Integrates mechanical, electronic, fluid power (hydraulics or pneumatics) and computer robotics to streamline processes and improve quality of production
OCC-CA, AAS; LCC-CC, CA	c	Computer Automated Design and Engineering Technology and Vehicle Design Option/Industrial Computer Graphics (position: CAD technician, mechanical industrial drafter, electrical CAD drafter, engineering CAD technician) Median Salary: $55,550	The Vehicle Design option focuses on preparation for entry-level vehicle design positions using the computer as a tool in engineering, analysis, design, industrial technology, and manufacturing systems. The VDO specialization covers the principles and concepts of vehicle underbody and upper-body design, creation of assembly structures, advanced modeling techniques, building parametric models, data organization, and advanced surface development.
LCC-CA	d	Industrial Maintenance Technology (positions: millwrights, maintenance workers, machinery) Median Salary: $51,630	This certificate is designed for an apprentice, pre-apprentice, or person interested in advancing his/her skill set in the industrial maintenance trade.
WCC-CC, CA; LCC – CC, CA, AAS	e	Industrial Electronics Technology/Electrical Technology - (positions: electronics technician, industrial electronic technician; industrial engineering technician) Median Salary: $55,460	Students will develop skills in the installation, maintenance, and troubleshooting of industrial control systems with a focus on programmable logic controllers, electronic sensors, and electronic control circuits.

Table 1 (cont'd)

-CA, AAS; LCC-CC, CA, AAS for MET; MCC – CC, AAS **under Machine Technology**; **For Manufacturing Engineering Technology at LCC** WCC-AAS	f	Machine Tool Technology/Manufacturing Technology/Computer Numerical Control (positions: machinists, computer-controlled machine tool operators, metal and plastic; computer-controlled machine tool programmers, metal and plastic; machine service/repair) Engineering Technologist Manufacturing (positions: engineering technologist or technician, instrumentation technician, electrical instrumentation and controls technician) Median Salary: $44,950	The program is designed to emphasize the concepts of manually operated and computer-driven metal cutting machinery. Instruction will include cutting principles, programming techniques, computer controls, and computer numerical control (CNC) machine tool operations. In addition, the interfacing of automated equipment with computer aided design (CAD) and computer aided manufacturing (CAM) systems will be addressed. Students in this program will demonstrate proficiency in the operation of various types of automated design/machine tool equipment. Competencies in design, programming, and materials and machine processing will be developed
MCC-CC, CA, AAS; LCC-CA, AAS	g	Electrical/Electronics Engineering Technology - (position: electrical engineering technician) Median Salary: $64.330	This program will provide the student with a strong background in electrical and electronic theory.
OC-CA, AAS; LCC – CA	h	Computer Information Systems – Software Engineering/Software Tester (position: software systems developer, software tester) Median Salary: $33,079	Fundamental computer skills that are generally required to design, create, and test software, or analyze business system requirements and design solutions, or support and protect the operation of technology resources.
MCC-CA, AS; LCC – AS	i.	Pre-Engineering/Physics/Chemistry (positions: electrical & electronics engineering technician, engineering technician, mechanical engineering technician, and machinery mechanic; chemical technician) Median Salary: $56,250	Pre-Engineering Program has been designed to give a strong foundation in math, science and basic engineering principles that one can build upon through further and more specialized study.

Table 1 (cont'd)

MCC – CA, WCC – CC, AAS;	j	Information Technology/Computer Information Systems – Programming in C++ (position: programmer/analyst, robotics developer, systems developer, and software developer) Median Salary: $84,280 for programmer; $105,590 for developer	For entry-level positions in the computer programming field, with the option of specializing in C++, database, Java or Net C# programming. Devices, troubleshooting, and debugging.
MCC – CA; WCC – CC, AAS	k	Information Technology/Computer Information Systems – Programming in Java (position: programmer/analyst robotics developer, systems developer, and software developer) Median Salary: $84,280 for programmer; $105,590 for developer	The student will learn how to organize and manage information, design databases with Structured Query Language and Extensible Markup Language, develop and critique sets of application-level specifications, design and execute test plans, configure wireless
MCC-AAS	l	Automotive Technology – Vehicle Development position: vehicle development technician, electro-mechanical technician) Median Salary: $57,790 for electro-mechanical technician	Prepares students to assist engineers in the development of electro-mechanical systems for safe, efficient, intelligent vehicles.
LCC-CA, AAS	m	Mechanical Systems (positions: electro-mechanical technician, robotics technician) Median Salary: $55,947 for robotics technician	Prepares machine maintenance technicians for the repair, maintenance, and installation of industrial equipment.
OCC-CA; LCC-CA, CC, AAS; WCC-CC, CA, AAS	n	Welding and Fabrication Technology (position: welding technician, welder fitter, welding machine setter, structural metal fabricator) Median Salary: $41,380	This program prepares a student to enter the field of welding technology.

Table 1 (cont'd)

MCC-CA, AAS; WCC – CC	o	IT – Cloud Computing/Applied Data Science (positions: data engineer, product technician, cloud architect, cloud developer) Beginning Salary: $123,070	Prepares students for positions that require knowledge of Cloud Infrastructure as a service (IaaS), Platform as a Service (PaaS) and development of cloud native applications. With better analytics across the enterprise, automotive companies can maximize uptime, improve first-time quality, and optimize machine productivity.
OCC-CA, AAS; LCC-AAS; WCC-CC, AAS; MCC – CC, AAS	p	Computer Information Systems – Cybersecurity (positions: information security analyst; network and computer systems administrator; document management analyst)	The program prepares students to continuously monitor and analyze databases, networks, hardware, firewalls, and encryption to mitigate risk.
GRCC – AAS	q	Plastics-Polymer Engineering Technology (positions: plastics-polymer engineering technician; process set-up technician; new product development technician)	A graduate in Plastics and Polymer Technology will have a working knowledge of plastic materials and processing techniques, such as injection molding, extrusion, thermoforming, blow molding, rotational molding, and composite manufacturing.
OCC; WCC; LCC; GRCC	r	Other (positions: auto servicing technician; collision auto repairer; HVAC/R technician; business systems analyst; networking associate; graphics and web designer; IoT specialist; computer support technician)	

Source: Community College websites and Workforce Intelligent Network (WIN) Data Report and WIN-CAV Skills Gap Analysis, Bureau of Labor Statistics and Community College website for new occupations not classified by BLS such as Software Tester, and Salary.com

Chapter 4: RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

This chapter outlines the components of a technician study to assess community college training to prepare workers for advanced manufacturing jobs. The research question is, "can community colleges provide Michigan workers with the technical skills needed for advanced manufacturing jobs?" The research design and method gathers information from students, instructors, and employers to assess the ability of community colleges to train the future workforce.

4.2. Basis for Research Design Model

The research design model for the study is taken from Advanced Manufacturing, Mechatronics, and Quality Consortium (AMMQC) – Final Evaluation Report ("Report") (Negoita et al., 2013); the Urban Institute's Mechatronics Technician Competency-Based Occupational Framework for Registered Apprenticeship (2018); and online sources – MyMajor Robotics Technician Skills and Knowledge and Eastern Kentucky University – What is Developing a Curriculum (DACUM)?. The report evaluates the ability of job training programs in advanced manufacturing to meet employers' demands. A consortium that includes four community colleges in four different states: Mount Wachusett Community College (MWCC) in Massachusetts, Bossier Parish Community College (BPCC) in Louisiana, North Central State College (NCSC) in Ohio, and Southwest Tennessee Community College (STCC) were studied. Nontraditional students were the target group and their ability to obtain middle-skill occupations was the purpose of forming the consortium.

The report identified the following key components: grant staffing; partnerships; participant recruitment and intake; student support and job placement; development of training programs and curricula;

articulation and career pathways; online and technology-enabled learning; and sustainability. These key components were tracked for each of the implementing colleges to identify common themes. An implementation study focused on what worked, what did not work, and why; the impact and outcomes studies focused on how the initiative contributed to participant, college, and consortium-level outcomes. While the full report focuses on the success of the training programs, elements will be taken primarily from the impact and outcomes studies of the report and apply them to an assessment of the preparedness of community college students for advanced manufacturing jobs of the future.

The report used multiple research methods including document review, semi-structured interviews, participant observation, a survey of student completers, an employer survey, and focus groups with selected students and employers. Data collection for many of these methods was taken during a series of three annual site visits to each college in the consortium. Descriptive analysis included calculation of outcomes. Multivariate models were used to study subgroup differences in outcomes. The following outcomes and impacts were measured: students' satisfaction with the program; employers' satisfaction with the initiative's success in providing qualified job candidates; participants' retention in academic program; completion of academic program; and students' employment status after participation. Additionally, a comparative interrupted time series methodology was used to estimate the impact of enrolling in noncredit programs on the probability of finding employment.

The analysis of this study will include the following elements from the report:

- The evaluation of impact and outcomes based on what worked, what didn't work, and why, student's satisfaction with program, student's retention in the academic program, whether on course to complete academic program, what initiatives the community colleges are taking to

improve academic programs and meet industry demands to increase students' chances of being hired, and employer's satisfaction with new hires

- Multiple research methods that include a survey of student's skill level, an instructor survey, and an employer survey

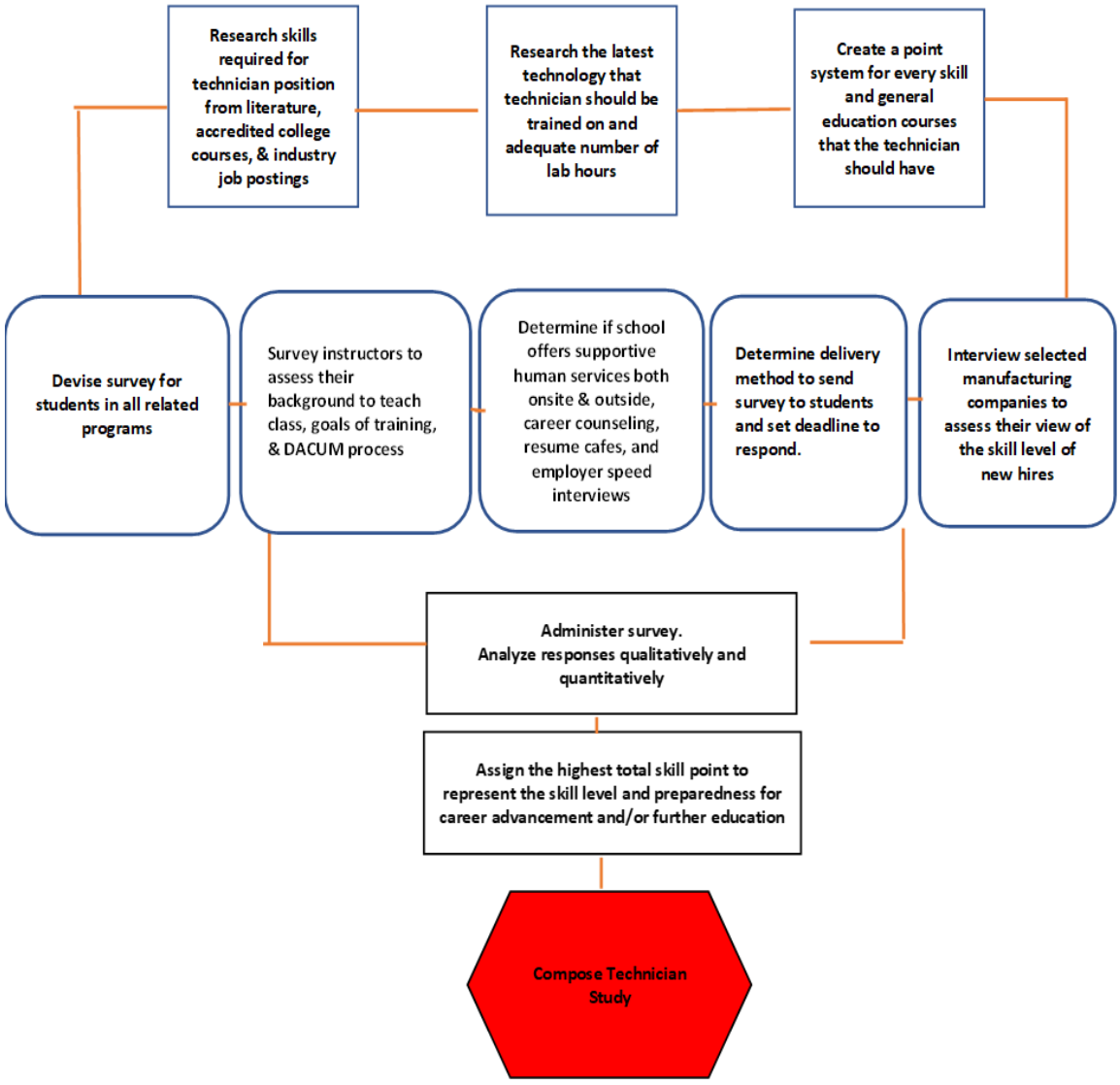
4.3 The Research Design and Methodology for a Technician Study

The advanced manufacturing programs at community colleges teach new techniques for various sectors. This technician study evaluates those techniques and the steps needed to get students employed upon graduation such as career counseling. The study first identifies the skills required for a technician position from the literature, accredited college courses, and industry job postings. Further, it describes the latest technology that technicians should be trained on and the adequate number of lab hours. As a way to determine the skill level of a student, a point system is created that assigns a ranking score to technical skills identified that the student should possess. Next a survey for students and instructors of these skills were created for all academic programs under study. Surveys were distributed to students and instructors at five community colleges with a set deadline to respond. The instructor survey assessed their background to teach a class, goals of training, and their process for designing a curriculum (DACUM). It is also important to determine how supportive the school is in addressing students' human service needs that may become a barrier to them completing their education, and the method career counseling and jobs are provided. Responses are analyzed qualitatively and quantitatively and the highest total skill point is assigned to represent the skill level and preparedness for career advancement and/or further education to a four-year institution.

The final stage was to understand the perspective of industry employers who were interviewed to assess their view of the skill level of new hires and the policies that can be implemented from all levels of

government to grow their businesses with a skilled labor pool. The research design is outlined in Figure 8.

Figure 8: Research Design and Methodology for a Technician Study



After all the data was collected, the survey variables were created and coded to run descriptive and inferential statistics. On the surveys, most of the questions are closed ended and multiple choice. Classes and skill level questions were then assigned points to indicate their effectiveness in providing a career

pathway. The methodology was guided from Dillman et. al (2014) who teaches that the first step in devising a survey is to write clear research questions or statements that identify what will be studied. Pace and Kuh (1998) created a survey on college student experiences and asked demographic questions to learn how college experiences vary.

In keeping with these methodology lessons to find out just who the community students are at each institution, the student is asked where they live to determine which city and county would benefit from their training. The demographics include age, race, highest education completed (high school or GED), current occupation and industry, and current salary. The student's enrollment on a part-time or full-time basis at one of the schools under study is asked and whether they are receiving tuition assistance from an employer or government source. It will be determined if students in an apprenticeship program while taking classes are more likely to have a higher skill level.

Dillman et al (2014) further explain that concepts of interest must continue to be broken down until the concepts of interest fit into domains or subdomains that can be measured with a single question. Therefore, to determine students post-graduate plans, the study explores how many of them are planning to go into the automotive industry and more specifically, autonomous and electric vehicle production, after graduation. If the student has a relationship with the automotive industry, such as laid-off worker, the number of bouts with unemployment is asked to see if that student still wishes to stay in the industry since this is where the Detroit Three and OEM's plan to make a big investment in mobility. Some schools under study partner with high schools that allow the student the experience of getting acclimated in an industrial setting in a career and technical education program and earn college credits at the same time. This experience and a STEM background provide the student with a higher skill level. A student can then earn a certificate and move into an entry-level position sooner and pay for continued studies. Advanced general study classes in chemistry, English, math, communications, and physics are required to be a

technician and have been assigned higher points. A statistics course is required for analytic skills and is computed in the totals for CIS – Software Engineering/Software Testing; Pre-Engineering/Physics/Chemistry; and CIS – Programming in C++ and Java.

The study rewarded students who study much longer by earning an associate's degree with the highest number of points in each program under study. The number of students who plan to transfer to a four-year institution is asked. A bachelor of science degree has more earning potential and job readiness for mobility positions. These students will make Michigan manufacturers competitive with foreign companies in their ability to make AV and EV's safe and placed on the road sooner. A student going straight through a program from their first semester to the last required class is ideal but life happens and that may not be the case.

Researchers Umbauch and Porter (2019) found few surveys that asked students about the barriers they face to completing college and wanted to provide a tool that colleges could use to eliminate those barriers and boost graduation rates. A student may be presented with barriers such as the inability to afford tuition to childcare issues that prevent them from going to school continuously. Like Umbach and Porter, the study uses the survey to identify what the barriers are and if any will prevent students from graduating on time. Also, Umbach and Porter captured students view of their programs. This question is asked on

4.3.1 Variables

The independent and dependent variables were derived from the literature on workforce development and community college and are presented in Table 2 on the next page.

Table 2: List of Variables

Independent Variables	Format	Source/Reason
City *The city the student resides in*	open-ended	Dillman et. al, 2014 To determine which city and county will benefit from a skilled worker
Age *The current age of the student*	open-ended	Pace and Kuh, 1998 Demographic background important because…
Gender *The sex that the student identifies with*	multiple choice	Pace and Kuh, 1998 Demographic background relevant due to access and occupation roles affected gender
Race *The racial identity of the student*	multiple choice	Pace and Kuh, 1998 Demographic background
School *The community college the student is enrolled at*	open-ended	Dillman et. al, 2014 To assess the number of students at each school

Table 2 (cont'd)

Community College Program		
The academic program the current/former community college student is enrolled in	multiple choice	Dillman et. al, 2014 To assess how many students are enrolled in each program to determine the impact future graduates will have on the field
Enrollment Status		
Part-time or Full-time	multiple choice	Dillman et. al, 2014 Shows students ability to graduate within 2 – 3 years
Credit Hours		
The number of completed credit hours	open-ended	Pace and Kuh, 1998 Shows students ability to graduate within 2 – 3 years
Tuition Assistance		
Any funding program that covers the student's tuition	multiple choice	Pace and Kuh, 1998 To assess how students are paying for college
Tuition Percent		
The percentage of the tuition that is covered from the funding program	open-ended	Pace and Kuh, 1998 To assess how students are paying for college
Highest Education Completed		
The highest education completed before enrolling in the community college	multiple choice	Dillman et. al, 2014 To determine traditional and non-traditional students
Apprenticeship		
A program that allows a student to gain work experience while enrolled at the community college	multiple choice	Dillman et. al, 2014 To determine if students are being exposed to hands-on job training
Current Industry		
The industry that the student currently is in	open-ended	Dillman et. al, 2014 To determine how many are entering manufacturing and how many will remain in manufacturing
Future Industry		
The occupational industry that the student plans to enter after graduating from community college or four-year university	open-ended	Dillman et. al, 2014 To determine how many people plan to remain in manufacturing

Table 2 (cont'd)

Future Manufacturing Sector		
The manufacturing sector that the student plans to work in after graduating from community college or four-year university	multiple choice	Dillman et. al, 2014 To determine how many people plan to remain in manufacturing
Automotive Industry Relationship		
If the student has been or is a current worker in the automotive industry	multiple choice	Dillman et. al, 2014 To determine if the student wishes to stay in industry
Future in Autonomous and Electric Vehicle		
If the student plans to work in the autonomous and electric vehicle division after graduating from community college or four-year university	multiple choice	Dillman et. al, 2014 To determine if the student wishes to work with new technology
Unemployment		
The number of bouts the student has experienced since 2007	multiple choice	Dillman et. al, 2014 To determine if the student wishes to stay in industry
Career and Technical Education Program	multiple choice	Dillman et. al, 2014 To determine high school preparation
If the student was in a CTE program in high school		
Career and Technical Education Program Partnership		
If the CTE program earned the student college credits toward a certificate or degree	multiple choice	Dillman et. al, 2014 To determine high school preparation
STEM Background		
If the student had STEM classes in high school	multiple choice	Dillman et. al, 2014 To determine high school preparation
Current College Program – 1, Robotics & Automated Systems Technology	closed-ended	WIN, 2017 High-demand field
Community College Program – 2, Mechatronics	closed-ended	WIN, 2017 High-demand field

Table 2 (cont'd)

Community College Program – 3, Computer Automated Design and Engineering Technology and Vehicle Design Option/Industrial Computer Graphics	closed-ended	WIN, 2017 High-demand field
Community College Program – 4, Industrial Maintenance Technician	closed-ended	WIN, 2017 High-demand field
Community College Program – 5, Industrial Electronics Technology	closed-ended	WIN, 2017 High-demand field
Community College Program – 6, Machine Tool Technology, Manufacturing Engineering Technology/ Computer Numerical Control/Engineering Technologist Manufacturing	closed-ended closed-ended	WIN, 2017 High-demand field
Community College Program – 7, Electrical Engineering Technology	closed-ended	WIN, 2017 High-demand field
Community College Program – 8, Computer Information Systems – Software Engineering/Software Tester	closed-ended	WIN, 2017 High-demand field
Community College Program – 9, Pre-Engineering/Physics/Chemistry	closed-ended	WIN, 2017 High-demand field
Community College Program – 10, Computer Information Systems – Programming in C++	closed-ended	WIN, 2017 High-demand field
Community College Program – 11, Computer Information Systems – Programming in Java	closed-ended	WIN, 2017 High-demand field
Community College Program – 12, Automotive Technology – Vehicle Development	closed-ended	WIN, 2017 High-demand field

Table 2 (cont'd)

Community College Program – 13, Mechanical Systems	closed-ended	WIN, 2017 High-demand field
Community College Program – 14, Welding and Fabrication Technology	closed-ended	WIN, 2017 High-demand field
Community College Program – 15, IT-Cloud Computing/Applied Data Science	closed-ended	WIN, 2017 High-demand field
Community College Program – 16, CIS Cybersecurity	closed-ended	WIN, 2017 High-demand field
Community College Program – 17, Plastics-Polymer Engineering Technology	closed-ended	WIN, 2017 High-demand field
Community College Program – 18, Other	closed-ended	WIN, 2017 Other fields such as automotive mechanics under advanced manufacturing academic programs
Certificate or Degree	multiple choice	Dillman et. al, 2014 Educational achievement
Future Associate's Degree	multiple choice	Dillman et. al, 2014 Educational achievement
Graduation Date	multiple choice	Dillman et. al, 2014 Educational achievement
General Studies – 1, Chemistry	closed-ended	Dillman et. al, 2014 Required course
General Studies – 2, English	closed-ended	Dillman et. al, 2014 Required course
General Studies – 3, Math	closed-ended	Dillman et. al, 2014 Required course
General Studies – 4, Statistics	closed-ended	Dillman et. al, 2014 Required course
General Studies – 5, Communications	closed-ended	Dillman et. al, 2014 Required course

Table 2 (cont'd)

General Studies – 6, Physics	closed-ended	Dillman et. al, 2014 Required course
General Studies – 7, Philosophy	closed-ended	Dillman et. al, 2014 Required course
General Studies – 8, Economics	closed-ended	Dillman et. al, 2014 Required course
Barrier Any issues that prevent student from continuing school and graduating on time	multiple choice	Umbach and Vallejo, 2015 & 2017 Umbach and Porter, 2019 To identify where more resources need to be allocated
View of Program The student's overall view of their academic program	open-ended	Umbach and Porter, 2019 To identify where more resources need to be allocated
Dependent Variable		
Current Occupation The current occupation of the student	open-ended	Pace and Kuh, 1998 Demographic background
Current Salary The current salary of the student	multiple choice	Pace and Kuh, 1998 Demographic background
Transfer to Four-Year University Whether the student will transfer to a four-year university after graduating from the community college	multiple choice	Pace and Kuh, 1998 To determine how many students are prepared to continue their studies
Future Residence Location The student's plans to stay in their apartment or home, move to another apartment or home in same city or another Michigan city or outside of Michigan	multiple choice	Dillman et. al, 2014 To create a labor pool in Michigan and to rebuild manufacturing communities
Score The accumulation of points for STEM background, CTE program, students' skills and general education classes	closed-ended	Dillman et. al, 2014 To determine if student is skilled in ….

Table 2 (cont'd)

Skill Level		
Designated levels that demonstrate the student's skill set and ability to obtain a future high-demand job: 1: Student is enrolled as a technician and has completed introductory courses. 2: Student has been trained in principles and methods used in their academic program. 3: Student has hands-on experience in technology related to their field and are taking the next level of skilled courses less than highest points for each college program. 4: Student has on-the-job training, may or may not have a STEM background, educational knowledge, credentials, and experience on the latest technology to advance in a career in advanced manufacturing and has been prepared to pursue a higher technical education at a four-year institution.	closed-ended	Dillman et. al, 2014 To determine if student is skilled
Monthly Income		
The amount of a monthly stipend that would allow a student to take up to an additional 4 credit class if they were able to work less	closed-ended	Dillman et. al 2014 To use as a policy recommendation

4.4 Data and Sampling

The research design is a mixed methods approach; both qualitative and quantitative. The quantitative portion consists of data collection from a survey of students in advanced manufacturing related courses at selected community colleges. The survey questions pertain to their demographic background (race, age, salary, current salary, educational attainment), exposure to a STEM curriculum suitable for future automotive jobs, and motivations for taking the class. The types of questions asked are expected job and wage after program and barriers to completing the program, and whether a student is in an apprenticeship program in addition to taking classes. The study looks at the State of Michigan education grants and other financial incentives for community college training to fill high-demand jobs such as a program like the Trade Readjustment Allowance (TRA) that has been administered in the past for workers who lose their jobs or whose hours of work or wages are reduced as a result of increased imports. TRA is the additional benefit that was paid after unemployment was exhausted. In this instance, an award would be given to students as an incentive to improve their skills for the automotive industry. They would be newcomers to the industry not necessarily displaced workers like the typical TRA program.

The instructors were interviewed to find out their background to make sure they have real world experience in addition to an educational background in the course they are teaching, to guide the evaluation of whether the training given is current with the technological demands required to fill future jobs. The parameters of the program are studied, and the instructors are probed to determine the goals of the training. Given an ever-changing market, instructors will be asked if there is anything about the program that they would change.

4.5 Survey Procedure and Data Collection

Michigan State University Office of Regulatory Affairs Human Research Protection Program granted the study exempt under 45 CFR 46.104(d) 2(ii) on April 27, 2020. After the office placed restrictions on human interaction in compliance with the State of Michigan's shelter-in-place order due to COVID-19, limited interaction with human subjects would take place and was the reason the study was granted an exemption. The student survey was conducted electronically as planned but no site visits could be conducted as first planned. The plan was that instructors would be interviewed through Michigan State University's Zoom platform but it became difficult to schedule the interviews and as an alternative a survey was created.

Each community college's Institutional Review Board reviewed an official application, the study's research methodology, survey questions, sample of e-mail to students and instructors to make sure that adequate safeguards for the rights and welfare of the participants in this study were exercised in the data collection. After it became difficult to set up a mutual time to interview instructors virtually at OCC, the methodology was revised to send the instructors a survey electronically. Grand Rapids Institutional Review Board took issue with not informing them of this change and asked for submittal of another application explaining why. They allowed the responses collected at that point to remain with the understanding that no further communication with the students or instructors would be conducted. The other four schools understood the reason for the change and accepted this new plan and required no further explanation.

A school representative at each community college was contacted and asked for their cooperation in administering the survey to the students in a set period. An e-mail with the reason for the survey and gratitude for participating was sent to the school representative to forward to all the Advanced Manufacturing, Computer and Information Systems, and Life Sciences students. At no time was there

direct contact with the students, except for WCC students. The Director of WCC's Institutional Research sent 186 student e-mail addresses directly to the researcher. The goal was to have survey responses back within three weeks of sending it out. A reminder e-mail went out to the students a week and a half after the first e-mail. It was hoped that at least 196 students among the five community colleges responded. This is based on a 95% confidence level, 5% confidence interval, and population size of 400 students. A financial incentive of a $5 Starbucks e-gift card was offered to WCC students after receiving a low response.

Instructors and students in Advanced Manufacturing, Computer Information Systems, and Life Sciences academic programs at the selected community colleges were surveyed beginning August 5, 2020 and August 27, 2020, respectively. Data collection ended on October 23, 2020. For most schools, both surveys were sent to the dean of the department to distribute. WCC has 186 students among Manufacturing and Computer Information Systems. LCC has Manufacturing students and 311 Engineering/Physics/Chemistry students. Grand Rapids has 864 Computer Information Systems students. Oakland Community College has 716 Engineering, Manufacturing, and Industrial Technology students and 315 Arts and Sciences students. MCC has 362 Business and Information Technology students and the number of Engineering and Advanced Technology students is unknown. The deans invited select instructors to participate. They were given a three-week deadline to respond. A reminder e-mail went to the instructors in the same manner as the students one and half weeks later.

After Wayne County Community College decided not to participate in the study, an attempt to reach Detroit students who represent Michigan's largest city, was made by contacting first-year transfer students from a community college in Computer Information Systems and Engineering at Michigan State University (MSU) and Oakland University (OU). MSU has 5 College of Engineering transfer students and

24 Computer and Engineering transfer students. The number of transfer students in OU's Engineering and Computer Science is unknown. The same procedure seeking approval from their Institutional Review Boards were followed like the participating community colleges. The deans of these schools granted permission to survey their students and asked their administrative assistants to distribute the survey through an outgoing e-mail. No instructors were surveyed. A reminder e-mail with the survey link was sent to the students by the administrative assistants one and half weeks after the first e-mail went out.

There was a low response from Washtenaw and Macomb students. An attempt was made to gain more participation from the Washtenaw students since the researcher had their e-mail addresses by offering the financial incentive. Unfortunately, only two more students were gained. The Macomb students were given extra time to respond because the deans had to send the e-mail to a communications center to distribute.

In total, there were 2,023 students that received the survey. There are 17 instructor and 190 student responses received that are usable. This is 9.39 percent return rate. There were 125 responses removed because of incomplete and no answers.

The instructor survey consisted of 11-open questions that pertained to their years, experience, and credentials in the subject they are teaching. They were asked their assessment of the skills that the students lack and how they attempt to cure those deficiencies. The student survey design consisted of 57 items, which were open and closed and multiple-choice questions (see Appendices). The items were asked in three parts. The first part centered on the student's demographics; the second part seeks their self-assessment of their academic skills and the third part asks their plans after graduation as far as staying in Michigan or moving to another city and whether they experienced any barriers while in school.

Table 3 : Questions for Instructors

Questions	Reason
1. Please identify your community college.	To obtain responses from all participating community colleges
2. What academic program are you in?	To obtain responses from many academic programs under study
3. How many years have you been teaching at this community college?	To determine the level of experience of instructor
4. Are you an adjunct or full-time professor?	To determine the level of teaching opportunity at the community college
5. Have you worked in the occupation that you are teaching? If so, what was the position and how many years?	To determine the level of experience of instructor
6. Do you possess any certifications. Please identify them.	To determine the level of experience of instructor
7. What deficiencies have you noticed that some students possess when starting out in the program?	To help determine the skill level of the student
8. What are you doing to address those deficiencies?	To help determine the skill level of the student
9. What is your process for designing a curriculum that keeps up with the latest trends in the industry?	To determine if the curriculum fits the demand of employers
10. What is the top skill that you teach in your program?	To determine the skill level of the student
11. How would you improve your program, if given the opportunity to advise your administration and local, state, and/or federal policymakers?	To utilize in the Policy Recommendations section of study

Employers in employment and training, autonomous vehicle development, pharmaceuticals and biomedicine in some of the study's counties were interviewed through Michigan State University's Zoom platform. The research found that the desire and needs of the business community do not always match with the training of a community college. Interviews were conducted with:

Table 4: Employers Interviewed

Director of Intelligent Mobility at FEV North America on Wednesday, January 29, 2020 at U of M's Center for Automobile Research Quarterly Meeting
Chief Executive Officer and Chief Scientific Officer of Velesco Pharma, in Wixom, Michigan on Tuesday, July 28, 2020 at 10:00 am.
President and CEO of MichBio in Ann Arbor, Michigan on Tuesday, September 8, 2020 at 11:00 am. (Mr. Rapunaldo set up the virtual meeting on his organization's platform)
Human Resources Manager of FEV North America on Tuesday, September 8, 2020 via e-mail.
Business Development Manager of Experis Engineering (a division of Manpower) on Friday, September 11, 2020 at 10:00 am.
Chief Executive Officer of Capital Area Michigan Works! on Friday, September 18, 2020 at 11:30 am.
Manager of Oakland County Workforce Development/Oakland County Michigan Works! on Friday, October 23, 2020 at 5:15 pm.

4.6 Analysis Design

4.6.1 Qualitative Analysis Plan

The qualitative analysis determined the background of the students before they enrolled at a community college and how the training they received will give the skills needed for future high-demand manufacturing jobs. The independent demographic variables used in the analysis are: school, age, gender, race, education completed, current occupation, current salary, current industry, city, current residence, and residence years.

The previous background, previous training and enrollment variables used in the analysis are: enrollment status, credit hours, tuition assistance, tuition percent, CTE program, apprenticeship, relationship to manufacturing industry, bouts of unemployment, STEM background.

The dependent variables tell the students' plans for the future and whether they can overcome any barriers to graduating: barriers, monthly income, future industry, future manufacturing sector, and future AV and EV plans.

4.6.2 Quantitative Analysis Plan

Most of the quantitative analysis consisted of running crosstabulations examining frequencies and measures of the mean, median, and Chi-Square and Cramer's V to determine the strength of the relationship between the independent and dependent variables.

A One-Way Anova is used to determine if being in a CTE program in high school contributed to the score a student received. No post-hoc test was given because the group of students were only analyzed in one time period. The F-value, degrees of freedom, and p-value are measured to determine if the relationship among the variables is significant.

An algebraic equation was created to calculate the monthly stipend that a student should receive to allow them to work less to be able to take more classes to complete their studies on time.

Table 5: Analysis Plan with Response to the Research Hypothesis

Research Hypothesis Determinants	Variables		Statistical Analysis
	Independent	Dependent	
Illustrate how students in community colleges are a diverse group with various socioeconomic backgrounds and formal education	All Demographic Previous Background & Training Barriers	Background and training before enrolling in their community college and any barriers to preventing graduation Future Residence	Descriptive Frequency, Crosstab, Mean Median Chi-Square Test Cramer's V
Determine the score for students in each academic program at every community college	Academic Program Community College	Score	Descriptive Frequency, Crosstab, Chi-Square Test Cramer's V
Determine how many students at each community college are enrolled in each general education class to see the highest level taken	STEM General Education Classes Academic Program	Community College	Descriptive Frequency, Crosstab, Chi-Square Test Cramer's V
Determine if being in a STEM program in high school contributed to the level of math a student reached	STEM Background	Math 1 - 9	Descriptive Frequency, Crosstab, Chi-Square Test Cramer's V
Determine if being in a CTE program in high school contributed to the score a student received	CTE Program	Score	One-Way Anova w/o Post Hoc Test F value *df* p value
Determine the monthly income it would take to allow a student the ability to take more classes due to working less (in Recommendation section)	Monthly Income	Credit Hours	Algebraic Equation

4.7 Reliability and Validity

The responses from the student survey were entered into SPSS for analysis to represent the role of community colleges in preparing workers for advanced manufacturing employment.. A reliability test of each skill, including general education requirements, and its Cronbach's Alpha was used. The validity of

the data measured the consistency of student responses that was then tested against the literature, job postings, and industry experts on skills needed for high-demand technical jobs in the manufacturing industry. Field (2013) explains that the reliability of a questionnaire should consistently reflect the construct that it is measuring. He states that a person should get the same score on a questionnaire at two different points of time if all things are equal. The Cronbach's Alpha measures scale reliability and a rating of .7 to .8 is acceptable.

The 297 skills assessed for the 17 academic programs in this study have a Cronbach's Alpha of .846. There were no respondents for one program, Plastics-Polymer Engineering Technology. The high rating established that there were no bias in how the questions were posed. Each skill set was posed to where if a student possessed it, they could mark it as one that they have been trained in it. Each skill was not phrased in a way that elicited a false claim. If a student did not possess a skill, they simply moved on to the next one until that section was completed.

Table 6: Some Represented Questions Considered Measurement of Reliability

Academic Program	Skill
Robotics	I can perform robotic maintenance, which includes the types of gears and gear reduction systems that are used in robots. I have been trained in mechanical adjustments, preventative maintenance, controller setting and procedures that influence the motion of the robotic manipulator and safety.
Machine Tool Technology	I have been trained in the practical application of machine hand tools through text materials and performance objectives. Beginning with simple operations such as layout, cutting, drilling, filing, and tapping objectives.

Table 6 (cont'd)

CIS- Software Engineering/Software Testing-	I have been trained in the fundamentals of database systems, which include the basics of database vs. file management systems; functions, components, and personnel involved in a database; database, client-server, and transaction processing architectures; and relational data models and operations.
Pre-Engineering, Physics, Chemistry	I have been trained in engineering problems and methods of finding solutions, manipulation and computation of data and results, and applied engineering concept.

CHAPTER 5: ANALYSIS AND FINDINGS FROM THE STUDENT SURVEY

5.1 Introduction

The study contains responses from a student survey to assess the advanced manufacturing training and skill level of the participants. The results of the survey were analyzed qualitatively and quantitatively to assess community college training and contribution to workforce development.

5.2 Student Survey-Demographics of Students

There are 190 student respondents from the five participating schools: 74 students from OCC; 12 students from WCC; 47 from GRCC, 18 students from MCC; and 39 students from LCC. Summary data of demographic details is discussed below and presented in Table 7.The majority of students are male and white, while the median age of all students is 23 years old. More than half (52.6%) of the students opted to attend school on a full-time basis while 46.8 percent of students attend school on a part-time basis. The mean for credit hours is 48 for the academic year with a standard deviation of 38. This means there are students that are just beginning their studies and those that are nearing completion with 60 – 62 credit hours.

A total of 50 students started their school this year; 44 in 2019; 32 in 2018; 20 in 2017; and 36 started before 2017. Tuition of 32 students (16.8%) is paid by their employer and 39 students (20.5%) receive a Pell Grant. Other tuition funding sources are military, State of Michigan, public school, scholarships, and student loans. Fifty-one percent of the students have 100 percent of their tuition paid. Most of the students' highest level of education is high school (57.9%), while 9 students (4.7%) have less than high school or are currently enrolled in a certificate program at community college and high school; 18 students (9.47%) have a certificate; 27 students (14.2%) have an associate degree; and 25 students (13.2%) have a bachelor's degree or higher and 1 student's (.53%) education attainment is unknown. The overall conclusion is that the students are traditional students that enrolled in a community college after high

school and are looking to gain entry into a career. The average age at the other 23 Michigan community colleges is higher at 25.7 (Michigan Community College Association, 2020). The white majority of advanced manufacturing students match the overall makeup of the population at the five community colleges and the counties they are located.

Table 7: Demographics of Students

Student Background

Variable	Frequency	Percentage
School		
Oakland Comm College	74	39.0%
Washtenaw Comm College	12	6.3%
Grand Rapids Comm College	47	24.7%
Macomb Comm College	18	9.5%
Lansing Comm College	39	20.5%
TOTAL	190	100.0%
Gender		
Male	137	72.0%
Female	51	27.0%
Other	1	0.5%
Prefer not to identify	1	0.5%
TOTAL	190	100.0%
Race		
White	151	79.5%
Black or African-American	16	8.4%
Hispanic or Latino	12	6.3%
Asian	11	5.8%
TOTAL	190	100.0%
Age (median)	23	

Table 7 (cont'd)

Enrollment Status

Part-time	89	46.84%
Full-time	100	52.63%
Unknown	1	0.53%
Total	190	100.00%

Credit Hours (mean)	48	
Year Started		
2020	58	30.5%
2019	44	23.2%
2018	32	16.8%
2017	20	10.5%
Before 2017	36	19.0%
TOTAL	190	100.0%
Credential Earned		
Certificate of Completion (25 credits or less)	7	3.7%
Certificate of Achievement (26 credits or more)	15	7.9%
Associate of Applied Science	134	70.5%
Other	20	10.5%
Associate of Arts	1	0.5%
Certificate and Associate	2	1.1%
Unknown	11	5.8%
Total	190	100.0%

Plan to Transfer to 4-Year University		
Yes	103	56.0%
No	81	44.0%
Total	184	100.0%
Tuition Assistance		
Employer	32	16.8%
Pell Grant	39	20.5%
Military Funds	5	2.6%

Table 7 (cont'd)

State Tuition Assistance	4	2.1%
Public School Funding	6	3.2%
Scholarship	3	1.6%
Student Loan	2	1.1%
Not applicable	98	51.6%
Unknown	1	0.5%
Total	190	100.0%

100% of Tuition Covered	51	

Education Completed

Less than high school/dual enrollment with comm college	9	4.7%
High school or GED	110	57.9%
Certificate	18	9.47%
Associate degree	27	14.2%
Bachelor's degree or higher	25	13.2%
Unknown	1	0.53%
Total	190	100.00%

There are 71 students (37.4%) who are currently working in manufacturing, 21 students (11.1%) in retail, 13 students (6.8%) in professional, scientific, and technical services, and 20 students (10.5%) in food services and 65 students in other occupations (34.2%). The respondents listed their occupation and places of work such as 2D/3D Designer at Ford; Adjunct Instructor; Aerospace Technician; Amazon warehouse worker; Cashier at Walmart; Tool and Die apprentice; and Uber Driver.

A total of 94 students (49.5%) plan to work in manufacturing after graduation. This means that 23 students will move into this industry. There are 61 students (32.1%) that plan to work in professional, scientific, and technical services that includes computer programming and software testing working in law

enforcement and at a corporation at as network administrator. Furthermore, 7 students (3.7%) want to work in government and 28 students (14.7%) in other areas.

Of the students that are or plan to go into the manufacturing sector, 41 students (21.6%) will be in automotive; 15 (7.9%) in industrial machinery; 17 (8.9%) in agriculture, construction, and machinery; 7 (3.7%) in furniture and related products; and 10 (5.3%) in other sectors that include food; plastic and rubber products; and computer and electronic product. There were 100 students (52.6%) that are unknown. Of the students that responded they have a relationship with the automotive industry; 43 (22.6%) are current workers looking to obtain new skills and 7 (3.7%) are laid-off automotive workers looking to obtain new skills. The other 140 respondents (73.7%) that are in manufacturing did not answer the question. A clearer response was given to the number of bouts of unemployment. There were 97 students that answered 1 – 5 times.

There are only 21 students (11.0%) who plan to work in autonomous vehicle and electric vehicle production. There are 49 students (25.8%) that had no plans of working in this much anticipated automotive technology and 65 (34.2%) said maybe. The reason given for “maybe” from one who works in the automotive industry said it is a matter of where management places them. A “yes” from respondents were because they thought the concept of both vehicles would be something to reckon with in 10 years, while others were open to the idea and thought the concepts are “cool”. A “no” response was given because they felt it was necessary to have a background in programming autonomous systems and they do not. There were 40 students (21.1%) that do not plan to work in the automotive industry and 15 students (7.9%) did not respond.

Only 16 students (8.0%) responded that they are in a registered apprenticeship and one student is in an informal/local apprenticeship, so that few gain workplace experience while studying. Student employment plans are presented in Table 8.

Table: 8: Current and Future Employment

Current Industry		
Manufacturing	71	37.4%
Retail	21	11.1%
Professional, Scientific, and Technical Services	13	6.8%
Food Services	20	10.5%
Other	65	34.2%
TOTAL	190	100.0%

Current Status and Future Plans		
Future Industry		
Manufacturing	94	49.5%
Professional, Scientific, And Technical Services	61	32.1%
Government	7	3.7%
Other	28	14.7%
Total	190	100.0%

Future Manufacturing Sector		
Automotive	41	21.6%
Industrial Machinery	15	7.9%
Agriculture, Construction, and Machinery	17	8.9%
Machinery		
Furniture and related product	7	3.7%
Other	10	5.3%
Unknown	100	52.6%
Total	190	100.0%

Table 8 (cont'd)

Relationship with Auto Industry		
Current worker that is looking to obtain new skills	43	22.6%
Laid-off worker that is looking to obtain new skills	7	3.7%
No relationship	140	73.7%
Total	190	100.0%

Planning to work in AV and EV		
Yes	21	11.0%
No	49	25.8%
Maybe	65	34.2%
I do not plan to work in the automotive industry	40	21.1%
Unknown	15	7.9%
Total	190	100.0%
Apprenticeship		
Yes - Registered	16	8.0%
Yes - Local/Informal	1	0.5%
No	172	91.0%
Unknown	1	0.5%
Total	190	100.0%

There are 111 students (60.3%) that did not have STEM classes in high school who will be compared to the 37 (20.1%) that did have STEM and the 19 (10.3%) that had advanced math classes. There are 17 students (9.3%) that had one STEM class either science only, technology only, or engineering only. Most of the students (62.43%) did not participate in a career and technical education program in high school. Their hands-on experience with equipment and technology systems will come from the community college classes.

There are 79 students (41.6%) who have not experienced a bout with unemployment, 50 students (26.3%) who have one time, 28 students (14.7%) two times, 10 students (5.2%) three times, 6 students (3.2%) four

times, and 3 students (1.6%) five times, no students 6 or more times. It is unknown for 14 students (7.4%). Seven of the students are current laid-off workers in automotive manufacturing looking to obtain new skills, while 43 students are current workers looking to upskill.

The current median salary range among all students is $15,000 - $24,999. The earning potential for a graduate in any one of the academic programs under study would be a substantial increase. Table 9 illustrates the STEM and Career and Technical Education (CTE) high school background of the students.

Table 9: High School STEM and Career and Technical Education Background and Unemployment History

STEM Background	Number	Percentage
Yes, I had advanced placement class in STEM	32	17.4%
Yes, I had advanced placement classes in Science only	9	4.9%
Yes, I had advanced placement classes in Technology only	6	3.3%
Yes, I had advanced placement classes in Engineering only	2	1.1%
Yes, I had advanced placement classes in Math only	19	10.3%
No, I had regular required courses	111	60.3%
No, I did not graduate from high school	5	2.7%
TOTAL	184	100%

Career and Technical Education		
Yes	67	37.02%
No	113	62.43%
Missing	1	.55%
Total	181	100.0%

Was CTE a joint partnership with a community college		
Yes	27	41.5%
No	38	58.5%
Total	65	100.0%

Table 9 (cont'd)

Bouts of Unemployment since 2007		
0	79	41.6%
1	50	26.3%
2	28	14.7%
3	10	5.2%
4	6	3.2%
5	3	1.6%
6 or more	0	0
Unknown	14	7.4%
Total	190	100.0%

5.3 Point System to Assess the Student's Skill Level

The point system in the study is modeled after rubric assessments. A rubric is a document that articulates the expectations for an assignment by listing the criteria or what counts and describes the levels of quality from poor to excellent (Andrade 2000; Stiggins 2001; Arter and Chappuis 2007). A rubric has three benchmarks: evaluation criteria (the leftmost column in Table 1), the quality definitions (the second, third and fourth columns in Table 1) and a scoring strategy (Popham 1997). Popham describes evaluation criteria as the factors that an assessor considers when determining the quality of a student's work. Quality definitions are detailed explanations of what a student must do to demonstrate a skill, proficiency, or criterion in order to attain a level of achievement (poor, fair, good, or excellent). Popham further explains that scoring strategies for rubrics involve the use of a scale for interpreting judgments of a product or process. This study takes a points scale system to form a score and combine it with a rubric to define the hierarchy of points for each technique and level of skill.

Table 10: Example of a Point Score in a Rubric

Table 1. Example rubric from undergraduate course on educational psychology. Rubric for the annotated bibliography.

	A	B	C	D	E
Research topic, questions and relevance (3 pts.)	The paper provides a clear, focussed description of your research topic and question(s), and discusses the relevance of your topic to education.	The paper tells the topic and lists the questions. The discussion of relevance is very broad but appropriate.	Information about the topic, research question(s) and relevance is too vague, unclear or incomplete.	Little appropriate information is given about the topic, questions or relevance.	0
References (4 pts.)	The paper gives complete bibliographic information in APA style for five relevant journal papers. No more than one paper is from a website.	The paper gives complete bibliographic information for five relevant journal papers but some or all citations are incorrectly formatted.	The paper gives incomplete or incorrect bibliographic information for five journal papers, some of which are not appropriate.	The paper gives bibliographic information for < five relevant journal papers.	0
Annotations (7 pts.)	In one page or less, the annotations identify the background or authority of the authors, summarise major themes and explain how the paper addresses your research questions.	The annotations summarise each paper but did not identify authority and/or make explicit connections to the research questions.	The annotations are either retellings of the paper, or unclear, or incomplete or off topic.	The annotations are token.	0
Implications for practice (7 pts.)	Each annotation notes practical implications for teaching that follow logically from the paper.	Practical implications are listed but more should have been noted. One or two may not follow logically from the papers.	The implications for teaching are limited, vague, distantly related to and/or in conflict with the literature.	Little accurate information is provided about teaching practices.	0
Conventions (4 pts.)	The paper has page numbers, is typed, double-spaced and well organised. All ideas are clearly articulated and carefully cited. No problems with paragraph format, spelling, punctuation, grammar, etc. Readable paper copies are attached.	A few problems with organisation, clarity or conventions should have been fixed but are not serious enough to distract the reader. Copies of each article are attached to the paper.	Numerous errors are distracting but do not interfere with meaning. Copies of some articles are attached.	Frequent problems make the paper hard to understand. Possible plagiarism risks the appearance of cheating. No copies.	0

Source: Andrade, H. (2000)

Table 11: Explanation of Points System in Determining Skill Level

Points have been assigned for having career and technical education and advanced STEM classes in high school and classes at a community college beginning with introductory math, ranging from 1 – 10 points.

1	➢ Career and Technical Education
2	➢ Only General Education courses in high school ➢ Introductory Math at the Community College level
3	➢ Science only, Technology only, Engineering only, or Math only in high school ➢ Intermediate Algebra at the Community College level
4	➢ Advanced placement STEM classes in high school ➢ Knowledgeable of industrial workplace local, state, and federal safety regulations ➢ Principle and theory introductory courses ➢ Knowledgeable of local, state, and federal industrial safety regulations ➢ General Studies courses: Communications, Philosophy, and Economics
5	➢ Enrolled in an apprenticeship along with taking courses ➢ Proficient in office software and on scientific calculators ➢ Next level courses from principle and theory introductory courses
6	➢ Proficient in principles and concepts for technical courses such as Robotics ➢ Proficient in technical software ➢ Met all lab requirements ➢ Knowledgeable on technical industry codes and requirements ➢ Pre-calculus ➢ Proficient in program language such as C++, Java, and Python
7	➢ Next level courses from principles and concepts for technical courses ➢ Knowledgeable of troubleshooting techniques and interfaces for equipment ➢ Knowledgeable on developing software such as in Linux ➢ Advanced Pre-calculus and Calculus
8	➢ Advanced level courses from principles and concepts for technical courses ➢ Knowledgeable and can design systems such as electrical wiring schematics ➢ Intermediate Calculus
9	➢ Can operate technical control technology and equipment ➢ Can build technical devices such as junction boxes and voltage electrical wiring ➢ Advanced Calculus ➢ Physics ➢ Chemistry ➢ Statistics
10	➢ Passed exam for certification ➢ Advanced Physics ➢ Advanced Chemistry

The results of the survey were compiled and downloaded into SPSS for analysis. The skill level falls into 4 categories ranging from introductory skills to proficient in advanced technical skills and the latest technology, whether earning a certificate or associate's degree. Each skill question has been assigned a point. The sequence of courses ranges from lowest to highest points, such as Robotics 1520 (6 points) and Robotics 2500 (7 points). Being a graduate of a CTE program is 1 point but it is realized that a student may not have had access to this training. The point will be considered a bonus. A STEM background is viewed as useful for technical careers and has been included in the skilled level definition. Basic principle and theory courses are 4 points following the assigned points of 1 – 3 that pertain to early learning. Proficiency in industry software and scientific calculators is 5 points. Introduction to technical skills are 6 points. The next level of courses from principles and concepts for technical courses are 7 points. Advanced level courses from principles and concepts for technical courses are 8 points. Knowledge and the ability to operate the latest industrial equipment after technical courses have been taken is 9 points.

The point system assumes that a student will be trained on only one piece of equipment as opposed to being trained on competing products such as a FANUC, Comau, or Kawasaki robotic systems. The study allocates 9 points instead of 27 points (9 points for each of the three robotic systems) in the cumulative skills level total. If the respondents check proficiency on more than one competing piece of equipment, adjustments to the total for each program will be made to reflect the increase in points. A student is assigned 10 points for obtaining a state certification or professional license. The students that are not graduating in 2020 will be assessed on where they stand in their program based on their credits at the time. It will be determined if they are on track to reach the highest skill level point. Finally, a ranking of a student's skill level will be designated according to the following criteria.

Examples of how points are calculated:

Community College Program 1: Robotics and Automated Technology

Level 3 = sum of points for all required courses = 150 – 165 points

Level 4 = sum of the following: 150 points + 1 – Apprenticeship + 4 – STEM background + 4 - English + 3 – Immediate Math + 4 – Communications = 166 points

Community College Program 10: CIS – Programming in C++

Level 3 = sum of points for all required courses = 84 + 9 – Statistics = 93 - 134 points

Level 4 = sum of the following: 93 points + 1 – Apprenticeship + 4 – STEM background + 4 - Technical English + 5 - Technical Math+ 6 – Pre-calculus + 7 – Advanced calculus + 7 – Calculus + 4 – Communications + 4 – Philosophy = 135 points

Determination of skill levels:

Level 1= Student is enrolled as a technician and has completed introductory courses.

Level 2= Student has been trained in principles and methods used in their academic program.

Level 3= Student has hands-on experience in technology related to their field and are taking the next level of skilled courses less than highest points for each college program. Student may or may not have a STEM background but does have the educational knowledge, credentials, and experience on the latest technology to obtain an entry-level position as a technician to contribute to the growth of advanced manufacturing.

Level 4= Student has on-the-job training, may or may not have a STEM background, educational knowledge, credentials, and experience on the latest technology to advance in a career in advanced manufacturing and has been prepared to pursue a higher technical education at a four-year institution.

The point system considers a student proficient in skills at levels 3 and 4 because courses move from introductory to technical and it takes into account the skills that should be achieved by the time they are near their last year of studies.

Required Points for Level 3

Community College Program 1: Robotics and Automated Technology = 150 – 165 points

Community College Program 2: Mechatronics = 242 – 301 points

Community College Program 3: Computer Aided Design and Engineering Technology and Vehicle Design Option = 123 – 139 points

Community College Program 4: Industrial Maintenance Technology = 170 – 186 points

Community College Program 5: Industrial Electronics Technology = 296 – 326 points

Community College Program 6: Machine Tool Technology/Engineering Technologist Manufacturing = 197 – 237 Points

Community College Program 7: Electrical/Electronics Technology = 276 – 310 points

Community College Program 8: Computer Information Systems = Software Engineering = 133 - 174 points

Community College Program 9: Pre-Engineering/Physics/Chemistry = 187 – 199 points

Community College Program 10: Computer Information Systems – Programming in C++ = 93 - 134 points

Community College Program 11: Computer Information Systems – Programming in Java = 97 – 138 points
Community College Program 12: Automotive Technology – Vehicle Development = 222 – 238 points
Community College Program 13: Mechanical Systems = 147 – 163 points
Community College Program 14: Welding and Fabrication Technology = 125 – 156 points
Community College Program 15: IT Cloud Computing/Applied Science Data = 107 – 128 points
Community College Program 16: Computer Information Systems – Cybersecurity = 86 – 105 points
Community College Program 17: Plastics–Polymer Engineering Technology = 111 – 141 points
Community College Program 18: Other = (manufacturing: 75 – 96 points); (CIS: 56 – 86 points)

Required Points for Level 4

Community College Program 1: Robotics and Automated Technology = $\geq$ 166 points
Community College Program 2: Mechatronics = $\geq$ 302 points
Community College Program 3: Computer Aided Design and Engineering Technology and Vehicle Design Option = $\geq$ 140 points
Community College Program 4: Industrial Maintenance Technology = $\geq$ 187 points
Community College Program 5: Industrial Electronics Technology = $\geq$ 327 points
Community College Program 6: Machine Tool Technology/Engineering Technologist Manufacturing = $\geq$ 238 Points
Community College Program 7: Electrical/Electronics Technology = $\geq$ 311 points
Community College Program 8: Computer Information Systems – Software Engineering = $\geq$ 175 points
Community College Program 9: Pre-Engineering/Physics/Chemistry = $\geq$ 200 points
Community College Program 10: Computer Information Systems – Programming in C++ = $\geq$ 135 points
Community College Program 11: Computer Information Systems – Programming in Java = $\geq$ 139 points
Community College Program 12: Automotive Technology – Vehicle Development = $\geq$ 239 points
Community College Program 13: Mechanical Systems = $\geq$ 164 points
Community College Program 14: Welding and Fabrication Technology = $\geq$ 157 points
Community College Program 15: IT Cloud Computing/Applied Science Data = $\geq$ 129 points
Community College Program 16: Computer Information Systems – Cybersecurity = $\geq$ 106 points
Community College Program 17: Plastics–Polymer Engineering Technology = $\geq$ 142 points
Community College Program 18: Other = (manufacturing: $\geq$ 97 points); (CIS: $\geq$ 87 points)

The rubric model will be used later in the Analysis section also after it has been determined the top skills the students possess in each academic program. Those skills will be matched up with the skills that are required if the student decides to pursue a four-year degree and the technical skills that will be needed for research and development in the automotive, pharmaceutical, aerospace, and biomedical industries.

5.4 Results of Student Survey

To simplify the analysis among all 17 academic programs, each has been grouped into three categories: Machine Tool Technology that interfaces with production equipment, Computer Information Systems and Vehicle Technology that involves computer technology and software, and Life Sciences that pertain to engineering and science. The main categories and their skills are presented in Table 12. These are the high-demand fields for the next five years (Workforce Intelligence Network, 2017). The composition of each category is as follows:

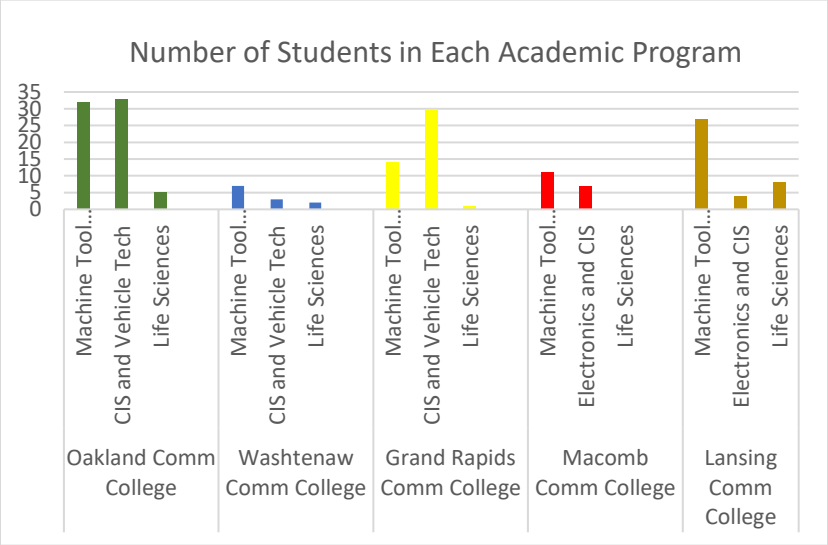
Table 12: Makeup of Each Grouped Category

Machine Tool Technology	Computer Information Systems and Vehicle Technology	Life Sciences
Robotics Mechatronics Industrial Maintenance Technology Industrial Electronic Technology/Electrical Technology Manufacturing Engineering Technology/Computer Numerical Control/Engineering Technologist Manufacturing Mechanical Systems Welding Other (includes but not limited to: auto servicing technician, collision auto repairer, HVAC/R technician)	Computer Aided Design and Vehicle Design Option/Industrial Computer Graphics Electrical/Electronics Engineering Technology Computer Information Systems – Software Engineering/Software Testing Computer Information Systems – Programming C++ Computer Information Systems – Java Automation Technology – Vehicle Development IT-Cloud Computing/Applied Data Science Computer Information Systems - Cybersecurity	Pre-Engineering/Physics/Chemistry

Of the 184 students that answered the question, "What academic program are you in?" OCC has 32 students (%) in Machine Tool technology, 33 in Electronics and Computer Information Systems, and 5 in Life Sciences. WCC has 7 students in Machine Tool Technology, 3 in Electronics and Computer Information Systems, and 5 in Life Sciences. GRCC has 14 students in Machine Tool Technology, 30 in Electronics and Computer Information Systems, and 1 in Life Sciences. MCC has 11 students in Machine Tool Technology, 7 in Electronics and Computer Information Systems, and none in Life Sciences. Lastly, LCC has 27 in Machine Tool Technology, 4 in Electronics and Computer Information Systems, and 8 in Life Sciences.

There is a moderate relationship between a student's community college and the academic program in which they are enrolled as determined by the Cramer's V. Chi-Square is 202.406, *df* = 64, p = < .000, Cramer's V = .524. It means the community college you attend may affect the success you have in an academic program. This will be determined by examining the total points of each student's skill sets at the current stages of their program (i.e., freshman and senior). A low number of points indicates that the student is beginning their program or is obtaining a certificate. This would be the case for Middle College students who are still in high school but taking community college courses. The highest level of skill will then be based on the highest score of points for students nearing completion of their studies. Results on enrollment in community college programs are presented in Figure 9.on the next page.

Figure 9: The Number of Students Enrolled in Each Academic Program



Chi-Square = 202.406, *df* = 64, p = < .000, Cramer's V = .524

Points have been assigned for having advanced STEM classes in high school and career and technical education classes at a community college beginning with introductory math, ranging from 1 – 10 points. The distribution of students by points, community college and field are presented in Table 13. The 32 students that are in Machine Technology at OCC have the highest score between 101 and 200 points. Two students scored over 201 points. Points considered $\underline{\geq}$ 200 means that the student is moving into a skilled range for an associate degree. The 33 students in Computer and Information Systems and Vehicle Technology are split relatively even with 14 students falling within 101 and 200 points, and 12 falling within 51 – 100 points, and 5 scoring 21 – 50 points, indicating they are in the early stages of their studies or in a certificate program. Four students in Life Sciences scored within 101 – 200 points.

Most of the 11 students at WCC are in Machine Tool Technology. Five students scored within 101 – 200 points and 1 student scored 51 - 75 points. Two students in Computer Information Systems and Vehicle

Technology scored 126 – 200 points and 1 student scored 76 – 100 points. The remaining 2 students are in Life Sciences with 201 – 300 points and 100 – 125 points, respectively.

GRCC is the school that has the most students in Computer Information Systems and Vehicle Technology. The 12 students that are in Machine Tool Technology did not score more than 100 points. Most of the 30 students that are in Computer Information Systems and Vehicle Development scored within 21 – 50 points. Two students that responded they are in the Life Sciences program have a score within 101 – 125 points.

MCC's 10 students in Machine Tool Technology have one scoring the highest within 201 – 300 points. The 6 students in Computer Information Systems and Vehicle Technology score within 126 – 200 points. There are no students in Life Sciences.

LCC's 27 students in Machine Tool Technology have 14 scoring within 101 and 200 points. The 4 students that are enrolled in Computer Information Systems and Vehicle Technology have only one with the highest score within 126 – 200 points. The 3 students in Life Sciences highest scored within 126 – 200 points.

There is a moderate relationship between a student's community college, the academic program they are enrolled in, and the score they have obtained . Chi-Square is 196.697, *df* = 64, p = $<$ .000, Cramer's V = .521. The means the community college you attend has some effect on the success you have in an academic program to be considered skilled.

Table 13: The Number of Points for Students in Each Academic Program at Every Community College

		Score (Total number of Points)							
Community College	Academic Program	3-20	21 - 50	51 - 75	76 - 100	101 - 125	126 - 200	201 - 300	Total
Oakland Comm College	Machine Tool Technology	4	7	1	3	7	8	2	32
	CIS and Vehicle Tech	1	5	6	6	7	7	1	33
	Life Sciences	0	0	0	1	2	2	0	5
		5	12	7	10	16	17	3	70
Washtenaw Comm College	Machine Tool Technology	0	0	1	0	2	3	0	6
	CIS and Vehicle Tech	0	0	0	1	0	2	0	3
	Life Sciences	0	0	0	0	1	0	1	2
	Total	0	0	1	1	3	5	1	11
Grand Rapids Comm College	Machine Tool Technology	2	4	5	1	0	0	0	12
	CIS and Vehicle	2	10	7	4	5	2	0	30
	Life Sciences	0	0	0	0	2	0	0	2
	Total	4	14	12	5	7	2	0	44
Macomb Comm College	Machine Tool Technology	2	0	2	3	1	1	1	10
	CIS and Vehicle Tech	0	0	0	1	1	6	0	8
	Life Sciences	0	0	0	0	0	0	0	0
	Total	2	0	2	4	2	7	1	18
Lansing Comm College	Machine Tool Technology	3	1	3	6	7	7	0	27
	CIS and Vehicle Tech	0	1	0	0	2	1	0	4
	Life Sciences	1	1	1	0	1	3	0	7
	Total	4	3	4	6	10	11	0	38

Chi-Square = 196.697, *df* = 64, p = < .000, Cramer's V = .521

5.4.1 General Technical Education Classes

The study evaluates general education classes that are highly technical and required for a technician to obtain an advanced manufacturing position. Students responded to the survey by making a declaration of their training accordingly:

Chemistry 1 - I have studied **general chemistry** from classroom instruction and laboratory course(s), which includes measurement, aqueous reactions, stoichiometry, thermochemistry, atomic structure, bonding, and acids and bases.

Chemistry 2 - I have studied **advanced chemistry** from classroom instruction and laboratory course(s) designed to stress basic laboratory techniques, writing lab reports, and critical thinking exercises, which include density determination, synthesis, empirical formulas, molecular geometry, gas laws, pH, chemical equilibrium, and water hardness.

Chemistry Lab - I have studied in a chemistry lab for 48 hours or more.

Introductory Math - I have studied the skills needed for **introductory math**, which includes numeracy, mathematical thinking & investigations, proportional reasoning, basic algebraic concepts, functions (linear & exponential), and basic statistical concepts.

Immediate Algebra - I have studied **immediate algebra**, which includes emphasis on graphing and diverse, real-life applications. Also, can solve functions & relations, polynomial, rational, radical, and quadratic expressions and equations, rational exponents, and absolute value equations and inequalities with an introduction to complex numbers.

College Algebra - I have studied the skills needed for **college algebra**, which includes properties and graphs of linear, quadratic, polynomial, rational, exponential and logarithmic functions, with an emphasis on applications including finance, business/industry, life and social sciences.

Technical Algebra - I have studied **algebra for technical programs**, with trigonometry. I can solve problems with algebraic expressions, powers, roots, ratio and proportion, variation, linear and quadratic equations, formulas, systems of equations, graphing, area, volume, Pythagorean Theorem, and right triangle trigonometry.

Pre-calculus - I have studied **pre-calculus**, which includes polynomial, rational, radical, exponential, and logarithmic functions; solving equations/inequalities algebraically and graphically; and mathematical modeling in problem solving.

Advanced pre-calculus - I have studied **advanced precalculus** that includes right triangle trigonometry, trigonometric functions, graphs, identities and equations, inverse trig functions, laws of sines/cosines, polar coordinates, vectors, systems of linear equations, matrices, sequences, series, conic sections, parametric equations, permutations, combinations, and binomial theorem.

Calculus - I have studied **calculus**, which includes limits, continuity, and derivatives of algebraic, trigonometric, exponential and logarithmic functions; linear approximation; L'Hopital's rule; Riemann sums; integration using substitution; and the fundamental theorem of calculus.

Intermediate Calculus - I have studied **intermediate calculus**, which includes techniques and applications of integration, improper integrals, sequences and infinite series, power series representation of functions, vectors, lines, planes, and 3D rectangular system.

Advanced Calculus - I have studied **advanced calculus**, which includes multivariable calculus and vector analysis. I can solve problems with vector algebra, curves and surfaces in 3D-space, vector

valued functions, partial derivatives, multiple integrals, vector fields, line integrals, and surface integrals.

Statistics 1 - I have studied introductory concepts and methods of **statistics**, with an emphasis on data analysis, which include methods for collecting data, graphical and numerical descriptive statistics, correlation, simple linear regression, basic concepts of probability, confidence intervals and hypothesis tests for means and proportions, and chi-square tests.

Statistics 2 - I have studied introductory probability and **statistics**, which include descriptive statistics, probability, random variables, normal distribution, t distribution, chi-square distribution, F distribution, confidence intervals, hypothesis testing, correlation, and linear regression.

Physics 1 - I have studied forces and motion, momentum, work and energy, conservation laws of energy and momentum, rotational motion, static equilibrium, gravitation, and oscillations.

Physics 2 - I have studied electric and magnetic forces and fields, electromagnetic energy, currents and circuits, electromagnetic oscillations and waves, mechanical waves and sound, light waves, physical and geometrical optics.

Physics Lab - I have studied in a chemistry lab for 48 hours or more.

The majority of the general technical education classes at OCC consist of students in Computer and Information Systems and Vehicle Technology. There are 18 students in Chemistry 1, 29 in Introductory Math, 28 in College Algebra, 3 in Immediate Calculus and 3 in Advanced Calculus. There are 13 students that are enrolled in Statistics 1 and 21 in Physics 1. Machine Tool Technology is unique with 5 students in Chemistry Lab. There are 3 students in Computer and Information Systems and Vehicle Technology and Life Sciences that have mastered math at the Advanced Calculus level.

WCC has 2 students in Machine Technology enrolled in Chemistry 1 and none in Chemistry 2. There are 6 students each in Introductory Math and Immediate Algebra. Like OCC, there is 1 student in Advanced Calculus. There are 2 students enrolled in Statistics 1 and 1 in Statistics 2. Seven students are taking Physics 1. One or two students in Life Sciences are taking all general education classes, with only 1 in Advanced Calculus.

Nine students in Machine Tool Technology are enrolled in Chemistry 1 at GRCC. There is 1 student with the highest level of math as Calculus. There are 17 students in Computer Information Systems and Vehicle

Technology in Chemistry 1. Twenty-four students are enrolled in Immediate Algebra. Two students are in Advanced Calculus. There are 9 students in Statistics 1, 14 in Physics 1, 8 in Physics 2, and 2 in Physics Lab. Life Sciences has 5 students in Chemistry 2. The highest level of math taken by 1 student is Calculus. There are 4 students enrolled in Statistics 1 and 1 in Physics.

MCC has 6 students in Machine Tool Technology in Chemistry 1 and 2 in Chemistry 2, 9 in Introductory Math, and 3 in Advanced Calculus, 2 in Statistics 1 and 5 in Physics 1. There are 7 Computer Information Systems and Vehicle Technology students in Introductory Math and Intermediate Algebra, 1 in Advanced Calculus, 5 in Statistics 1, 3 in Statistics 2, and 7 in Physics 1. There are no students in Life Sciences.

The majority of students in Chemistry 1 at LCC are in Machine Tool Technology. Two students have the highest level of math in Intermediate Calculus, 6 are in Statistics 1, 11 in Physics 1, 6 in Physics 2, and 3 in Physics Lab. There are 2 students in Computer Information Systems and Vehicle Technology in Chemistry 1, 4 in Intermediate Math, 2 at the highest level of math in Advanced Pre-Calculus, 3 in Statistics 1, and 9 in Physics 1. Five students in Life Sciences are enrolled in Chemistry 1, 5 in Introductory Math, 5 in Immediate Algebra, and 5 in College Algebra. The highest level of math, Advanced Calculus has 3 Life Science students. Three students are in Statistics 1, 5 in Physics 1, 6 in Physics 2, and 2 in Physics Lab.

The expectation was more students would be enrolled in Advanced Calculus. Generally speaking, the number of students in math starts to decrease after Calculus. Although few in number, most of these students in all programs would qualify for a technician apprenticeship.

In Table 14, the relationship between a student's academic program and the general technical education classes they are taking at their community college is a weak one (Chi-Square is 16.696, , *df* = 8, p = < .033, and Cramer's V = .215.). This demonstrates that no community college under study has superior STEM classes over the others.

Table 14: The Number of Students in Academic Programs that are Enrolled in General Technical Education Classes at Every Community College

Community College	Academic Program	Chem 1	Chem 2	Chem Lab	Intro Math	Immed Algebra	Coll Algebra	Alg for Tech Programs	Pre-Cal	Adv. Pre-Cal	Cal
Oakland Comm College	Machine Tool Technology	13	4	5	26	21	11	8	7	7	5
	CIS & VT	18	6	0	29	19	28	22	15	11	12
	Life Sciences	4	0	1	0	4	4	4	4	3	5
	Total	35	10	6	55	44	43	34	26	21	22
Washtenaw Comm College	Machine Tool Technology	2	0	0	6	6	4	3	4	2	1
	CIS & VT	4	0	1	2	2	5	4	2	4	3
	Life Sciences	2	1	1	2	2	2	2	2	2	2
	Total	8	1	2	10	10	11	9	8	8	6
Grand Rapids Comm College	Machine Tool Technology	9	0	0	11	8	11	8	2	1	1
	CIS & VT	17	1	4	18	24	13	13	14	8	8
	Life Sciences	1	5	0	8	1	8	1	1	2	1
	Total	27	6	4	37	33	32	22	17	11	10
Macomb Comm College	Machine Tool Technology	6	2	0	9	6	7	6	5	5	3
	CIS & VT	3	1	1	7	7	3	4	3	3	2
	Life Sciences	0	0	0	0	0	0	0	0	0	0
	Total	9	3	1	16	13	10	10	8	8	5
Lansing Comm College	Machine Tool Technology	10	4	2	19	20	17	14	5	3	3
	CIS & VT	2	0	1	4	2	2	2	2	0	0
	Life Sciences	5	1	2	5	5	5	4	4	3	0
	Total	17	5	5	28	27	24	20	11	6	3

Note: When looking at the totals, a student can be enrolled in multiple classes at one time.

Table 14 (cont'd)

Community College	Academic Program	Immed Cal	Adv Cal	Stat 1	Stat 2	Physics 1	Physics 2	Physics Lab
Oakland Comm College	Machine Tool Technology	1	1	8	1	15	3	1
	CIS & VT	3	3	13	6	21	9	2
	Life Sciences	4	3	3	0	4	1	1
	Total	8	7	24	7	40	13	4
Washtenaw Comm College	Machine Tool Technology	2	1	2	1	7	1	1
	CIS & VT	3	3	3	3	1	2	1
	Life Sciences	2	1	1	1	2	1	1
	Total	7	5	6	5	10	4	3
Grand Rapids Comm College	Machine Tool Technology	0	0	5	4	9	1	0
	CIS & VT	5	2	9	5	14	8	2
	Life Sciences	0	0	4	0	1	0	0
	Total	5	2	18	9	24	9	2
Macomb Comm College	Machine Tool Technology	2	3	2	1	5	4	2
	CIS & VT	2	1	5	3	7	4	0
	Life Sciences	0	0	0	0	0	0	0
	Total	4	4	7	4	12	8	2
Lansing Comm College	Machine Tool Technology	2	0	6	1	11	6	3
	CIS & VT	0	0	3	2	9	1	0
	Life Sciences	3	3	3	1	5	6	2
	Total	5	3	12	4	25	13	5

Chi-Square 16.696, , *df* = 8, p = < .033, Cramer's V = .215

This study seeks to determine if a STEM background is instrumental in achieving a high level of math such as Advanced Calculus. According to Chi-Square a STEM background only assisted students in Calculus. The Michigan Board of Education supported the Michigan STEM Partnership with grant money and support, with the goals to target populations of organizations conducting student-focused, project-based

programs and competitions, either in the classroom or extracurricular in science, technology, engineering, and mathematics subjects such as, but not limited to, robotics, coding, and design-build-test projects for schools with achievement gaps from Pre-K through college level. The results of Table 15 show a student can grasp later in life such concepts as limits, continuity, and derivatives of algebraic, trigonometric, exponential and logarithmic functions; linear approximation; L'Hopital's rule; Riemann sums; integration using substitution; and the fundamental theorem of calculus with the right teaching and tutoring.

Table 15: The Relationship Between STEM Background and Math

Courses	Number of Students	Chi-Square	*df*	significance level	Cramer's V
Advanced Pre-Calculus	25	20.555	7	0.005	0.334
Calculus	28	39.341	7	0.000	0.462
Immediate Calculus	16	14.473	7	0.043	0.28

5.4.2 Career and Technical Education Programs

An advanced manufacturing technician requires precision skills when it comes to occupations such as CNC operator, Welding, and CAD (see Appendices). In order to be proficient and capable to operate the latest equipment such as FANU robotics equipment and systems, a One-Way Anova determined whether there is a relationship between a student having a background in a Career and Technical Education (CTE) program in high school where hands on training was gained and their score.

There are 67 students that were in a CTE program in high school and their mean score is 102.34 and standard deviation is 50.899 (presented in table 16). The 113 students that were not in a CTE program have a mean score of 91.19 and the standard deviation is 53.765. There is 1 student missing. It can be stated that 95 of those 100 confidence intervals would contain the true population mean between 89.93 and 114.76 for the 67 students that were in a CTE program and between 81.16 and 101.21 of the 113 students that were not in a CTE program. There is no statistically significant difference between the mean values of both groups. Being in a CTE program in high school helps in learning the latest technology

equipment and systems at a community college but it is not necessary for a student to become skilled in advanced manufacturing. If a student was in a CTE program that had a joint partnership with a community college, it allows the student to be able to obtain a certificate upon high school graduation.

Table 16: The Relationship Between CTE Program and Score (One-Way ANOVA)

Were you in a CTE Program in high school?	Mean Score	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound
67 students - Yes	102.34	50.899	6.218	89.93	114.76
113 students – No	91.19	53.765	5.058	81.16	101.21
1 student - missing					

SD = F-value = 1.310, *df* = 2, p < .272

5.4.3 Students Highest Scores That Are Considered Skilled

The top skills were determined for each skill category by taking the frequency of each skill in every academic program at the community colleges. Then the skills were ranked by their score in relation to sequence of classes and complexity. Finally, the skills were placed in a Rubric of Levels 1 – 4, lowest to highest degree of competency considered by employers, with results presented in Table 17.

Students in Machine Tool Technology had skills that range from introductory skills such as performing robotics maintenance to being able to operate a lathe machine. The student with the highest level of skills with 207 points is enrolled at OCC in robotics. His background is as follows:

White, male, age 49, has bachelor's degree or higher; does not have apprenticeship; currently unemployed, former field service engineer in the industrial robotics field in auto industry; earned between $50,000 – $74,999. Future industry – professional, scientific, and technical (indicated elsewhere manufacturing). Started at OCC in 2015 and has been laid off five times since 2007. No stem background. Seeking associate of applied science degree. Will graduate in December 2021.

Composition of skills: Regular classes, no STEM – (2 pts) + Robotics skills 1 – 6, 9, (47 pts.) + Robotics skill 15, 16 – FANUC equipment, ABB Equipment (18 pts.) +Robotics skills 20- 23 (29 pts.) +Chemistry 1, 2, and Lab (24 pts) + Math 1-8 (42 pts.) + English 1 (4 pts.) + Statistics 1, 2 (18 pts.) + Communications (4 pts.) + Physics 1 and Lab (15 pts.) + Philosophy (4 pts) = 207 points

Students in Computer Information Systems and Vehicle Technology have been trained in advanced drafting and design and the difficult computer language, Python. The student with the highest level of skills with 112 points is in Cybersecurity at OCC as well.

White, male, age 18, completed high school; works in Information Technology - Education Services, wants to remain in Information Technology. Currently earns $15,000 – $24,000. Started at OCC in 2019. Does not want to work in the automotive industry. Lives at home with parents. Was in a CTE program that was a joint partnership with a community college; Had advancement placement courses in Technology. Seeking an Associate of Applied Science. Will graduate in August 2021. Initially, does not plan to attend a 4-year institution, wants to see how far an Associate will take him.

Composition of skills: CTE Program (1 pt.) + STEM Background (3 pts.) + Cybersecurity 1 – 9, 11 - 14 (65 pts.) + Math 1 – 5 (20 pts.) + English 1 (4 pts.) + Physics 1, 2 (19 pts.) = 112 points

Students in Life Sciences have been trained in engineering problems and methods to linear algebra. The student with the highest level of skills with 238 points is enrolled at WCC in Pre-Engineering. Their background is as follows:

White, nonbinary, age 27, started WCC in 2013, is not in an apprenticeship program, currently a computer programmer; Does not plan to work in the automobile industry; has had 3 bouts of unemployment since 2007; currently earns $75,000 or more; Was not in a CTE program; Had advanced placement courses in Technology; Will graduate in December 2020. Plans to transfer to a 4-year institution.

Composition of skills: STEM Background (3 pts.) + Pre-Engineering 5, 6, 8 – 12, 16, 17, 21, 22, 23 (101 pts.) + Chem 1, 2, and Lab (24 pts.) + Math 1 – 9 (51 pts.) + English 1 (4 pts.) + Statistics 1,2 (18 pts.) + Communications (4 pts.) + Physics 1, 2, and Lab (25 pts.) + Philosophy (4 pts.) = 234 points

Table 17: Rubric of Students Skill Level

	Level 1	Level 2	Level 3	Level 4	Score (Highest total points)
Machine Technology (robotics, mechatronics, industrial maintenance, industrial electronics, CNC, engineering technologist, mechanical systems, Welding, and other)	• I can perform robotics maintenance. • I can perform robotics controller maintenance. • I have been trained in industrial workplace local, state and federal safety regulations.	• I have been trained in direct electrical current theory. • I have been trained in wiring three-phase motor control circuits utilizing two- and three-wire control and machine control circuit. • I have been trained in the concepts and principles of programmable logic controllers (PLCs).	• I have been trained in the principles of Geometric Dimensioning and Tolerancing (GD&T) as applied to engineering design, manufacturing and quality control. • I have been trained in the theory of basic hydraulic and pneumatic principles as they relate to automated systems. • I am knowledgeable of Boolean algebra and digital circuits.	• I can operate a lathe machine. • I can change welding wire when required. • I can operate Fanuc robotics systems and equipment. • I can operate Allen Bradley control technology.	207, Robotics at OCC, N=1
Computer Information Science and Vehicle Technology (CAD, Software Engineering/Tester, C++ Programmer, Java Programmer, Automotive Tech.-Vehicle Development, Cloud Computing, Cybersecurity)	• I have been trained in advanced drafting and design techniques. • I have been trained in principles and theory of both disc and drum brake designs. • I have been trained in the basic principles and concepts of networking,	• I have been trained in an electronic software program applied in various circuits. • I have been trained in the principles and methods of dimensioning and tolerancing for specific design requirements on engineering drawings. • I have knowledge of the security policies and frameworks.	• I can install and administer a Linux/Unix operating system using a virtual machine software product. • I can use Electronics Workbench to simulate electronic circuits and instrumentation. • I have been trained in the syntax and semantics of the ANSI C++ language.	• I have been trained in Python as well. • I have been trained in contemporary database theory and practice, which includes terminology, database structures, SQL (structured query language), and NOSQL concepts and application. • I can manage test vehicle or dynamometer modifications, including electrical systems, design modifications, installations and commissioning/de-bug.	112, Cybersecurity at OCC, N=1

Table 17 (cont'd)

Life Sciences (Physics, Chemistry, Pre-Engineering)	• I have been trained in engineering problems and methods of finding solutions, manipulation and computation of data and results, and applied engineering concept.	• I have been trained in kinetics, chemical equilibrium of gaseous and aqueous environments, acid-base interactions, electrochemistry, nuclear chemistry, and coordination compounds.	• I have been trained in differential equation, which includes the methods of undetermined coefficients, variation of parameters, series, Laplace transforms, and numerical methods.	• I have been trained in linear algebra includes the study of systems of linear equations, matrix algebra, vector spaces, linear transformations, eigenvalues and eigenvectors, with applications.	238, Pre-Engineering at WCC, N=1

The limited number of students to achieve the highest points to deem them as skilled can be illustrated by the following example: The top score of 244 is held by a Black/African American, male, age 30, student in Electrical/Electronics Technology at OCC. He only received 244 points and not $\geq$ 311 points because he has not been trained yet in any one of the following skills: Skill #9 – how to program and interface simple circuitry using the Basic Stamp interface board. (7 pts); Skill 13 – 15 (21 pts); Skill 18 – can use virtual circuit software (6 pts.); Skill 21, 22 – Hasn't passed either the State of Michigan Journeyman Electrician Licensing exam or the International Society of Certified Technician exam (10 pts. ea.); Skills 24 – 35 – such as strong knowledge in E-motor testing and battery testing according to standards (95 pts), all requirements for a position with FEV. He, like most technician students, does have knowledge of the industrial workplace local, state and federal safety regulations (4 pts). He has been trained in Chemistry 1,2 and Math 1 – 9; English 1, 2; Statistics 1, 2; Communications; Physics 1, 2, and Economics.

This study has no bias towards OCC. However, It is clear that students at OCC have a higher chance of being successful in their academic program based on the number of students that received the highest points as they near completion of their studies.

5.4.4 Students' Technological Training and Skills That Are Transferrable to Other Manufacturing Sectors

New automotive technology can be divided into three parts: Intelligent Mobility Technology; Materials and Manufacturing Processes; and Light Duty Vehicle Propulsion (Smith et al, 2017). When it comes to whether community colleges are teaching the new technologies in the areas under study such as vehicle connectivity for autonomous vehicles, it is being done on an introductory scale. Vehicle connectivity includes telematics (GPS systems, OnStar, and hand-free mobile calling) and infotainment (combination of information and entertainment) for vehicle-to-vehicle and vehicle-to-infrastructure communications for safety. MCC's Automotive Technology – Vehicle Development 2000 class – Connected, Automated, and Intelligent Vehicles - trains on various technologies and systems that will enable automating various driving functions, connecting the automobile to sources of information that assist with this task, and allowing the automobile to make autonomous intelligent decisions concerning future actions of the vehicle that potentially impact the safety of the occupants.

It is not clear if MCC Automotive Technology – Vehicle Development 2000 covers enabling technologies that could speed up the market availability of full automation such as human-machine interface, driver monitoring, object recognition, artificial intelligence, sensors, and cloud computing. MCC does offer a separate cloud computing curriculum but there was no indication that a student in Automotive Vehicle Development could take a class in Cloud Computing.

Engineering, Chemistry and Physics majors are introduced to kinetics, chemical equilibrium of gaseous and aqueous environments, acid-base interactions, electrochemistry, nuclear chemistry, and coordination compounds. It is not clear if the labs require students to think about developing new materials that will assist automakers in reducing the weight of a U.S. fleet. Further, joining technologies, such as adhesives and advanced fasteners, are important for mixed-material architecture to join any combination of

dissimilar materials. The understanding of the chemistry components needed for increasing battery capabilities and less charging time are techniques that students also should be learning. If a Life Sciences student is going into aerospace or the biomedical field, 3D printing is important. 3D bioprinting is the manufacturing and prototyping of devices, organs, and solid drug products in various shapes, geometric designs, and spatial dimensions of the active and inactive ingredients. Overall cost of production and products are reduced because of this technology and skilled labor. In the aerospace industry, parts going into airplanes are best suited for 3D printing. The Boeing 787 Dreamliner contains hundreds of 3D parts (Automation Alley, 2020). The study found no evidence that the schools under study own a 3D printer. Unfortunately, a site visit could not be conducted due to covid restrictions.

Table 18 on page 130 shows all skills at Level 4 for each academic program and compares them to industry required skills, knowledge, and abilities. Then those skills move into what are transferrable skills, knowledge, and abilities for other high-demand sectors such as pharmaceutical, aerospace, biomedical manufacturing, and research and development in all areas for a two-year or four-year degree. This skill analysis is designed for students who have some skills but may have been laid off or unemployed yet seek to transfer their skills to other sectors.

Machine Tool Technology students, with a high aptitude in math, trouble shooting, and machining are desired in the industry. With this industrial manufacturing background and plans to pursue a bachelor's degree, they could get hands-on training in biomedical manufacturing. Also, once he obtained a bachelor's degree, preferably in electrical engineering, electronics engineering, or electronics technology, he would qualify for a federal Electronic Technician position in aerospace at The Department of the Air Force Selfridge Air Force Base in Macomb County. The technician provides technical expertise to install, operate, and maintain theater air and space operations center's RF communications, and associated equipment. The duties entail maintaining and operating assigned subsystems to ensure compliance with

established standards and safety requirements determined when equipment malfunctions warrant shutdown of various systems. The pay grade is GS 5 – 14 and pay range is $33,394 - $157,663 per year (see Appendices).

Technician students in Computer Information Science and Vehicle Development with knowledge of theory and practice in SQL (structured query language), programming, and debugging are sought after. Their critical thinking, problem solving, programming, and active listening skills can be transferred to aerospace manufacturing and research and development.

Students in Life Sciences that include Physics, Chemistry, and Pre-Engineering gain the foundational education at a community college to transfer to a four-year institution. An advanced degree of a bachelor's or more is needed to obtain a position in pharmaceutical and biomedical research and development. The Engineering graduate's transferrable knowledge is shown in the Rubric. Their knowledge of Engineering science design and principles for design and production of goods and services is transferrable to a position after obtaining a bachelor's. Physics and Chemistry majors who are proficient in computer and electronics, complex problem solving, and inductive reasoning can transfer their skills to the pharmaceutical, aerospace and biomedical sectors. However, a technician with an associate degree can obtain a position in manufacturing in one of these areas. An example is a Lab Technician at H.B. Fuller in Grand Rapids. The company's website states their engineering adhesives division develops solutions for electronics, automotive, clean energy, medical and other related industries. The chemistry major will be able to perform quality checks of raw materials, submit daily batch release reports, and enter all quality assurance test results while keeping up with production (see Appendices).

Table 18: Skills Assessment for Certificate, Associate, and Bachelor's Degree in Academic Programs

Skills	**Top Skills of Surveyed Students**	**Top Industry Required Skills, Knowledge and Abilities**	**Transferable Skills, Knowledge, and Abilities to Other High-Demand Sectors such as pharmaceutical manufacturing, aerospace manufacturing, biomedical manufacturing, and research and development in all these sectors (can be with a two or four-year degree)**
Machine Technology (robotics, mechatronics, industrial maintenance, industrial electronics, CNC, engineering technologist, mechanical systems, Welding, and other	• I can operate a lathe machine. • I can change welding wire when required. • I can operate Fanuc robotics systems and equipment. • I can operate Allen Bradley control technology.	Blueprint, Measurements, Mathematics, Fabrication, Trouble Shooting, Machining, Manufacturing Processes, Safety. TIG Welding, Gas-Medal Arc Welding, Aluminum MIG Welding	Product Design, Lean Manufacturing, Electrical Engineering, Engineering Management, Process Improvement, Mathematics, Concept Development, CAD software, Monitoring, Operation and Control, Critical Thinking, Quality Control
Computer Information Science and Vehicle Technology (CAD, Software Engineering/Tester, C++ Programmer, Java Programmer, Automotive Tech.- Vehicle Development, Cloud Computing, Cybersecurity)	• I have been trained in Python as well. • I have been trained in contemporary database theory and practice, which includes terminology, database structures, SQL (structured query language), and NOSQL concepts and application. • I can manage test vehicle or dynamometer modifications, including electrical systems, design modifications, installations and commissioning/de-bug.	C++, Hardware/Software Configuration, Debugging, Java, Extensible Markup Language (XML), Original Equipment Manufacturers (OEM) Systems, Software Architecture, Unix, Net, SQL, SQL Server, Technical Support, Technical Writing/Editing, Data Analysis/Management	Quality Control Analysis, Critical Thinking, Complex Problem Solving, Active Listening, Programming
Life Sciences (Physics, Chemistry, Pre-Engineering)	• I have been trained in linear algebra includes the study of systems of linear equations, matrix algebra, vector spaces, linear transformations, eigenvalues and eigenvectors, with applications.	Analyze Chemical Compounds or Substances, Interpret Research or Data, Maintain and Set-up Laboratory Equipment, Prepare Scientific or Technical Reports	Engineering Science and Technology Principles and Techniques for Design and Production of Goods and Services, Computers and Electronics, Complex Problem Solving, Inductive Reasoning

Source: EdEn Inc. Oakland County Michigan Skills Needs Assessment, 2013 and O*Net online

5.4.5 Barriers to Completing Certificate or Degree

Students confront many barriers to completing their community college programs, as shown in Table 19. There were 39 (20.5%) students that said they cannot afford the tuition, in spite of Michigan's initiatives to fund tuition as a "last dollar" scholarship once all federal funding has been allocated. As some students pointed out in the survey, these sources of funds have maximum family income limits such as $30,000 - $60,000. A student can qualify for some funding but probably not the full amount for the 2019 – 2020 academic year of $6,195 (Pilgrim, 2020). A student will not get funded if their family makes over $60,000. As one student stated, this amount may seem like a lot to the federal government, but $60,000 may not be a lot, depending on family size. If a student's tuition is covered, they still have to fund their living expenses throughout the academic year.

Twenty (10.5%) students responded that they have to take more credits to graduate, while 18 (9.5%) students said they are having academic challenges in their class(es); 13 (6.8%) students are having childcare issues, 10 (5.3%) students are having transportation issues; and 9 (4.7%) are having housing stability issues. There were 8 (4.2%) students that have decided to transfer to another school. The 7 (3.7%) students that responded in the other category cited illness, caring for a family member, and the difficulty in balancing work and school. The remaining 66 (55.3%) students stated no barriers to completion.

Table 19: Barriers of Students

Barrier	No. of Students	Percentage
I cannot afford the tuition.	39	20.53%
I am having academic challenges in my class(es).	18	9.47%
I am having childcare issues.	13	6.84%
I am having transportation issues.	10	5.26%
I am having housing stability issues.	9	4.74%

Table 19 (cont'd)

I will have to take more credits to graduate.	20	10.53%
I have decided to transfer to another school.	8	4.21%
No, I do not have any barriers.	66	34.74%
Other (please specify) _____	7	3.68%
TOTAL	190	100.00

Most students reside in cities where the community college is located while some students live up to 15 miles away, as in the case of a LCC student living in Potterville. There are 14 percent of students living in Kent County in Grand Rapids and the other percent range from .5 to 6 percent. Lansing students in Ingham County make up the 6 percent.

5.4.6 Future Residence of Students

There were 67 (39.41%) students that said they plan to remain in their current home/apartment; 20 (11.76%) students plan to move to a new apartment in their current city; 20 (11.76%) students plan to move to a new apartment in another city in Michigan, and 7 (4.12%) students plan to move to a new apartment outside of Michigan.

Some students plan to become homeowners. There are 13 (7.65%) students that plan to move to/purchase a new home in their city; 33 (19.41%) students plan to move to/purchase a new home in another city in Michigan; and 10 (5.88%) students plan to move to/purchase a new home outside of Michigan. This helps answer the question on whether Michigan can have a skilled labor pool. Fortunately, most students plan to remain in their current home/apartment, thus the state of Michigan. As students become homeowners, they contribute to their local and state government in income and property tax revenue. This is how manufacturing communities will recover from the population losses and blight of past years. Table 20 on the next page shows students' responses on their future residence.

Table 20: Future Residence of Graduates

I plan to remain in my current home/apartment.	67	39.41%
I plan to move into a new apartment in my city.	20	11.76%
I plan to move to a new apartment in another city in Michigan.	20	11.76%
I plan to move to a new apartment outside of Michigan.	7	4.12%
I plan to move to/purchase a new home in my city.	13	7.65%
I plan to move to/purchase a new home in another city in Michigan.	33	19.41%
I plan to move to /purchase a new home outside of Michigan.	10	5.88%
Total	170	100.00%

In summary, the student survey shows that although the 190 students surveyed may not have a STEM high school background as the literature suggest is needed to advance in STEM career training, with the right instruction and exposure to the latest equipment at a community college, they can still excel. Unfortunately, these students are not exposed to the latest equipment that a classroom or apprenticeship will bring them. Recommendations for this deficiency are made in Chapter 8.

CHAPTER 6: ANALYSIS AND FINDINGS FROM INSTRUCTOR SURVEY

6.1 Introduction

The study contains responses from an instructor survey that assesses their knowledge of the course they are teaching and what they are doing to address deficiencies in students. The results of the survey were analyzed qualitatively and quantitatively to assess community college training.

6.2 Perspectives of Instructors

To understand the perspective of instructors, 17 were teaching at the target community colleges and responded to the survey. Two faculty members are from GRCC (Manufacturing and Computer Information Systems); 5 from LCC (3 in Technical Careers, 1 in Welding, and 1 in Chemistry); 6 teach at MCC (2 in Automotive Technology Repair, 1 in IT Cloud Computing, 2 in Engineering and Advanced Technology, 1 in Media and Communication Arts, and 1 in Engineering Technology); 2 teach at OCC (1 in Welding Fabrication and 1 in CIS); and 2 instruct Computer Information Systems at WCC.

The teaching experience ranges from 5 – 32 years and they have work experience in the field they are teaching. Fourteen are full-time professors and the other three are adjunct instructors.

Table 21: Instructor Survey Responses

Instructor Certifications	Academic Deficiencies in Students	Steps Taken to Address Deficiencies	How would you improve your program?
Solidworks and Fanuc – basic level 1 CompTIA Linux (Powered by LPI) Full Vocational Authorization Welder and Welder Inspector State of Michigan IX and VT Professional Education Certification ASE Master with L1, L3, G1 AWS Certified Solutions Architect Associate AWS Certified Solutions Developer Associate Master of Hydraulics ASE A1 through A8, L1 Aera Master Machinist Oracle Certified Developer Cisco Certified Network Associate and Professional	Using technology. Students are wizards at using apps on their phones but they struggle with computer software (e.g, converting documents to PDF). Measuring Math and Chemistry are simple but can't read a tape measure/ scale/ ruler/ calipers Poor reading and math skills, terrible penmanship, and addicted to phone while in class Some students never had the opportunity to attend a high school auto program so they have less fundamental skills coming in. Poor reading and comprehension skills Motivation a lot respond to instant gratification Study skills	Advise on knowing how to use professional software (word processing, spreadsheets, MRP systems, computer/cloud services etc.) Helping them learn how to "College" Demonstrations, games, quizzes, and individual help as needed No phones during lecture unless needed for math problems or searching a topic of discussion Math - refer to college resources and model problem solving Writing - reports and written short answer questions Start with basics and in nearly all but the most advanced classes.	Rebuild advanced manufacturing labs in middle school and high school. Most high school advisers aren't very familiar with skilled trades and lead students to four-year degrees. Cybersecurity and technology are getting more than their fair share of attention these days. I don't ever feel as though I want for resources. Allow students to take electives that directly apply. For example, if a student wants to be a pipe welder, we would have more elective training in this area. We at LCC are very fortunate in the fact that we have a supportive corporate sponsor and administration. I think it is important for state and federal policy makers to promote an alternative to the standard 4-year college and for the federal government to help promote apprenticeships sponsored by the United States Department of Labor.

Table 21 (cont'd)

Solidworks and Fanuc – basic level 1 CompTIA Linux (Powered by LPI) Full Vocational Authorization Welder and Welder Inspector State of Michigan IX and VT Professional Education Certification ASE Master with L1, L3, G1 AWS Certified Solutions Architect Associate AWS Certified Solutions Developer Associate Master of Hydraulics ASE A1 through A8, L1 Aera Master Machinist Oracle Certified Developer Cisco Certified Network Associate and Professional	Using technology. Students are wizards at using apps on their phones but they struggle with computer software (e.g, converting documents to PDF). Measuring Math and Chemistry are simple but can't read a tape measure/ scale/ ruler/ calipers Poor reading and math skills, terrible penmanship, and addicted to phone while in class Some students never had the opportunity to attend a high school auto program so they have less fundamental skills coming in. Poor reading and comprehension skills Motivation a lot respond to instant gratification Study skills	Advise on knowing how to use professional software (word processing, spreadsheets, MRP systems, computer/cloud services etc.) Helping them learn how to "College" Demonstrations, games, quizzes, and individual help as needed No phones during lecture unless needed for math problems or searching a topic of discussion Math - refer to college resources and model problem solving Writing - reports and written short answer questions Start with basics and in nearly all but the most advanced classes.	Rebuild advanced manufacturing labs in middle school and high school. Most high school advisers aren't very familiar with skilled trades and lead students to four-year degrees. Cybersecurity and technology are getting more than their fair share of attention these days. I don't ever feel as though I want for resources. Allow students to take electives that directly apply. For example, if a student wants to be a pipe welder, we would have more elective training in this area. We at LCC are very fortunate in the fact that we have a supportive corporate sponsor and administration. I think it is important for state and federal policy makers to promote an alternative to the standard 4-year college and for the federal government to help promote apprenticeships sponsored by the United States Department of Labor.

The results show the instructors have a wide range of experience and that they give guidance to students that may come to a community college unprepared. Most instructors surveyed responded that students came to their schools with many academic challenges. The study views favorably their need to address any deficiencies they are presented with and also the school has resources to address these challenges.

Some instructors stated that some students possess poor writing skills. Pierre (2013) states the best way to tackle this is to give lots and lots of writing assignments. That way they can gauge whether a student needs to work with a writing tutor. She cites this is where the instructor's own writing level comes into play and is giving community colleges more of a reason for hiring candidates with a Ph.D. Regardless of any deficiency the instructor recognizes a student has, they should be held to a high academic standard.

When it comes to how curricula are designed or their DACUM process, the instructors responded that they rely on input from industry experts on their advisory boards and the requirements for certifications once a year.

> A GRCC advanced manufacturing instructor stated, *We are members of multiple associations to keep current on equipment and trends. We also have semi-annual advisory board meeting that includes GRCC employees along with leading local business leaders who benefit from our graduates. We have a schedule to review our class curriculum and course selections every year. We rely on industry partners such as CompTia, the Cisco networking Academy, EC|Council, Microsoft, Amazon, VMware, and others who provide us with support in the form of software and even curriculum. We also make a point to stay involved with industry groups, such as the ISSA, the ISC^2, and local conventions.*

> A LCC Welding instructor described the dilemma with keeping up with the latest technology, "*The whole world of welding is changing and if we don't keep up the rest of the world will be doing our work. Robotics [and] CNC programming are added to our curriculum. We must still keep basics but reach further to get more diversified . We are welding more types of materials yearly.*

Without having the ability to evaluate the instructors teaching styles and effectiveness in person, going by their responses and the results of the points of the students, the study found all participating schools investing in their instructors as their budgets permit and are constantly open to new programs to address students' needs. As one instructor responded, more support for community colleges should come on the state level.

In summary, the instructors have a wealth of knowledge and credentials in the subject they are teaching. The results of the instructor survey show that students need more college preparation training in high school of the basic education skills to be successful in college. The instructors spend a lot of time in remedial teaching. The instructors expressed that they are supported by their administrators; however, recommendations are made in this study to allow them to be able to teach on the latest equipment to meet the demand of the business community.

CHAPTER 7: ANALYSIS AND FINDINGS FROM EMPLOYER INTERVIEWS

7.1 Introduction

The study contains responses from employer interviews. The results of the interviews were analyzed quantitatively to determine the skill set that they look for in new hires and if they influence the curriculum of their respective community college.

7.2 Perspectives of Employers

Michigan oftentimes is thought of for its manufacturing labor. This study wanted to look at manufacturing labor but also the state being recognized for its research and development in the automotive sector and others such as pharmaceuticals, aerospace, and biomedicine. Table 22 shows seven employers that fit into these categories that were interviewed from Oakland County, Washtenaw County, and Ingham County.

Table 22: Employers Interviewed and Their County

Director of Intelligent Mobility at FEV North America in Oakland County on Wednesday, January 29, 2020 at U of M's Center for Automobile Research Quarterly Meeting
Chief Executive Officer and Chief Scientific Officer of Velesco Pharma, in Oakland County on Tuesday, July 28, 2020 at 10:00 am.
President and CEO of MichBio in Washtenaw County on Tuesday, September 8, 2020 at 11:00 am. (Mr. Rapunaldo set up the virtual meeting on his organization's platform)
Human Resources Manager of FEV North America in Oakland County on Tuesday, September 8, 2020 via e-mail.
Business Development Manager of Experis Engineering (a division of Manpower) on in Oakland County on Friday, September 11, 2020 at 10:00 am.
Chief Executive Officer of Capital Area Michigan Works! in Ingham County on Friday, September 18, 2020 at 11:30 am.
Manager of Oakland County Workforce Development/Oakland County Michigan Works! on Friday, October 23, 2020 at 5:15 pm.

The following are questions posed:

Table 23: Questions for Employers

Question	Reason
1. What skills do you look for in new hires?	To determine if the community colleges are teaching these skills
2. Do you have a relationship with a community college?	To determine if the employers in a county participate in designing the curriculum
3. .Do you consider Michigan a research and development hub and not solely for manufacturing production?	To determine if Michigan can be considered for research and development not just a labor-intensive state
4. Please explain training dollars and the flexibility in setting policies to use them.	To learn if there are extra dollars that can allocated for training to assist students with their tuition costs
5. What wraparound services do you offer workers (clients)?	To determine if barriers that may prevent students from completing their studies can be addressed

The employees from Michigan firms were consulted about their need and qualifications for skilled manufacturing workers. The firms selected are considered central to the diversity of Michigan's advanced manufacturing and supplying labor in the market.

FEV North America, Inc., located in Auburn Hills, Michigan in Oakland County, is a global engineering services leader providing full vehicle support to the automotive community as well as the heavy-duty and commercial engine industry. The company has 450 employs at this location and 5,500 at advanced technical centers globally. The company proudly boasts it assists customers in the design, analysis, prototyping, powertrain and transmission development, as well as vehicle integration, calibration and homologation for advanced internal combustion gasoline-, diesel-, and alternative-fueled powertrains. FEV also designs, develops and prototypes advanced vehicle / powertrain electronic control systems and hybrid-electric engine concepts that address future emission and fuel economy standards. The company is a contributor to the Detroit Three's vision for AVs and EVs.

The company is one of a few that are currently offering apprenticeships in Mechatronics and Welding. According to the job postings provided by the Human Resources Director, a Mechatronics Technician Apprentice combines electrical, mechanical, and electronic competencies to identify, analyze and solve systems-based problems. FEV would like the technician to support engineers, modify machines, make minor changes and repair, test and maintain related equipment. A Welder Apprentice must be skilled on manual operation lathes, manual mills, axis machines, and have an extensive understanding of machine tooling use and the ability to understand complex Engineering drawings. When speaking with the Director of Intelligent Mobility at FEV, he stated they look for a technician to have a high degree of math and statistics competencies.

The President and CEO of MichBio in Washtenaw County, a bioscience industry organization located in Ann Arbor in Washtenaw County, gave his insight into the ability of someone in automotive manufacturing transferring to the biomedical sector. MichBio represents professionals in pharmaceuticals and therapies (human and animal health), medical devices, diagnostics, and informatics (healthcare and bioinformatics). He stated that a student who has taken math, biology, and chemistry to enhance their analytical skills and who has computer literacy, and problem-solving for conducting research would be desired. If the students have taken Statistics and Data Manipulation this would be rooted in what companies would seek. The common thread between automotive manufacturing and biomedical manufacturing is die casting and injection molding but you have two different models. The automotive is high volume, low margins and the biomedical is low volumes and high margins. The director believes that the transfer to this sector can be done but it will not be easy. Some who attempted to make the leap had to go back to college but those with a background in advanced engineering can make the transition through on-the-job learning and training as shown in Table 19. This technician student at OCC may have to take more classes but this

gives him another option as the medical industry and U.S. supply chain is being reviewed, given we are in a pandemic but had to go outside our country for needed supplies and medicine.

Velesco Pharma, a pharmaceutical company, in Wixom in Oakland County, is a small company with 20 employees but has a large impact on the industry. It provides early phase drug formation for pharmaceutical clients. The Chief Executive Officer and Chief Scientific Officer brings his expertise to the company from working at Pfizer for 19 years in the Pharmaceutical Sciences Division of Research & Development. He is an accomplished scientist with broad expertise in drug formulation, drug product development, GMP manufacturing, clinical supply provision and facility management. He has extensive experience in managing complex scientific and technical drug development projects, many of them outsourced to contract research organizations (CRO).

A research company such as this one would be ideal for a technician to gain entry into this sector. At one time, the CEO stated the company hired workers with less than an associate degree as an operator or technician in manufacturing clinical supplies. When the pandemic is over, they may look to adding more technicians.

The Chief Executive Officer of Velesco Pharma, believes there is a role for a person with an associate degree for developing a drug and he/she does not necessarily have to have a Ph.D. He stated Velesco's plans for hiring depends on their clients and how the market returns after the pandemic. He believes, *"If they restart their projects then, yes, we will be recruiting and we will be signing contracts to do work with them."*

The question was posed to the CEO, "Do you see the possibility of pharmaceutical companies reshoring pharmaceutical production to the U.S. and do we have the labor pool in Michigan if we were to bring back pharmaceutical production to the U.S.?" He responded, "*I believe that Michigan has the pharmaceutical infrastructure with companies like Pfizer over in Portage, Perrigo in Allegan, and JHP Pharmaceuticals in Rochester Hills. There is also Amway in Grand Rapids that does dietary supplements, which is like pharmaceutical. I think there are the people with the skills and [can] train people not in the industry. I think that Michigan is in a gooder [better] place as any other state to take over that. From a manufacturing viewpoint, I think the cost of operating in Michigan is far lower than the typical pharmaceutical states of California, Massachusetts, and New Jersey. California and Massachusetts are predominately research and development and New Jersey and the Philadelphia area are the big manufacturing states.*

Pfizer has partnered with BioNTech, a German company, and given the green light in North America, Europe, and the Middle East to administer their vaccine for COVID-19. Pfizer in Portage, Michigan is producing the vaccine for global distribution. Scientists found the vaccine reduces coronavirus infections by 95 percent (Bloomberg.com, 2021).

Experis Engineering, a division of worldwide Manpower Group, has an office in Oakland County. The employment agency places accomplished engineers into manufacturing companies on a permanent, temporary, and temp-to-perm basis. The company has placed engineers in companies throughout Southeast Michigan. Per the Business Development Manager, he explained that the company completed a study in 2019 with Digital Manufacturing and Design Innovation Institute in Chicago, Illinois. *The Future Factory* study helped them find 165 emerging roles in digital and advanced manufacturing for positions that do not exist today but will in the future (cybersecurity in plants, robot operators, etc.). He confirmed the findings of this technician study of the future high-demand positions and that a lot of the lower

manufacturing positions will be eliminated unless they get upskilled in computers and robotics. However, he believes that more jobs will be created because of the digital manufacturing initiatives.

In response to the Experis and Digital Manufacturing and Design Innovation Institute study (Manpower Group, 2019), Experis is focusing on micro-credentialing not a full two-year degree. This alternative gives a student a credential (i.e., 10 credentials to certify in robotics maintenance) where the training is more customized to the employers' needs. They offer free online college classes through Phoenix University. A student worker is able to obtain a new skill and subsequently get a raise afterward. The Business Manager stated that companies now realize if they just advance workers and do not train them, there will not be any resources for the company.

The Business Manager relished in the fact that other countries' workers seek out Michigan to understand the cutting-edge technologies in automotive innovation. He considers Michigan an automotive research hub with advanced engineering talent. That is why companies such as Honda, Isuzu, Kia, and Mercedes Benz have research facilities in the state. Yet, to fill positions requires these companies to seek foreign talent because of the shortage of Michigan workers who possess the skill set for advanced research.

The Business Manager gave a critical analysis of community college training. He cited the 5-6 years long period for a program to become accredited and the need for it to happen in a year like at a university. For example, the need to incorporate data science into their curricula to teach students for advanced manufacturing today requires data for predictive analytics to evaluate a problem in production before it happens is not being taught. The CIS Dean at OCC has expressed that they are looking at starting a Data Science program in January 2021. The business community would have expected this to happen a year or

two ago. Also, budget constraints keep the latest equipment and systems from getting purchased as an OCC CIS instructor noted in the instructor survey. He states the school needs,

> hardware for the students with SQL Server, . NET, IBM Security Scan, HP WebInspect, LogRhythm, and Cisco Network Simulator. It would be nice if the students had network sniffers and intrusion detection hardware. It would be nice if the students had more computers in the classrooms with more RAM, better processors, console ports, HDMI, etc. There should be newer and more hardware firewalls, routers and switches too. Ideally, it would be nice to have at least five servers, twelve hardware firewalls, fifteen different high-capacity switches, fifteen Cisco 1941 w/802 11 a/b/g/n ports, Iris recognition equipment, face recognition equipment, and other related security equipment. A Forensic Recovery Evidence Device would be excellent. Some ISR 4221s with 2 port serial WANs, some ADA 5506-x would be great too.

Michigan Works!, a quasi-public agency of state government, provides services and employment and educational funding support to Michigan's unskilled and dislocated workers. There is an office in 16 regions of Michigan. Both of the executives of the Ingham County office and Oakland County office stressed that they operate with the intent of making sure they are meeting the employment needs of growing businesses in their region. Reports are generated on a regular basis to keep them abreast of where to direct workers for employment opportunities. In addition, funding to award workers to pursue higher education to be trained and upskilled is provided from the federal government.

The Oakland County Michigan Works! like Experis has focused on micro-credentialing. They have a programmable logic controllers program with OCC that is funded through the federal Workforce Innovation and Opportunity Act and other funds from the U.S. Department of Labor to train unemployed and low-income workers. The cost of tuition is covered and funding exist for wraparound services such

transportation, books, and factory clothing (e.g., work boots). After the trainee completes the program, they receive an OSHA 10 certification and a PLC in Robotics certificate from OCC, and a FANUC 1 certification. This was created to meet the needs of employers in the region. These employers have expressed that they want workers to be skilled in Industry 4.0 capabilities that include 3D printing and artificial intelligence. The agency also partners with OCC for Computer Numerical Control classes.

Oakland County Michigan Works! conducted a Skills Need Assessment Report for Connected Mobility (2017) and found that the top position that participating companies were looking for does not exist. It is a hybrid of an automotive engineer, electrical engineer, and software developer. Unfortunately, OCC did not respond by designing a curriculum that would encompass these occupations.

The Oakland County executive elaborated that she finds their clients have significant barriers that need to be addressed. There is a digital literacy gap, the cost of education is unattainable, childcare is an issue, and clients have a fear of venturing into a high-tech field and being intimidated by going back to school. To tackle this, the agency will focus on getting people trained in advanced manufacturing, IT, and health sciences to meet a set goal for the region outside of Michigan's credential goal. Oakland County is planning to get 80 percent of their residents a recognized credential or higher by 2030. They will continue to host My Career Quest, a yearly manufacturing expo, for 10,000 high school students that are from the Oakland, Macomb, Wayne, Washtenaw, and Monroe counties. Students get hands-on demonstrations of skills such as using a welding simulator to introduce them to the different fields they can pursue. She expressed her disappointment in the fact that very few employers are signing on to offer apprenticeships.

The Ingham County executive expressed the same need to provide wraparound services for cases that may involve funding a client to get a health screening to start a new job, reimbursing mileage, and

providing bus tokens. She found that its helpful to have a network established and that is why they have a partnership with the 211 – Resource Center of the United Way. A client can call the number and immediately get help for emergencies such as an unexpected eviction. She believes if you do not take care of the clients Maslow's Hierarchy of Needs then they will not be successful in an institution of higher learning.

The Ingham County executive expects the Lansing region will always be in manufacturing because of the GM plants but she sees specialized manufacturing rise due to Michigan State University as a research institution. An example of the bio solutions on the horizon is the development of an anthrax vaccine. There is a partnership with LCC. Unlike other regions, the Capitol Area Michigan Works! has a LCC advisor housed in their agency's office. The advisor helps clients with an on-site tutor for placement exams and teaches them how to complete the Pell Grant application. LCC has a seat at the table when it comes to planning policies at the agency. They have also collaborated on writing grants for various programs.

When a client comes to the agency, a training plan is devised for them. The agency exercises flexibility and sets aside yearly training dollars in what is called an individual training account. The maximum is $10,000 and can pay for an associate at a community college or bachelor's degree at a four-year institution.

In conducting this study, it was realized that every county has its own economic story. As the Chief Executive Officer of Capital Area Michigan Works! explained manufacturing in the Lansing area is one of the smallest sectors compared to other industries. The area is more dominated by education because of Michigan State University and Lansing Community College. She has seen reports that expect manufacturing to be stagnant through 2028. On the other hand, Oakland County, Macomb County, and Kent County are dominated by manufacturing. Washtenaw County has a mix of medical companies and

institutions, manufacturing and research and development. It is incumbent upon the respective community colleges to make sure that they are teaching skills in these areas of dominance so that the students will have jobs when they graduate.

In summary, the employers find that community colleges can be instrumental in training students for future jobs in advanced manufacturing but believe they need to find a way to make sure that their curricula are current with the industry's needs. There have been attempts to build relationships among local employers and the community college but there is more work that needs to be done. One way to address this is to offer apprenticeships to the students. The study found that the majority of students are not in a formal apprenticeship program.

CHAPTER 8: POLICY RECOMMENDATIONS

8.1 Introduction

The surveys and research on community colleges and interviews of employers in Michigan can inform workforce development policies, with this chapter devoted to recommendations for elected officials and government administrators on the federal, state, and local levels to increase enrollment of Michigan workers in advanced manufacturing at a community college. Public policy is designed to alter behavior of individuals and organizations to achieve a goal. In the case of workforce development, the goals would be to provide a stream of well-trained and educated workers capable of working in advanced manufacturing. Additional goals would be to support underrepresented groups in their attainment of skills and careers, and to assist those with limited resources to pay for tuition and also take time off from working to complete courses.

8.2 Federal Policy

For the Brookings Institution's Future of Middle-Class Initiative, one of the papers cited on automation was composed by Paul Osterman (2019). Osterman's "Employment and Training for Mature Adults: The Current System and Moving Forward" explains how society should better prepare adults for labor market changes caused by technological change. Like this dissertation study found, technological change contributes to increased risk of job displacement and occupational skills requirements. Osterman recommends policies that increase federal funding for workforce development programs.

As a national challenge to competitiveness in advanced manufacturing, the federal government has a number of policy options to upskill the workforce to obtain a certificate or degree. The research for this dissertation showed the importance of financial support for more than just tuition as a way to promote further education.

A new federal policy should be different from other proposed policies from presidents in the past such as tax credits and last dollar scholarships. While worthy policies, they do not go far enough to cover all the student's expenses. The tax credits are filed on annual taxes and last dollar scholarships only cover costs after other federal funds are applied. The scholarship only covers the tuition. A student still has to take out a student loan to pay for their housing and other living expenses.

Therefore, one policy model could be the federal GI Bill of 2008 for veterans that includes payments to cover tuition and fees, a monthly housing allowance, and a stipend for textbooks and supplies for up to 36 months (Dortch, 2018). Additional dollars would be awarded to individuals that pursue STEM fields that are in high demand.

Policies that offered full support for students would pay for tuition and fees, books, and housing at a public community college and four-year university for individuals making less than $50,000 per year, the amount according to Pell Grant guidelines (Scholarships.com, 2021). The monthly allowance for housing should be the HUD fair market allowance for their area up to 36 months. For instance, the fair market rent for a three-bedroom for a family of three or four in the Lansing – East Lansing, Michigan metropolitan statistical area for FY 2021 is $1,171 (HUD User, 2021).

To answer any lawmaker's opposition on where the money to pay for these new policies would come from, existing funds such as the Pell Grant would be redirected. The Department of Education's funds set aside for the Pell Grant, would go towards tuition, fees, books, and housing for the student.

The COVID-19 experience showed the importance of domestic production as a way to serve national needs. One policy option to develop capacity would be Senator Gary Peters' bill to form the National Institute of Manufacturing Act (NIM), patterned after the National Institute of Health (Peters.senate.gov, 2020). The NIM would have all 58 federal programs over 11 agencies that include and are associated with manufacturing under one agency such as the Department of Commerce Domestic Field program that deals with trade in the global marketplace; Small Business Administration; and Departments of Labor and Education (GAO.gov, 2017). There would be a Chief Manufacturing Officer who would be responsible for creating and enforcing a National Strategic Plan for Manufacturing across the Executive Branch (Peters.senate.gov, 2020). Areas such as Research and Development and Technology would be under review. This will allow the elimination of policies that do not work and the addition of policies that will work (Automation Alley, 2020).

A new federal ruling on expanding apprenticeships was published on March 11, 2020. The U.S. Department of Labor ruled under the authority of the National Apprenticeship Act that any person designated by the Administrator must recognize third party entities, known as Standards Recognition Entities (SREs) that will evaluate and recognize Industry-Recognized Apprenticeship Programs (IRAPs). All parties are on the same page of what entities may become recognized SREs and establishes their responsibilities and requirements and standards for IRAPs. The Administrator will oversee SREs (Federalregister.com, 2020). This will help community colleges work with employers to establish an apprenticeship.

8.3 State Policy

Usually, workforce development policies are often the responsibility of the states, evidenced by many different policy formats that reflect state needs and political realities. Michigan offers a range of policies that provide assistance to students, educational institutions, and through its economic development functions such as Going Pro Talent Fund; Michigan Advanced Technician Training Program; and Michigan Reconnect, like the Tennessee Reconnect, which gives free college tuition to students enrolled strictly in a technical college. (Michigan.gov/Leo, 2021).

Michigan's Sixty by 2030 plan has the mission of getting 60 percent or 540,000 adult-age workers a credential or degree by 2030 (State of Michigan.gov, 2020). The spin-off program, Futures for Frontliners program, further helps the state to meet its goal (State of Michigan.gov, 2020). These workers that are grocery store clerks and restaurant servers have been some of the people that have been most impacted by the pandemic. Frontliners are able to attend a community college for free.

In looking at what other states have done to increase education attainment, Massachusetts promoted increased collaboration across community colleges, state universities, and the University of Massachusetts to get information out that will inform curriculum enhancements, industry collaboration and faculty development to improve the workforce readiness and competitive position (Massachusetts Department of Higher Education, 2015). This dissertation study supports this idea for Michigan.

One way Michigan can improve its workforce readiness and competitive position is through a bond proposal that would fund education at public community colleges and universities. Normally, a school district issues a bond proposal before the voters to eliminate a deficit (mlive.com, 2020). This dissertation study proposes a bond issuance by the state of Michigan to enable students, especially in STEM academic

programs, to get a monthly stipend that is based on the equation in Figure 10. The monthly stipend equals the intercept (a), the area's fair market rent plus a dollar amount per credit multiplied by the number of credits for that semester. It is believed that this financing source for education has a better chance of passing the legislature and by the voters as opposed to an increase in a gasoline tax to fund road improvements. Voters have supported funding education but cannot agree on how to finance fixing the roads (Jones, 2020; mlive, 2020). Michigan has been hit hard by the pandemic but it Is in a better position than anticipated because it is still bringing in tax revenue above its projections (Mauger, 2020).

Figure 10: Equation for Monthly Stipend

Monthly stipend = a + (dollar amount per credit hour) X (number of credits)

Michigan can make the monthly stipend directly to students through Michigan Works!, a quasi-public agency of state government that provides services and employment and educational funding support to Michigan's unskilled and dislocated workers. or their school like the City University of New York (CUNY) that was successful in increasing the number of graduates (Sommo et al., 2018). The CUNY program required students to enroll full-time in the fall and spring, with summer school attendance highly recommended. Students were encouraged to take remedial courses immediately. Structured advising occurred twice a month in the first semester and financial incentives were provided to students who remained in the program. Students in remedial courses were required to attend at least three hours of tutoring per month. Program students were granted waivers for the portion of tuition and fees not covered by financial aid packages. This could be covered by the state of Michigan.

Students in New York also received financial assistance to cover the costs of textbooks at the campus bookstore (at least $300 during each of the fall and spring semesters and half during the summer). There

was also a monthly incentive of a $50 gift card for the purchase of groceries or gas. This led to 45 percent receiving three or more payments in each semester. The program was measured by its effect on two groups: the program group and control group. The program group's graduation rate more than doubled to 19 percent with a degree or credential after two years compared with 8 percent of the control group.

Michigan has made attempts to get more people to pursue higher education through their last-dollar scholarship awards. However, Hightower (2019) believes the last-dollar scholarship is money better spent if it went towards free transportation, intensive advising, career services, special seminars, and other supportive services. It is not means-tested and wealthy students qualify and can go technical schools and certificate programs in addition to community colleges tuition free. The monthly stipend illustrates a better way of helping students based on the responses of this study's student survey.

With a bond proposal, a student's cost to attend a public community college or university would be covered by a monthly stipend that included the fair market rent plus $35 per credit for non-STEM students and $50 per credit for STEM students multiplied by the number of credits as shown in Figure 11 on the next page. Additional financial assistance of $300 will be granted at the beginning of each semester to cover the cost of textbooks at the campus bookstore.

Figure 11: Example of Tuition Assistance of a Student at Lansing Community College

Expenses covered are housing, transportation, and food.

Monthly stipend = a + (dollar amount per credit hour) X (number of credits) + $300 each semester for textbooks

Monthly stipend for a non-STEM student = $1,171 + ($35 per credit) x (12 credits) =
$1,171 + $420 = $1,591.00

Monthly stipend for STEM student = $1,171 = ($50 per credit) x (12 credits) =
$1,171 + $600 = $1,771.00

Textbooks = $300

(Note: Tuition will be paid by the federal Department of Education through the Pell Grant)

Until a bond is passed, the state does have the ability to pay for adult and dislocated worker education and training with the federal Workforce Innovation and Opportunity Act (WIOA) funds (State of Michigan Workforce Development, 2020). In Michigan, the funds are issued through the Michigan Work Agencies (MWA). Each agency has its own governing body and can set policies freely as long as they qualify under the WIOA guidelines. Under WIOA, there is a Needs Related Payment (NRP) that can be used for supportive services depending on an unemployed individual's circumstances and the absence of other resources and funding limits (State of Michigan Workforce Development, 2020). In most cases, if an unemployed worker is receiving unemployment, they are not eligible for NRPs. This can be changed with an act of the governing body of the MWA. This will allow the worker to receive a per diem payment for education and training.

In Ohio, the NRP is $25 for every day that the worker is in training (Ohio Means Jobs, 2019). Training constitutes taking classes at a community college or four-year university. An additional $25 should be

given to a worker in a STEM program that will lead to filling a high-demand job. This can amount to a student in advanced manufacturing that attends a class twice a week receiving a monthly Needs Related Payment of $400 ($50 x 8 class days for the month).

8.4 Local Policy

The role of local government is to work with their state to identify individuals through their local workforce development agency who would qualify for the state programs outlined above. The local government should also be in the business of putting their locale on display to attract companies as more residents pursue a higher education. This can be done through incentives such as one or more of the following: abating property taxes, offering a parking subsidy for city-owned lots or ramps, and lower personal income tax (Byrd-Hill, 2019; Livengood, 2020).

Local governments could also work with nonprofits through a city workforce development agency to get more high school students and young adults interested in manufacturing. The University of Illinois at Chicago's Great Cities Institute (Cordova et al, 2018) devised a report on how the manufacturing sector can meet the needs of the jobless, in particular jobless Black and Latino young people who have not received any post-high school education. The report points out that Chicago's Learn, Plan and Succeed Initiative for the city's high schools have recognized the need for high school graduates to enter a job training program or community college. The Great Cities Institute found that young people of color not in such a program were being obstructed from entering engineering, sales, computer programming, and business roles in manufacturing. Modern career education programs should be integrated alongside rigorous college prep academic work, have high-quality work-based learning experiences supervised by employers with time for learning from work, and be racially and socioeconomically diverse.

All the policy recommendations create systems of “lifelong learners” where workers who have experienced (or are at risk of) technological displacement can more easily obtain new skills that better compliment automation in the workplace.

CHAPTER 9: CONCLUSIONS

9.1 Introduction

Community Colleges play an important role in the development of a skilled workforce and also serve as a way to promote education for low income, underrepresented, and displaced workers. The motivation for this study was concern both for career development that maintains traditional manufacturing communities in Michigan and also provides a career ladder for economic success for individuals and communities bypassed by recent economic trends. The study focused on ways to get unskilled and dislocated workers equipped to handle the change that is occurring in Michigan's largest employment sector, manufacturing.

9.2 What are the implications that change in manufacturing will have on employment of Michigan workers?

This dissertation study concludes the implications of changing manufacturing labor demand are both positive and negative Positive implications are that Michigan will have a skilled labor pool that will be trained in advanced manufacturing techniques for lean production and if more jobs are offshored, these workers will have the skill set to transfer to the growing pharmaceutical, aerospace, and biomedical sectors and contribute to the research and developments of all areas. Michigan will then be more attractive to national companies looking to bring a concept into production. Negative implications are that Michigan workers who do not pursue training and upskilling will find themselves displaced as companies adopt new technologies while the state will not be viewed as competitive in terms of talent for advanced manufacturing.

The answer to the central research question, "Are community colleges providing Michigan workers with the technical skills needed for advanced manufacturing jobs?", is "yes" but more work needs to be done.

There is a divide between what the businesses wish community colleges were teaching and the rate it is being taught and what the budget constraints of the community colleges allow them to teach and how fast.

When speaking with dissertation committee member, Dr. Berghorn, a former community college dean, to understand how the budget process works, it is understood that funding for new equipment only occurs every two years or more and by that time, there is newer equipment to be had.

As Michigan sets policies to get more students to meet its Sixty by 2030 goal, the question then becomes, "Will this help the new direction of the Detroit Three and other OEM's and will it improve job opportunities for Michigan workers?" The answer is "yes". GM has recently announced its intention to hire 3,000 engineers, designers, and IT workers nationally to speed up electric vehicle production (LaReau, 2020). It is expected that a lot of the 3,000 jobs will be for Michigan. The company wants to have 20 new model electric vehicles on the road by 2023. LaReau emphasizes that GM wants to realize a world where there are zero emissions, zero crashes and zero congestion, that can be achieved through electric and autonomous vehicles. The types of engineers they are seeking are electrical system engineers; infotainment software engineers; developers of Java, Android, iOS and other platforms, and controls engineers. While most of the jobs require a bachelor's degree, the hope is that once the technology advances, there will be a need for technicians and the current 103 associate degree candidates in this study that are planning to attend a four-year institution will have better job opportunities by 2023.

This study found the same concern as the Business Manager of Experis in regard to the quality of Michigan engineers and the need for more foreign engineering workers. It was evidenced by the OCC Electrical/Electronics Technology student with 207 points needing to take more classes to gain skills for

complex duties like working on electrical systems and testing batteries for an AV and EV. Also, the industry certifications have not been passed. While it is believed that a company's urgent need to create training programs to get more of their workers credentialed to take on the immediate tasks at hand is commendable, it does not solve the problem of filling the high demand jobs that require an advanced degree. Any attempts to have training outside of a community college campus should be avoided to not encounter the pitfalls that Indiana dealt with when the Navistar Engine Plant and Foundry eliminated jobs. Applying for funding and classes were held at a local union hall. No connection to the community college itself caused confusion when applying for funding and classes were cancelled. Companies should have all their training classes and advising at a community college campus where more resources are available. It is believed that with the right curricula intervention from more state funding and by the intersection of the community colleges and the business community having more dialogue on how both of their needs can be met, that the quality and quantity of engineers and students in general will improve.

Like Salzman's (2013) conclusion there is not a shortage of STEM educated students in the U.S workforce, it does not appear that there is a shortage of engineers in Michigan. The recent cut of 4,000 engineering jobs at GM, mostly in powertrain, traditional engineering and internal combustion prove a different type of engineer is now in demand (LaReau, 2020). The electrical engineer, software developer, and those with data sciences and information technology skills will be utilized as the automotive companies look to implement their AVs and EVs. Blue-collar job losses will also follow.

The second question was, "Can community colleges provide a path for students to gain skills in demand for the automotive industry of the future?" It was stated that the definition of skilled is having training (classroom and apprenticeship) to fill the technological requirements to produce autonomous and electric vehicles and new lightweight materials for the exterior and interior. Unfortunately, the community

college students under study may be gaining classroom training but do not have apprenticeships. There is not a concrete answer as to the reason why not. This was happening before COVID-19, so the economic downturn is no excuse. There will have to be more done by the state such as incentivizing companies by offering tax credits to the employers that do offer apprenticeships and then hire those students.

The community colleges should develop advanced manufacturing curricula for all sectors that highlight components of Industry 4.0, courses that discuss new technologies such as 5G. 5G is the fifth-generation technology for broadband cellular networks, which cellular phone companies began deploying worldwide in 2019, and is the successor to the 4G networks which provide connectivity to most current cellphones. 5G technologies' ability to affect real-time environments by collecting data from artificial intelligence and machine learning. Devices will collect data and take it up to a cloud to make quick production decisions.

Students should learn that manufacturing companies can develop their own applications to talk to the cloud that gives them the ability to impact factory maintenance. For example, if a machine gets too hot and parts need to be replaced, 5G allows the worker the ability to look at the machine before it malfunctions (Automation Alley, 2020). 5G technology is a couple of years from fully rolling out because municipalities need to put up more towers. In addition, a course on augmented reality (AR) training would be important by teaching the future use of it in relation to job training instead of having written manuals and for surveillance of the quality of products. Students should learn the plan of companies to have robots roam around the factory floor and take pictures of production. An example is a robotic dog at Ford that quickly moves products. These are examples of how community colleges can get out ahead of their norms of teaching a technology that has since years passed. These courses give potential technicians the ability to be more marketable when it comes to finding a job after graduation. There may be budget constraints

for the community college to actually buy the equipment but collaborations with companies that have the equipment can be formed where students gain access through labs or apprenticeships. As found in Illinois, 91 percent of apprentices retain employment at a median salary of $50,000 (Young Invincibles, 2018).

When comparing elements from, Advanced Manufacturing, Mechatronics, and Quality Consortium (AMMQC) – Final Evaluation Report ("Report"), this study can measure what worked (addressing barriers), what did not work (underlying factors), student's retention in the programs; student's satisfaction with program; and whether they are on course to complete academic program.

When reviewing what did work to address barriers, contact with on-campus social service staff could not be obtained because of the pandemic. Although 66 (55.3%) students responded they have no barriers, there are still students who have them. Each school's website was reviewed to see if support is offered to their students for wraparound services that assist with childcare, transportation, vouchers for books, etc. The school that came close to what proved successful at Amarillo College in Texas through their Advocacy and Resource Center (ARC) is WCC. The center was created as part of the No Excuses Poverty Initiative in 2010 to promote college attainment to escape poverty. ARC offers an on-site food pantry or emergency grant, case management, academic support, curriculum development, and college-wide hiring and evaluation processes. ARC also offers assistance for childcare, transportation in the form of bus passes, textbooks, and tuition. WCC has a student resource center. In addition, a Student Emergency Fund has been established for childcare; tuition; books; bus tokens; avoiding utility shutoffs, unexpected car repairs; and rent assistance. A student must have completed a semester and be in good academic standing and meet the income guidelines. WCC's resource center has an on-site emergency food pantry

for food and hygiene products. The school has an onsite childcare facility for children 18 months through 5 years old.

LCC and GRCC have on-site resources as well but not to the degree of WCC. LCC's center grants partial payment for childcare based on the FAFSA. The requirement for funds is that children must be in an outside licensed day care during the time the student is attending a class. There is a Financial Aid Book Voucher up to $600 for students that receive a refund for aid greater than tuition and fees. GRCC has a food pantry onsite that allows eligible students the ability to purchase non-perishable food and hygiene items such as soap. There are also six snack pantries throughout the campus. A student is required to complete an intake form every academic year to have pantry access twice a month. OCC and MCC only provide online access to outside supportive human services such as childcare options in both counties.

What did not work is the instructors attempt to design a curriculum to keep up with the changing demand of skills needed for advanced manufacturing. They are making noble attempts by having industry experts on their advisory boards but there is still a disconnect in teaching skills for technologies such as different materials for 3D printing. Automation Alley's monthly discussions among researchers and corporate executives have shared that some companies are slow to adopt these technologies that can increase their efficiency. Therefore, it becomes a question of who are the experts advising the instructors?

Most students left the question of overall comments about their program blank. The students that did respond commented on the need to balance work and school and how employers should be more flexible in their work schedule to accommodate students to complete their coursework. Another student would like to see more online programs offered during the evening time. It was believed this would certainly allow more working professionals to join the classes. Students thought the time in academic programs

could be accelerated by removing "*the pointless general studies classes*" and focus on the core requirements. As one student put it, "*The biggest thing I would like to see made is for an ability to test out of classes with an assessment if someone is already in the industry. I have been a CAD designer for 11 years and feel that there are only a few classes that are teaching me things in the degree I am going for*." One student was an advocate for instructors receiving a pay increase after one class this semester was almost cancelled because an instructor could not be found to replace the outgoing professor. Lastly, a student replied, *"I feel there is a need for more internship programs as well as job placement for the Robotics field.*"

Students' attendance in the academic programs appeared to be within the 2 – 3-year period to obtain a certificate or associate, depending on whether they are enrolled part-time or full-time. Further review as to the reason why the 36 (19%) students that have been enrolled at a school prior to 2017 have not completed their studies would have to be made and was not a part of this study.

One reason may be that students need to take remedial courses upon entering a community college. In Pennsylvania, Ginsberg (2015) found that the low enrollment in technical and career specific majors was explained by the fact that 70 percent of the new Community College of Philadelphia had to take remedial courses. Research found the requirements of the Accelerated Study in Associate Programs (ASAP) in Ohio is an excellent example to keep students on a completion track (Sommo et al., 2018). Like the City University of New York (CUNY), students were required to enroll full-time in the fall and spring. Summer school attendance was highly recommended also. Students were encouraged to take remedial courses immediately. Structured advising occurred twice a month in the first semester and financial incentives were provided to students who remained in the program. Students in remedial courses were required to attend at least three hours of tutoring per month.

The point system developed for this study was able to ascertain that the students who were not at a Level 4 were on track to complete their academic program, it was more a matter of whether they were considered skilled based on the classes that they have had to this point and the overall courses offered. The students appeared to be completing their general technical education requirements before some skill courses.

In summary, the research hypothesis that community college training is an effective way to prepare Michigan workers for the changes manufacturing will have on employment was found to be true but improvements to the curricula must be met.

9.3 Limitations for the Study

The following are limitations to this study:

- Coronavirus

The World Health Organization explains that coronavirus is a large virus family that may cause illness in animals or humans. It is believed that in the winter of 2019, the coronavirus was generated in Wuhan, China from the transmission of a person eating an infected bat. This gives the virus the name COVID-19. It has been the deadliest virus since the Spanish Flu in 1918. In Michigan, as of November 30, 2020, there are 432,072 people that have tested positive for the virus and 10.513 people that have died as of it (State of Michigan, 2020). Infected people are overwhelming some hospital systems in multiple states. There has been a shortage of personal protective equipment such as medical masks, ventilators, gloves, gowns, and testing swabs for frontline workers that include the doctors and nurses.

Two of the Detroit Three, because of their size and ability to retool a plant quickly, were called to the rescue to address the shortage of specific personal protective equipment. On March 27, 2020, former

President Trump invoked the federal Defense Production Act and ordered GM to finalize their partnership with Ventec Life Systems to make ventilators at its Kokomo, Indiana plant (Dzhanova, 2020). GM had already committed to mass producing medical masks at it closed Warren, Michigan plant in March. The masks were made at 100,000 per day. In addition, Ford partnered with GE Healthcare in April 2020 to build 50,000 ventilators by July 13, 2020 (Grzelewski, 2020).

The virus has wreaked havoc on the economy by causing businesses (department stores, restaurants, and offices) and all schools to shut down because a vaccine has not been developed to prevent the spread of it. Americans were told to stay in their homes and only go out if they had to go to essential places like a grocery store or pharmacy. If they do have to go out a mask and keeping 6 ft. from another person has been mandated in most states. Michigan Governor Whitmer shut down the state in March 2020 after the World Health Organization and U.S. government alerted Americans of the danger the virus was causing. In June when Governor Whitmer like other governors started to ease restrictions and let some businesses such as restaurants reopen, infected cases began to surge again because people disobeyed the orders of wearing a mask and social distancing.

In April and May of 2020, Michigan's state and local leaders surveyed had been impacted from Covid-19 (Horner et al., 2020). There were 93 percent of local leaders that cited they were impacted; 88 percent cited their local schools were impacted, 86 percent of leaders say their local schools have been impacted; 86 percent of local leaders have seen a change in local economic conditions, 70 percent cite the pandemic affecting residents' welfare, and 67 percent of local leaders feel their community overall has been impacted. On the federal level, the Congressional Budget Office projects the unemployment rate will fall to 5.3 percent in 2021 and to 4 percent between 2024 and 2025 (Franck, 2021).

- Low Minority Participation

Wayne County Community College District, located in Michigan's largest city of Detroit, decided not to participate in the study after being approached two times. The reason the Office of Institutional Effectiveness gave is they had no one on staff to monitor students' participation. The community college has majority black students from the city and would have given a perspective on the plans of students not in other metropolitan areas of the state.

- Inability to monitor students as they near graduation to see if they obtain a position in advanced manufacturing.

There was pushback from Institutional Review Boards to approach their students twice. As it turns out, the ability to gather data from the students and instructors proved taxing at times because everything had to be done electronically and not in-person due to the pandemic shelter-in place order from the State of Michigan and subsequently from the Michigan State University Human Research Protection Program, which oversees all research projects.

- The researcher was not able to interview employers in Macomb and Kent counties.

Attempts were made to contact employers in these counties but due to the pandemic's shelter-in-place calls and e-mails sent to companies were unanswered.

- Some automotive plans needed by the Detroit Three may be confidential.

The limitations of this study may come from some automotive plans being classified as confidential. Ford Motor Company has made recent news for purchasing the old Michigan Central train station for $740 million in the Detroit Corktown neighborhood. The company plans to make it along with other buildings the hub for their mobility division by employing autonomous and electric vehicle tech workers. The campus will take four years to complete. (Pinho, 2018). This will impact the number of available jobs.

- Ratification of New NAFTA Agreement by Congress (USMCA)

The New NAFTA Agreement, United States-Mexico-Canada Agreement (USMCA) increases from 62.5 percent to 75 percent the percentage of car parts that must come from one of the three countries to qualify for duty-free tax. It also requires that 40-45 percent of an automotive content be made by workers earning at least $16 per hour. Cars not meeting the requirements would be subject to a 2.5 percent duty tax (Lang, 2018). Congress has ratified the pact and former President Trump signed it into law on January 29, 2020 (Swanson and Cochrane, 2020). Mexico ratified the pact on June 19, 2019 (Lopez and Graham, 2019). Canada has put the pact before their House of Commons hoping it will be ratified soon (Johnson, 2020). Time will tell if production of vehicles will shift from Mexico and Canada (more so Mexico) and increase workers in the United States.

- Increase in tariffs on automotive parts and vehicles from European Union and China

Former President Trump made a pact with China. He should have also made a pact with the European Union. The automotive sector is a large source of employment in Europe and is attractive to U.S. carmakers for assembling parts of cars sold in the U.S. In 2017, European Union (EU) automotive exports to America reached $38 billion, against only $6 billion in EU imports of American cars (Staffor, 2018). The United States, meanwhile, imposes a 2.5 percent tariff on imported passenger cars from the EU, though the tariff is 25 percent for vehicles like pickup trucks. Some analysts believe that Mexico, Canada, and Europe are not the problem when it comes to an imbalanced trade of vehicles among countries, but China is the main culprit (Melloy, 2018). As of December 2018, China has agreed to reduce the tariffs on American automotive imports from 40 percent to 15 percent in a move that could break an escalating trade war between the two countries. The percentage amount was escalated in July in response to President Trump's enforcement of tariffs to remedy the trade imbalance in his estimation. Chinese officials are also looking to amend the Made in China 2025 plan, which is designed to give Chinese

companies an edge in several industries, including artificial intelligence and robotics. The United States is opposed to this because it allows Beijing to engage in unfair trade practices.

After contentious negotiations with China on imposing tariffs to rein the country into more equitable trade, a 94-page trade deal was reached in early 2020 as a first phase (Heeb, 2020). China has agreed to purchase American products and services that include agricultural and energy exports by an increase of $200 billion within the next two years. The U.S. scored a victory that will impact technological advances by China agreeing to no longer force foreign companies to hand over technology when they apply for permits and work with the government. Furthermore, China has pledged not to direct or support investments that would cause the gain of foreign technology to satisfy the Made in China 2025 plan. This is key to the race among countries to utilize new technologies such as 5G networks. This new wave of technology allows vehicle-to-vehicle (V2V) and vehicle-to-everything (V2X) connectivity. Vehicle connectivity covers telematics (GPS systems, OnStar, and hand-free mobile calling) and infotainment (type of media, usually television, that combines information and entertainment) to vehicle-to-vehicle and vehicle-to-infrastructure communications for safety. In return, the Treasury Department has decided not to label China a currency manipulator. The U.S. dollar will still be strong but exports will still be more expensive abroad. In a forthcoming second phase, subsidies and cheap loans to businesses in China, which the U.S. believes put domestic companies at a disadvantage in the global market, should be addressed. Also, the remaining tariffs on more than $360 billion worth of shipments from China will likely be reviewed. Until then, U.S. workers need to be armed with technical skills to compete with Chinese workers and increase the demand for U.S. products to decrease the trade deficit.

- The shuttering of the GM Hamtramck plant

GM announced in November 2018 that it intends to idle five automotive plants, Detroit-Hamtramck, Warren Transmission, Lordstown Assembly in Ohio, Oshawa Assembly in Ontario and Baltimore Operations in Maryland. A total of 14,300 workers will be affected. That includes 6,000 salaried workers (Naughton and Noble, 2018). The Detroit-Hamtramck plant may not have an allocated product and this will affect Michigan's labor market. In response to this news, former President Trump was threatening to cut GM's electric-car subsidies in retaliation. The subsidy calls for a tax credit of $7,500 offered to buyers of electric cars to be capped at 200,000-vehicle sales. It is estimated that 196,850 vehicles qualified for the credit through October 2018. The company said it expects to hit the cap before the end of the year (Naughton and Noble, 2018).

Under a deal between GM and former Governor Rick Snyder's administration in 2015, the company can apply the Michigan Economic Growth Authority tax credits to a maximum of 34,750 retained jobs through the end of 2029. The tax credits are under the Michigan Business Tax. The automaker's current in-state workforce totals 51,000 employees (Livengood, 2018). The United Automobile Workers Union's (UAW) duty is to make sure that its rank and file are working with market worthy wages. The proposed job cuts by GM put the 2019 contract negotiations up front and center. GM's choice in stating the reason to leave the four U.S. plants as "unallocated" and not idled or closed because in the last contract in 2015, The "Plant Closing and Sale Moratorium," outlined on page 356 of the agreement, states that GM will not close or idle "in any form, any plant, asset, or business unit of any type" outside of collective bargaining, with a caveat for extreme market conditions or an "act of God." The UAW charges that the company has always had long term plans to move the jobs to Mexico (Naughton, 2018).

- New UAW bargaining contract in 2019

GM decided to strike after contract negotiations broke down in the summer of 2019. The strike lasted 40 days in 2019 and a new four-year contract was reached on October 26, 2019 (LaReau, 2020). The UAW reached similar deals with Ford and STELLANTIS thereafter. GM workers will increase their salary from $63 per hour to $71 per hour by 2023. Ford workers' salary will increase from $61 per hour to $69 per hour by 2023. STELLANTIS workers' salary will increase from $55 per hour to $66 per hour by 2023. The UAW was not successful in reversing GM's plans to shut down Warren Transmission, Baltimore Transmission, and Lordstown Assembly plants. The Hamtramck plant will have the GMC Hummer electric truck allocated to it in 2021 and will be designated the first EV-only plant (Phelan, 2020). Two thousand workers will be employed. The UAW also was successful in getting GM to make 1,350 temporary workers with three years of continuous service full-time by the end of March 2020 (LaReau, 2020).

9.4 Suggestion for Future Study

Future research should entail following the progress of Michigan's Sixty by 2030 plan. It is believed that the state's goals will not be met unless measures are taken like the ones recommended to help students cover their cost of going to school. If you are a frontline worker making a minimal wage, you have to balance the need to work with finding the time to take classes.

The pandemic may prove to spur more residents to pursue higher education as some experience permanent job loss and they find themselves wondering what to do next. Research found that people tend to go back to school in a crisis like during the Great Recession but as the market picks up and they are able to find a job, they may drop out.

Michigan can ill-afford to have residents not buy into the Sixty by 2030 plan. The state has to be able to attract businesses outside of the automotive industry, given that the Detroit Three are in a precarious

position by investing billions of dollars in AVs and EVs. It is not known whether consumers will adopt these concepts like the automotive companies are banking on. Michigan cannot afford to lose hundreds of thousands of jobs like before. The state should instead look to further building its pharmaceutical, aerospace, and biomedical industries as an alternative. These industries are capturing the nation, as Elon Musk is funding Space X expeditions that have not occurred for years and the pandemic is causing Americans to look at our U.S. supply chain for pharmaceuticals and the pandemic has us studying the biomedical field.

APPENDICES

APPENDIX A

STUDENT SURVEY

Table 24: Student Survey

Variable and Type of Data			Question/Item	Points
School - nominal		1	What school are you enrolled at?	
Age -nominal		2	What is your age?	
Gender-nominal		3	What gender do you most identify with?	
			(Check the appropriate one)	
			Male	
			Female	
			Other	
			Prefer not to identify	
Race - nominal		4	How would you describe yourself?	
			(Check the appropriate one)	
			White	
			Black or African American	
			Hispanic or Latino	
			Asian	
			American Indian or Alaska Native	
			Native Hawaiian	
			Pacific Islander	
			Other (please specify)	
Enrollment Status - nominal		5	Are you enrolled part-time or full-time?	
			(Check the appropriate one)	
			Part-time	
			Full-time	

Table 24 (cont'd)

CreditHours - scale		6	How many cumulative credits have you currently earned from your academic program?	
TuitionAssistance - nominal		7	Do you receive tuition assistance from an employer or government source?	
			(Check the appropriate one)	
			Employer	
			Government source (check and specify)	
			Not applicable	
TuitionPercent - scale		8	If receiving tuition assistance, what percentage is covered?	
EducCompleted - nominal		9	What is your highest level of education completed?	
			(Check the appropriate one)	
			Less than high school	
			High school or GED	
			Certificate	
			Associate degree	
			Bachelor degree or higher	
Apprenticeship - nominal		10	Are you in an apprenticeship program?	
			(Check the appropriate one)	
			No	
			It is a registered apprenticeship.	5
			It is a local/informal apprenticeship.	0
CurrOccupation - nominal		11	What is your current occupation?	

Table 24 (cont'd)

CurrentIndustry - nominal		12	What is your current industry?	
			(Check the appropriate one)	
			Manufacturing (includes automotive)	
			Construction	
			Agriculture, Forestry, Fishing, Mining	
			Retail	
			Finance and Insurance	
			Real Estate	
			Education Services	
			Professional, Scientific, and Technical Services	
			Healthcare	
			Arts, Entertainment, Recreation	
			Food Services	
			Government (local, state or federal)	
			Other (please specify)	
FutIndustry1 - nominal		13	What industry do you want to work in after graduation?	
			(Check the appropriate one)	
			Manufacturing	
			Construction	
			Agriculture, Forestry, Fishing, Mining	
			Retail	
			Finance and Insurance	
			Real Estate	
			Education Services	
			Professional, Scientific, and Technical Services	
			Healthcare	
			Arts, Entertainment, Recreation	
			Food Services	
			Government (local, state or federal)	

Table 24 (cont'd)

			Other (please specify)	
FutManufSector1 - nominal		14	What manufacturing sector will you work in after graduation? (Check the appropriate one)	
			Automotive Manufacturing	
			Industrial Machinery Manufacturing	
			Food Manufacturing	
			Beverage and Tobacco Product Manufacturing	
			Apparel Manufacturing	
			Chemical Manufacturing	
			Plastics and Rubber Products Manufacturing	
			Computer and Electronic Product Manufacturing	
			Electrical Equipment, Appliance, and Component Manufacturing	
			Furniture and Related Product Manufacturing	
			Pharmaceutical and Medicine Manufacturing	
			Medical Equipment and Supplies Manufacturing	
			Agriculture, Construction, and Mining Machinery Manufacturing	
			Other (please specify)	
Relationship - nominal		15	What is your relationship to the manufacturing industry?	
			(Check the appropriate one)	
			Current worker that is looking to obtain new skills	
			Laid-off worker that is looking to obtain new skills	
			None	
FutureAEV - nominal		16	If planning to work in the manufacturing industry after graduation, will it be in autonomous and electric vehicle production?	
			Yes	
			No	

Table 24 (cont'd)

Unemployment - scale		17	How many bouts of unemployment have you experienced since January 1, 2007? (Check the appropriate one)	
			0	
			1	
			2	
			3	
			4	
			5	
			6 or more	
CurrSalary - scale		18	What Is your yearly salary?	
			(Check the appropriate one)	
			Less than $10,000	
			$10,000 - $14,999	
			$15,000 - $24,999	
			$25,000 - $34,999	
			$35,000 - $49,000	
			$50.000 - $74,999	
			$75,000 or higher	
City - nominal		19	What city do you live in?	
CurrResidence - nominal		20	Are you a renter or homeowner?	
			(Check the appropriate one)	
			Renter	
			Homeowner	

Table 24 (cont'd)

ResidenceYrs - scale		21	How many years have you lived in your apartment or home?	
CTEProg - nominal		22	Were you in a Career and Technical Education program in high school?	
			(Check the appropriate one)	
			Yes	1
			No	
CTEPartnership - nominal		23	Was the Career and Technical Education program a joint partnership with a community college to receive credits towards your certificate or degree?	
			Yes	
			No	
STEMBackgrd - nominal		24	Did you have advanced placement courses in STEM (Science, Technology, Engineering, and Math) in high school? Or in the International Baccalaureate Program Middle Years Programme?	
			(Check the appropriate one)	
			Yes, I had advanced placement classes in STEM	4
			Yes, I had advanced placement classes in Science only	3
			Yes, I had advanced placement classes in Technology only (computer programming or other technological studies)	3
			Yes, I had advanced placement classes in Engineering only	3
			Yes, I had advanced placement classes in Math only	3

Table 24 (cont'd)

			No, I had regular required courses	2
			No, I did not graduate from high school	0
			Total STEM Background	
				4
CommCollProg - nominal		25	What program are you in?	
			(Check the appropriate one)	
	OCC-CA, CC, AAS; LCC-CC, CA	a	Robotics & Automated Systems Technology (positions: robotics technician, robotics engineer)	
	MCC-CA, AAS; LCC-AAS; WashCC-AAS;	b	Mechatronics (positions: robotics programmer, robotics technician, robotics engineer, controls technician, maintenance technician, electro-mechanical technician, automated equipment technician, mechatronics technician, mechanical engineering technician)	
	OCC-CA, AAS; LCC-CC, CA,	c	Computer Automated Design and Engineering Technology and Vehicle Design Option/Industrial Computer Graphics (positions: CAD technician, mechanical industrial drafter, electrical CAD drafter, engineering CAD technician)	

Table 24 (cont'd)

	LCC-CA	d	Industrial Maintenance Technician (positions: millwrights, maintenance workers, machinery)	
	LCC-CC, CA, AAS	e	Industrial Electronics Technology/Electrical Technology - (positions: electronics technician, industrial electronic technician)	
	OCC-CA, AAS; LCC-CC, CA, AAS for MET **Also for Manufacturing Engineering Technology at LCC**	f	Machine Tool Technology/Manufacturing Engineering Technology/Computer Numerical Control (positions: machinists, computer-controlled machine tool operators, metal and plastic; computer-controlled machine tool programmers, metal and plastic; machine service/repair)	

Table 24 (cont'd)

	WCC-AAS		Engineering Technologist Manufacturing (positions: engineering technologist or technician, instrumentation technician, electrical instrumentation and controls technician)	
	MCC-CC, CA, AAS; LCC-CA, AAS	g	Electrical/Electronics Engineering Technology - (position: electrical engineering technician)	
	OC-CA, AAS; LCC-CA	h	Computer Information Systems - Software Engineering/Software Tester (position: software developer, software tester)	
	MCC-CA, AS; AS only - Chemistry	i.	Pre-Engineering/Physics/Chemistry (positions: electrical & electronics engineering technician, engineering technician, mechanical engineering technician, and machinery mechanic, chemical technician)	
	MCC - CA	j	Computer Information Systems - Programming in C++ (position: programmer/analyst)	
	MCC - CA	k	Computer Information Systems - Programming in Java (position: programmer/analyst)	
	MCC-AAS	l	Automotive Technology - Vehicle Development (position: vehicle development technician, engineering technician)	
	LCC-CA, AAS	m	Mechanical Systems - (positions: electro-mechanical technician, robotics technician, machine maintenance technician)	

Table 24 (cont'd)

	OCC-CA; LCC-CA, CC, AAS; WCC-CC, CA, AAS	n	Welding and Fabrication Technology (position: welding technician, welder fitter, welding machine setter, structural metal fabricator)	
	MCC-CA, AAS; WCC - CC	o	IT - Cloud Computing/Applied Data Science (positions: data engineer, product technician, cloud architect, cloud developer)	
	OCC-CA, AAS; LCC-AAS; WCC-CC, AAS; MCC - CC, AAS	p	Computer Information Systems - Cybersecurity (positions: information security analyst; network and computer systems administrator; document management analyst)	
	GRCC - AAS	q	Plastics-Polymer Engineering Technology (positions: plastics-polymer engineering technician; process set-up technician; new product development technician)	
	OCC; WCC; LCC; GRCC	r	Other (positions: auto servicing technician; collision auto repairer; HVAC/R technician; business systems analyst; networking associate; graphics and web designer; IoT specialist; computer support technician)	
CertDegree - nominal		26	Are you seeking a certificate or associate degree?	
			(Check the appropriate one)	
			Certificate of Completion (25 credit hours or less)	
			Certificate of Achievement (26 or more credit hours)	
			Associate of Applied Science degree	
			Other (please specify)	
FutAssoc - nominal		27	If you are studying for a certificate, will you pursue an associate's degree after completion?	
			(Check the appropriate one)	
			Yes	
			No	
GradDate - nominal		28	I plan to complete my certificate or degree program by: (specify date)_____, 20 _____	
Trans4Yr - nominal		29	Do you plan to transfer to a four-year institution after completion of your studies?	
			(Check the appropriate one)	
			Yes	
			No	

Table 24 (cont'd)

			Unsure	
			For the following questions, check all the statements that apply to your level of skills obtained from your currently enrolled or completed academic program. Do not check if you still have to take the course. If you have comments on some of the skills listed or want to add skills that are not listed, please add in the comment boxes below.	
CommCollProg1 - nominal		30 connect to 25a	**Robotics & Automated Technology**	
	OCC ROB 1520	1	I can perform robotic maintenance, which includes the types of gears and gear reduction systems that are used in robots. I have been trained in mechanical adjustments, preventative maintenance, controller setting and procedures that influence the motion of the robotic manipulator and safety.	6
	OCC ROB 2500	2	I can perform robotic controller maintenance, which includes the techniques and components involved in controller settings; electrical/electronic architecture; analysis and troubleshooting techniques of robot controllers. I utilize observations, documentation, and prints to diagnose and correct problems on the robotic controllers.	7
	OCC ROB 1620	3	I have been trained in industrial robotic applications that allows me to study, program, and work with stand-alone robots and with robots integrated into work cells. I have been trained in palletizing and packaging, material joining, material removal and material handling.	7
	OCC ROB 1640	4	I can perform interpolated welding robotic applications. I have been trained in controller frame set-up and programming techniques for interpolated linear and circular motions. I can set weld schedules to enable robotic welding applications using Gas Metal Arc Welding (GMAW) and resistance welding.	7
	OCC ROB 1650	5	I have been trained in collaborative robot parameters and programming techniques for safe and effective interaction with human workers while performing industrial tasks.	7
	OCC ROB 1660	6	I have been trained in utilizing point-to-point wiring interfaces, field device networks, and data networks to investigate how controllers are programmed to interact with the types of signals the sensors will supply to the controller.	7

Table 24 (cont'd)

	OCC ROB 2040	7	I have been trained in programming interface to troubleshoot applications. I can write, enter, and execute application programs using the programmable controllers and Human Machine Interface (HMI).	7
	OCC ROB 2400	8	I have been trained in the process requirements, programming, and communication for implementing robotic applications. I know how these systems are interfaced together mechanically, electrically and software wise. I can use Robotic simulation and machine vision sensors in robotic work cell applications.	8
	OCC ROB 1640 & others	9	I have studied on Robotics Lab equipment for 32 or more hours to give me the practical programming and troubleshooting skills used in the maintenance of automated systems.	6
	GM job posting	10	I am knowledgeable of industrial workplace local, state and federal safety regulations.	4
	LCC ELTE 260	11	I can use Allen Bradley control technology.	9
	LCC ELTE 260	12	I can use Siemens control technology.	9
	Ford job posting	13	I can operate Square D control technology.	9
	Ford job posting	14	I can operate Control Logix control technology.	9
	Ford job posting	15	I can operate Fanuc robotic systems and equipment.	9
	Ford job posting	16	I can operate ABB robotic systems and equipment.	9
	Ford job posting	17	I can operate Kawasaki robotic systems and equipment.	9
	FCA job posting	18	I can operate Comau robotic systems and equipment.	9
	FCA job posting	19	I have passed the International Society of Certified Technician exam.	10
	FCA job posting	20	I have intermediate level knowledge of Microsoft Office software.	5
	FCA job posting	21	I have intermediate level knowledge of Google Suite software.	5
	FCA job posting	22	I am Green Belt/Red X/Sigma Certified.	10
	FCA job posting	23	I have experience in automotive/OEM body, paint, stamping press automation or general assembly.	9
				177
			Comments:	
CommCollProg2 - nominal		31 connect to 25b	**Mechatronics**	
	LCC ELTE 108	1	I have been trained in direct current electrical theory, which covers series, parallel and combination circuits.	4

Table 24 (cont'd)

	LCC ELTE 131	2	I have been trained in wiring three-phase motor control circuits utilizing two- and three-wire control and machine control circuits utilizing limit and proximity switches, timers, relays, etc. I can identify correct symbols and standard construction of wiring and ladder diagrams.	4
	LCC ELTE 260	3	I have been trained in the concepts and principles of programmable logic controllers (PLCs) that include the basics of ladder logic and function block programming, discrete input and output field device connections, as well as troubleshooting software, hardware, communications and other PLC related equipment.	6
	LCC METD 150	4	I have been trained in industrial blueprint reading and concepts in orthographic projection, with emphasis on interpretation of engineering drawings that include measurement systems, technical sketching, dimensioning, sectional and auxiliary views, and tolerancing.	5
	LCC METM 108	5	I have been trained in machine tool principles used in industry.	4
	LCC METS 110	6	I have been trained in theory and industrial application of power transmission gear drive systems, chain drive systems, belt drive systems, couplings, clutch and brake and more.	5
	LCC METS 125	7	I have been trained in the theory of basic hydraulic and pneumatic principles as they relate to automated systems, which include application of components, causes of malfunctions in the system, and system troubleshooting strategies.	5
	LCC METS 260	8	I have been trained in basic robotic knowledge to include robot vision systems, robot safety zones and interlocks, and advanced programming.	6
	LCC WELD 110	9	I have been trained in the technical understanding and applications of gas metal arc welding and flux cored arc welding to include fundamentals, safety, equipment adjustments, metal transfers and shielding gases.	5
	LCC ELTE 108	10	I have at least 32 hours of lab time using meters to measure and confirm the relationships between voltage, current, resistance, and power in studied circuits.	6
	LCC ELTE 108	11	I have knowledge of electricity licensing law.	6
	FCA job posting	12	I have passed the International Society of Certified Technician exam.	10
	LC METS 102 & GM job posting	13	I have been trained in industrial workplace local, state and federal safety regulations.	4
	LCC ELTE 260	14	I can use Allen Bradley control technology.	9
	LCC ELTE 260	15	I can use Siemens control technology.	9
	Ford job posting	16	I can operate Square D control technology.	9
	Ford job posting	17	I can operate Control Logix control technology.	9
	Ford job posting	18	I can operate Fanuc robotic systems and equipment.	9
	Ford job posting	19	I can operate ABB robotic systems and equipment.	9

Table 24 (cont'd)

	Ford job posting	20	I can operate Kawasaki robotic systems and equipment.	9
	FCA job posting	21	I can operate Comau robotic systems and equipment.	9
	FEV- HEV & EV job posting	22	I can build High-Voltage and Low-Voltage electrical wiring.	9
	FEV- HEV & EV job posting	23	I can build junction boxes, power distribution boxes and fuse boxes.	9
	FEV- HEV & EV job posting	24	I have knowledge of High-Voltage safety of batteries and electrical wiring.	8
	FEV- HEV & EV job posting	25	I have a strong knowledge in High-Voltage and Low-Voltage electrical design system.	8
	FEV- HEV & EV job posting	26	I am well-versed in designing electrical wiring schematics for safe system integration.	8
	FEV- HEV & EV job posting	27	I have been trained in High-Voltage system implementation.	8
	FEV- HEV & EV job posting	28	I have strong knowledge in automotive Network design (CAN, LIN, FlexRay, and Ethernet)	8
	FEV- HEV & EV job posting	29	I have strong knowledge in E-motor and battery systems.	9
	FEV- HEV & EV job posting	30	I have strong knowledge in Hybrid and EV system architecture design (P0-P4, Parallel-Series).	9
	FEV- HEV & EV job posting	31	I have strong knowledge in E-motor testing and Battery testing according to standards.	6
	FEV- HEV & EV job posting	32	I have knowledge of vehicle control system requirements.	6
	FEV- HEV & EV job posting	33	I have knowledge of engine and vehicle controls interface.	7
	FEV- HEV & EV job posting	34	I can use Poweranalyzer, Multimeter, Cable crimpers, Cable cutters, and Plyer Cutters.	9
	FEV- HEV & EV job posting	35	I can use a Soldering iron, E3 wireworks and Visio for schematic development.	9
	FEV- HEV & EV job posting	36	I have intermediate level knowledge of Microsoft office.	9
	FCA job posting	37	I have intermediate level knowledge of Google Suite software.	5
				269
			Comments:	

Table 24 (cont'd)

CommCollProg3 - nominal		32 connect to 25c	**Computer Aided Design and Vehicle Design Option/Industrial Computer Graphics**	
	LCC METD 110	1	I have been trained in advanced drafting and design techniques needed to project successive auxiliary views from various orthographic views that include layout and design concepts.	4
	LCC METD 130	2	I have been trained in the principles and methods of dimensioning and tolerancing for specific design requirements on engineering drawings that include uniform practices for stating and interpreting these requirements will be stressed.	4
	LCC METD 130	3	I am knowledgeable on the ASME/ANSI M14.5Y 1994 standards.	5
	LCC METD 150	4	I have been trained in industrial blueprint reading and concepts in orthographic projection, with emphasis on interpretation of engineering drawings that include measurement systems, technical sketching, dimensioning, sectional and auxiliary views, and tolerancing.	4
	LCC METD 220	5	I have been trained in the fundamentals of the Unigraphics System of interactive design that covers comprehensive CAD concepts of 2-D and 3-D construction and basic solid modeling, as well as some of the concepts of drafting.	5
	LCC METM 108	6	I have been trained in the machine tool principles used in industry, which include safety, measurement, and procedures will be used to complete projects.	4
	LCC METM 190	7	I have been trained in the science of metallurgy, a domain of materials science that studies the physical and chemical behavior of metallic elements. I have the working knowledge of the properties, uses and heat treat processes of commonly used metals and alloys.	4
	LCC METM 195	8	I have been trained in the science of precision measurement, focusing on accuracy and application as well as problem solving as it relates to dimensional metrology, which includes measurement processes and feasibility, industry standards, quality systems, calibration systems, and Statistical Process Control.	4
	LCC METS 115	9	I have been trained in the theory and selection criteria for mechanical power systems, which include pneumatics, hydraulics, mechanical drives, and fundamentals and real-life applications in designing basic systems.	4
	OCC CAD 2602	10	I have been trained in the automotive-based approach to developing a typical vehicle underbody, which includes the creation of individual component parts, designed assemblies, positioned, analyzed, and multiple components within the full underbody assembly.	5

Table 24 (cont'd)

	OCC CAD 2702	11	I have been trained in surfacing scenarios related to different design situations encountered. I can create new parts from information such as: sections and reference surfaces; scan data; and modification of existing surfaces.	5
	OCC CAD 2702	12	I am knowledgeable of the methodology of adding such features as flanges, stiffeners and holes and the extensive use of Freestyle and Generative Shape Design workbench programs.	5
	LCC METD 111	13	I am knowledgeable of Autodesk AutoCAD software.	6
	LCC METM 195	14	I can operate the Coordinate Measuring Machine.	9
	LCC METM 220	15	I am knowledgeable of Mastercam software.	6
	OCC CAD 2602	16	I am knowledgeable of CATIA software.	6
	NX-CAM info.	17	I am knowledgeable of Siemens PLM Software NX.	6
	Audie job posting	18	I am knowledgeable of die design.	6
	Audie job posting	19	I am knowledgeable of surface geometry.	6
	Audie job posting	20	I can surface Class "A" large surface panels.	6
	Audie job posting	21	I have knowledge of die construction tools and machinery.	9
	Amer Axle job posting	22	I have intermediate level knowledge of Microsoft office.	5
	FCA job posting	23	I have intermediate level knowledge of Google Suite software.	5
				123
			Comments:	
CommCollProg4 - nominal		33 connect to 25d	**Industrial Maintenance Technology**	
	LCC METD 150	1	I have been trained in industrial blueprint reading and concepts in orthographic projection, with emphasis on interpretation of engineering drawings that include measurement systems, technical sketching, dimensioning, sectional and auxiliary views, and tolerancing.	4

Table 24: Student Survey (continued)

	LCC METS 102	2	I am knowledgeable of industrial workplace local, state and federal safety regulations.	4
	LCC METS 130	3	I have been trained in industrial hydraulics, which includes the theory of fluid power and circuits covering pumps, pressure valves, flow valves, cylinders, filters and motors, etc.	4
	LCC WELD 103	4	I have been trained in the safe operations and applications of oxyacetylene welding, torch cutting, plasma cutting, brazing and shielded metal arc welding.	4
	FCA job posting	5	I have passed the International Society of Certified Technician exam.	10
	LCC METS 130	6	I have 64 or more lab hours in industrial topics.	6
	LCC WELD 103	7	I have 32 hours or more in welding techniques.	6
	Amer Axle job posting	8	I can operate CNC machines and presses.	9
	Amer Axle job posting	9	I have knowledge of welding, sheet metal fabrication and pipe fitting combined.	7
	Amer Axle job posting	10	I can troubleshoot lube and grease systems.	7
	Amer Axle job posting	11	I can repair, rebuild or setup mechanical gear box assemblies.	7
	LCC ELTE 260	12	I can operate Allen Bradley control technology.	9
	LCC ELTE 260	13	I can operate Siemens control technology.	9
	Ford job posting	14	I can operate Square D control technology.	9
	Ford job posting	15	I can operate Control Logix control technology.	9
	Ford job posting	16	I can operate Fanuc robotic systems and equipment.	9
	Ford job posting	17	I can operate ABB robotic systems and equipment.	9
	Ford job posting	18	I can operate Kawasaki robotic systems and equipment.	9
	FCA job posting	19	I can operate Comau robotic systems and equipment.	9
	Amer Axle job posting	20	I have intermediate level knowledge of Microsoft office.	5
	FCA job posting	21	I have intermediate level knowledge of Google Suite software.	5
	WIN Report	22	I am Six Sigma Green Belt certified.	10
	WIN Report	23	I am Six Sigma Black Belt certified.	10
				170
			Comments:	

Table 24 (cont'd)

CommCollProg5 - nominal		34 connect to 25e	**Industrial Electronics Technology/Electrical Technology**	
	Wash ELE 134	1	I have been trained in the theory and application of AC and DC electrical machines and their controls, which include DC generators, DC motors and controls, three-phase power, three-phase transformers, alternators, three-phase and single phase AC motors and controls, electronic motor drives, synchronous motors, servo motors and stepper motors.	4
	Wash ELE 134	2	I can read and interpret schematic diagrams, connect motors and controls, test and troubleshoot motors and controls.	5
	Wash ELE 204	3	I have been trained on the National Electrical Code as a tool to plan the safe installation of electrical equipment in industrial locations. I can determine the required number and sizes of branch circuits, conductors, fuses, raceways and boxes.	6
	Wash ELE 204	4	I have knowledge of grounding, motor circuits and controls, local codes, and code changes.	6
	LCC ELTE 108	5	I have been trained in direct current electrical theory, which covers series, parallel and combination circuits.	4
	LCC ELTE 121	6	I have been trained in electrical mathematics, which has algebra, vector algebra and trigonometry to solve DC and AC electric circuit problems. I know units, Ohm's Law, network analysis, series parallel and combination DC and AC circuits, inductance, capacitance, AC power relationships and power factor correction.	6
	LCC ELTE 122	7	I have been trained in solid-state circuitry used in industry. I am knowledgeable of diodes, transistors, SCRs, triacs, optical isolators, transducers, power circuits, etc.	5
	LCC ELTE 132	8	I have been trained in the construction of an industrial control panel, which includes layout, assemble, wire, connect, troubleshoot and operate an industrial control panel for an oscillating table drive.	5
	LCC ELTE 232	9	I have been trained with larger and more complex machine control diagrams, automation interlocking, automatic continuous cycling of machinery, variable speed motor drives, design of control circuits for more complex machines, and the use of AutoCAD for drawing electrical schematics.	6
	LCC ELTE 260	10	I have been trained in the concepts and principles of programmable logic controllers (PLCs), which include the basics of ladder logic and function block programming, discrete input and output field device connections, as well as troubleshooting software, hardware, communications and other PLC related equipment.	6
	LCC METS 115	11	I have been trained in the theory and selection criteria for mechanical power systems, which include pneumatics, hydraulics, mechanical drives, and fundamentals and real-life applications in designing basic systems.	4

Table 24 (cont'd)

	LCC METS 160	12	I am an expert on industrial robot fundamentals with regards to safety, types, applications, programming, operation, and troubleshooting.	5
	LCC ELTE 122	13	I have 64 lab hours or more that include oscilloscope usage.	8
	LCC ELTE 122	14	I am knowledgeable of Boolean algebra and digital circuits.	9
	LCC ELTE 260	15	I can operate Allen Bradley control technology.	9
	LCC ELTE 260	16	I can operate Siemens control technology.	9
	Ford job posting	17	I can operate Square D control technology.	9
	Ford job posting	18	I can operate Control Logix control technology.	9
	Ford job posting	19	I can operate Fanuc robotic systems and equipment.	9
	Ford job posting	20	I can operate ABB robotic systems and equipment.	9
	Ford job posting	21	I can operate Kawasaki robotic systems and equipment.	9
	FCA job posting	22	I can operate Comau robotic systems and equipment.	9
	FCA job posting	23	I have passed the International Society of Certified Technician exam.	10
	Wash ELE 134	24	I have passed the State of Michigan Journeyman Electrician Licensing Exam.	10
	GM job posting	25	I have been trained in industrial workplace local, state and federal safety regulations.	4
	FEV- HEV & EV job posting	26	I can build High-Voltage and Low-Voltage electrical wiring.	9
	FEV- HEV & EV job posting	27	I can build junction boxes, power distribution boxes and fuse boxes.	9
	FEV- HEV & EV job posting	28	I have knowledge of High-Voltage safety of batteries and electrical wiring.	8
	FEV- HEV & EV job posting	29	I have a strong knowledge in High-Voltage and Low-Voltage electrical design system.	8
	FEV- HEV & EV job posting	30	I am well-versed in designing electrical wiring schematics for safe system integration.	8
	FEV- HEV & EV job posting	31	I have been trained in High-Voltage system implementation.	8
	FEV- HEV & EV job posting	32	I have strong knowledge in automotive Network design (CAN, LIN, FlexRay, and Ethernet)	8
	FEV- HEV & EV job posting	33	I have strong knowledge in E-motor and battery systems.	8

Table 24 (cont'd)

	FEV- HEV & EV job posting	34	I have strong knowledge in Hybrid and EV system architecture design (P0-P4, Parallel-Series).B346:B347	8
	FEV- HEV & EV job posting	35	I have strong knowledge in E-motor testing and Battery testing according to standards.	6
	FEV- HEV & EV job posting	36	I have knowledge of vehicle control system requirements.	6
	FEV- HEV & EV job posting	37	I have knowledge of engine and vehicle controls interface.	7
	FEV- HEV & EV job posting	38	I can use Poweranalyzer, Multimeter, Cable crimpers, Cable cutters, and Plyer Cutters.	9
	FEV- HEV & EV job posting	39	I can use a Soldering iron, E3 wireworks and Visio for schematic development.	9
	FEV- HEV & EV job posting	40	I have intermediate level knowledge of Microsoft office.	5
	FCA job posting	41	I have intermediate level knowledge of Google Suite software.	5
				296
			Comments:	
CommCollProg6 - nominal		35 connect to 25f	**Machine Tool Technology/Manufacturing Engineering Technology/Computer Numerical Control/Engineering Technologist Manufacturing**	
	OCC MTT1100	1	I have been trained in the practical application of machine hand tools through text materials and performance objectives. Beginning with simple operations such as layout, cutting, drilling, filing, and tapping objectives.	4
	OCC MTT1100	2	I have been trained on simple operations on the lathe, band saw and the milling machine.	4
	LCC METD 150	3	I have been trained in industrial blueprint reading and concepts in orthographic projection, with emphasis on interpretation of engineering drawings that include measurement systems, technical sketching, dimensioning, sectional and auxiliary views, and tolerancing.	5

Table 24 (cont'd)

	OCC MTT1200	4	I have been trained in the practical application of machine set up and operation through related projects, text materials and performance objectives such as mill tramming and alignment as well as setup of auxiliary devices that include rotary tables, super spacers, vises, angle plates, and boring heads and lathe setups that have 3-jaw universal chucks, 4-jaw chuck, between centers, and offset tailstock.	4
	OCC MTT1300	5	I have been trained in advanced skills in machine tool operation, which include more complex machining operations on the surface grinder, OD grinder, lathe, and vertical mill.	4
	OCC MTT1400	6	I have been trained in manufacturing processes such as safety, materials, machining, welding, casting, forging, forming, molding, design, inspection, quality, just-in-time manufacturing, lean manufacturing and automation.	4
	OCC MTT2100	7	I have knowledge of CNC programming including coordinating systems and G & M codes.	5
	OCC MTT2200	8	I have been trained in G and M code manual programming of CNC mills and lathes and can create programs for many processes such as drilling, milling, turning, facing, grooving, tapping, threading, and boring.	5
	OCC MTT2300	9	I have been trained the basics of Computer Aided Machining (CAM) as it relates to the machine tool metal cutting industry and have the techniques to prepare design for machining 2D and 3D contour products.	5
	OCC MTT2400	10	I have knowledge of jig & fixture assemblies as it relates to the manufacturing industry and can develop techniques to design and machine rigid, repeatable, and robust fixturing for holding parts to perform various manufacturing operations.	5
	OCC CAD 1050	11	I have been trained in the principles of Geometric Dimensioning and Tolerancing (GD&T) as applied to engineering design, manufacturing and quality control, which includes geometric concepts and standards used to communicate engineering design intent and to provide a basis for design and productions.	4
	OCC CAD 1050	12	I have been trained in national and international geometric standards of symbols and terms, datum feature modifiers, types of tolerances, datum reference frames, material boundary modifiers and other related topics.	4

Table 24 (cont'd)

	OCC CAD 1050	13	I have been trained in the concepts of basic part print reading as it relates to GD&T.	4
	OCC CAD 1101	14	I have been trained in computer aided design techniques and principles to create drawings related to various architectural, mechanical, interior layout, landscape, and other applications, which include the basic concepts of three-dimensional modeling, design modification, basic computing, and the system hardware and software related to CAD and rapid prototyping.	4
	OCC CAD 1501	15	I have knowledge of Fusion 360 Design	5
	MATH	16	Load LCC MATH 121, 122, 151, and 152	8
	OCC MSE 1000	17	I have knowledge of the theory and practice of metallurgy, including the nature, manufacturing and principles of heat-treated metals, which include material structure at the molecular level, including exposure to nanotechnologies as they relate to the scientific changes being explored in forming composite materials.	4
	OCC ROB 1500	18	I have knowledge of robotic and automated systems technology, which includes basic manufacturing techniques, robot terminology, different types of automation, safety, basic robotic programming, interfacing robotic communications, automated work cells, and robotic applications.	4
	OCC WEL 1000	19	I am learned a general overview of welding, and the various processes used in order to prepare for industry certifications and safety in welding, basic electricity used in welding, different weld joints and positions, and an introduction to metallurgy.	4
	OCC WEL 1000	20	I can perform various welds in the flat and horizontal positions using the processes GMAW, GTAW, SMAW, and STELLANTISW.	4
	OCC MTT2100	21	I have been trained in the fundamental CNC concepts of tool and work offsets, machine setup, and basic machine maintenance through text materials, demonstrations, and hands on activities and can display a working knowledge of CNC programming including coordinating systems and G & M codes.	5
	OCC MTT2100	22	I have passed the NIMS (National Institute for Metalworking Skills) certification exam.	10
	LCC METD 111	23	I have passed the MSSC (Manufacturing Skills Standards Council) certification.	6
	LCC METM 195	24	I am knowledgeable of Autodesk AutoCAD software.	9

Table 24 (cont'd)

	LCC METM 220	25	I can operate the Coordinate Measuring Machine.	6
	OCC CAD 2602	26	I am knowledgeable in Mastercam software.	6
	Audie job posting	27	I am knowledgeable of CATIA software.	6
	Audie job posting	28	I am knowledgeable of die design.	6
	Audie job posting	29	I am knowledgeable of surface geometry.	6
	Audie job posting	30	I can surface Class "A" large surface panels.	6
	Audie job posting	31	I have knowledge of die mechanics.	6
	Amer Axle job posting	32	I have knowledge of die construction tools and machinery.	5
	FCA job posting	33	I have intermediate level knowledge of Microsoft office.	5
		34	I have intermediate level knowledge of Google Suite software.	5
	WIN Report	35	I am Six Sigma Green Belt certified.	10
	WIN Report	36	I am Six Sigma Black Belt certified.	10
				197
			Comments:	
CommCollProg7 - nominal		36 connect to 25g	**Electrical/Electronics Engineering Technology**	
	MCC ELEC 1161	1	I have been trained in the theory and practical experimentation in the following areas as applied to D.C. circuits: Series, Parallel, and Series-Parallel circuits. I can use meters to measure and evaluate signals and operating voltages; identify basic electronic components as they relate to actual and schematic symbols, Ohm's Law, Watt's Law, Kirchhoff's Laws, and the Superposition Theorem.	6
	MCC ELEC 1171	2	I have been trained in the theory and experimentation in the following areas as applied to A.C. circuits: alternators, sine waves, capacitance, inductance, RC, RL and RCL series and parallel circuits, phase shift and filter, phase lead and lag circuits.	6
	MCC ELEC 1171	3	I can use meters, the oscilloscope, and the function generator.	5

Table 24 (cont'd)

	MCC TMTH 1150	4	I have been trained in basic algebra, formula transposition, scientific notation (powers of 10), trigonometry, special products and factoring; application of algebra and formulas to solving network simplification; simultaneous equations; resistive D.C. circuits and reactive A.C. circuits (inductive and captive).	7
	MCC ELEC 1182	5	I have been trained in the knowledge required to understand and troubleshoot electronic circuits containing diodes, transistors, FETs, and MOSFETs; Thevenin's Theorem, semiconductor theory, half-wave and full-wave rectifiers, transistor biasing circuits, FET and MOSFET biasing.	7
	MCC ELEC 1192	6	I have been trained in theory and practical experimentation using the following electronic devices: BJT, SCR, UJT, PUT, Triac, Diac, Four Layer Diode, SUS, SBS, Op-amps, and optoelectronic devices. I have knowledge of circuit designs, which include amplitude control, phase shift control, relaxation oscillators inverting, and non-inverting amplifiers.	7
	MCC ELEC 1211	7	I have the knowledge required to understand and troubleshoot digital electronic circuits; number systems, codes, logic gates, Boolean statements, combinational logic, flip-flops, counters, shift registers, memory and storage, and integrated circuit technologies.	7
	MCC ELEC 1221	8	I have the knowledge required to understand, program, and apply microcontrollers (pic chips) to robotic applications using the Basic Stamp.	7
	MCC ELEC 1221	9	I can program and interface simple circuitry using the Basic Stamp interface board.	7
	MCC ELEC 2270	10	I have been trained in the concepts of microcontroller programming including instruction sets, loops, software delays and data structures.	7
	MCC ELEC 1221	11	I can operate a mobile robot with onboard sensors. I am knowledgeable of pic chip programming, controlling inputs and outputs, motion and rotational control, digital displays, measurement of light, frequency and sound, controlling servo motors, robotic navigation, tactile sensing, light sensitive navigation, and robotic control with distance detection.	7
	MCC ELEC 2005	12	I have been trained in the theory and practical experimentation dealing with discrete transistor amplifiers and basic operational amplifier circuits; Voltage, Power, CC and CB amplifiers as well as inverting, non-inverting, differential, and summing op-amp amplifiers.	7
	MCC ELEC 2010	13	I have been trained in the theory and application of the following devices and topics: Thevenin's Theorem, operational amplifiers, passive and active filters, loading, oscilloscope operation and the following transducers: I.C. temperature, thermistor, RTD, thermocouple, capacitance sensor, strain gauge, LVDT and others.	7

Table 24 (cont'd)

	MCC ELEC 2490	14	I have been trained on operational amplifier applications, passive and active filters, voltage compositors, phase-locked-loop and data acquisition.	7
	MCC ELEC 2400	15	I have been trained in the interfacing the microcomputer in serial and parallel format, which include handshake control, PIA, ACIA, UARTS, AD and DA conversions, interfacing the microcomputer to TTYs CRTs Modems, floppy disks, dynamic and static memories, and electrical/mechanical devices.	7
	MCC ELEC 1161	16	I have been trained in an electronic software program applied in various circuits.	6
	MCC ELEC 1161	17	I can use scientific calculators.	5
	MCC ELEC 1211	18	I can use virtual circuit software.	6
	MCC ELEC 2010	19	I can use Electronics Workbench to simulate electronic circuits and instrumentation.	6
	MCC ELEC 2150	20	I can use the LabVIEW graphical system design platform.	5
	Wash ELE 134	21	I have passed the State of Michigan Journeyman Electrician Licensing Exam.	10
	FCA job posting	22	I have passed the International Society of Certified Technician exam.	10
	GM job posting	23	I have been trained in industrial workplace local, state and federal safety regulations.	4
	FEV- HEV & EV job posting	24	I can build High-Voltage and Low-Voltage electrical wiring.	9
	FEV- HEV & EV job posting	25	I can build junction boxes, power distribution boxes and fuse boxes.	9
	FEV- HEV & EV job posting	26	I have knowledge of High-Voltage safety of batteries and electrical wiring.	8
	FEV- HEV & EV job posting	27	I have a strong knowledge in High-Voltage and Low-Voltage electrical design system.	8
	FEV- HEV & EV job posting	28	I am well-versed in designing electrical wiring schematics for safe system integration.	8
	FEV- HEV & EV job posting	29	I have been trained in High-Voltage system implementation.	8
	FEV- HEV & EV job posting	30	I have strong knowledge in automotive Network design (CAN, LIN, FlexRay, and Ethernet)	8
	FEV- HEV & EV job posting	31	I have strong knowledge in E-motor and battery systems.	9
	FEV- HEV & EV job posting	32	I have strong knowledge in Hybrid and EV system architecture design (P0-P4, Parallel-Series).B346:B347	9

Table 24 (cont'd)

	FEV- HEV & EV job posting	33	I have strong knowledge in E-motor testing and Battery testing according to standards.	6
	FEV- HEV & EV job posting	34	I have knowledge of vehicle control system requirements.	6
	FEV- HEV & EV job posting	35	I have knowledge of engine and vehicle controls interface.	7
	FEV- HEV & EV job posting	36	I can use Poweranalyzer, Multimeter, Cable crimpers, Cable cutters, and Plyer Cutters.	9
	FEV- HEV & EV job posting	37	I can use a Soldering iron, E3 wireworks and Visio for schematic development.	9
	FEV- HEV & EV job posting	38	I have intermediate level knowledge of Microsoft office.	5
	FCA job posting	39	I have intermediate level knowledge of Google Suite software.	5
				276
			Comments:	
CommCollProg8 - nominal		37 connect to 25h	**Computer Information Systems - Software Engineering/Software Testing**	
	OCC CIS 1200	1	I have been trained on the fundamentals of database systems, which include the basics of database vs. file management systems; functions, components, and personnel involved in a database; database, client-server, and transaction processing architectures; and relational data models and operations.	4
	OCC CIS 1200	2	I have been trained in business requirements analysis, perform data definition, manipulation, and queries using basic SQL, create forms and reports; and can analyze macros, procedures and triggers.	4
	OCC CIS 1200	3	I have been trained in concepts of database planning, design, and administration fundamentals, data warehousing, and data mining.	4
	OCC CIS 1300	4	I have been trained in communications hardware and the interconnection of servers and clients within LANs and WANs that include network architectures, standards, protocols and access methods used within intranets and the Internet.	4
	OCC CIS 1300	5	I have been trained on the functions of network operating systems such as Windows Server, Unix, and Novell NetWare, centralized computing, client/server and peer-to-peer environments, their services and their program-to-program communication protocols , data security and system component protection.	4

Table 24 (cont'd)

	OCC CIS 1420	6	I have been trained in developing web pages by designing, entering, and testing code using this standard (with a simple text editor) rather than by using web development tools, which include - HTML5 element structure, web forms, multimedia, style sheets (CSS3) to apply formatting and layout characteristics in addition to applying special effects.	4
	OCC CIS 1440	7	I have been trained in the fundamentals of JavaScript as a client-side scripting language for the purpose of developing dynamic Web-based applications that run within a Web browser. I have knowledge of on programming techniques and Web technology, which include functions, data types, operators, strings, arrays, control structures, form validation, event handling, the Document Object Model, and debugging.	4
	OCC CIS 1500	8	I have been trained in the fundamental techniques and syntax for understanding, designing, constructing, debugging, and testing object-oriented programs by studying the Java programming language.	4
	OCC CIS 1500	9	I have been trained in the structured programming basics of process, selection and iteration, primitive and complex data typing, methods, parameters and input/output; the basics of graphical user interface (GUI) programming such as event handling, windows and widgets.	4
	OCC CIS 1512	10	I have been trained on formal methods and approaches used in the design, development, testing and maintenance of computer software and each stage of the software development life cycle (SDLC), which include low-level design, high-level design, modeling with UML (Unified Modeling Language), iterative development models, rapid application development (RAD), formal testing methods, incremental deployment, formal metrics, and appropriate use of associated tools.	4
	OCC CIS 2111	11	I have been trained in the techniques used by system analysts and programmers in the analysis and design of computer-based business information systems with focus on the Unified Modeling Language (UML), which include system and object-oriented development life cycles (SDLC and ODLC) and subjects in computer-aided software engineering (CASE) such as project management, requirements modeling, data flow and entity relationship diagrams (DFD and ERD) and data dictionaries.	6
	OCC CIS 2151	12	I have been trained with the techniques and structures used to solve these problems with the Java language, which include exception handling, file input and output, composition, inheritance, polymorphism, abstract classes and interfaces, Advanced Graphic User Interface (GUI) design and implementation techniques.	6
	OCC CIS 2252	13	I have been trained in the syntax and semantics of the ANSI C++ language, which include control structures, arrays, pointers, strings, dynamic memory management, class definition and object-based development, file I/O, overloading, exception handling, and template libraries.	6

Table 24 (cont'd)

	OCC CIS 2353	14	I have been trained in the programming techniques and theories involved in implementing linked lists, queues, stacks and tree structures, recursion, searching techniques and sorting algorithms.	5
	OCC CIS 2991	15	I have been trained in special topics such as development of material for a personal 'software' portfolio that may be used to support employment opportunity applications to become a software developer.	5
	OCC CIS 2151	16	I have been trained in complicated programming problems and techniques and structures used to solve these problems with the Java language, which include exception handling, file input and output, composition, inheritance, polymorphism, abstract classes and interfaces, and Advanced Graphic User Interface (GUI) design and implementation techniques.	5
	OCC CIS 2454	17	I have been trained in Web application architecture; design patterns and application frameworks; PHP language basics; Java technologies for server-side Web development; database access; Extensible Markup Language (XML) and Asynchronous JavaScript and XML (AJAX)-based request processing; and Web application security.	5
	OCC CIS 2616	18	I have been trained in design and development of database applications using Oracle PL/SQL, Oracle development tools, and use of Oracle XML data types for implementation of PL/SQL programs, procedures, functions, packages, and triggers.	5
	OCC CIS 2616	19	I have passed the Oracle Program with PL/SQL exam to become an Oracle Certified Associate or Oracle Certified Professional.	10
	OCC CIS 2818	20	I have been trained in the design and implementation of wireless handheld application software on the Android platform for business and personal use, that includes the use of the Android Studio integrated development environment (IDE) to develop and test application software.	6
	Ford job posting	21	I am knowledgeable and can develop an infotainment feature technology, such as navigation, voice recognition, media phone, or a similar technology.	7
	Ford job posting	22	I have been trained in Bluetooth Technology.	6
	Ford job posting	23	I have been trained in USB Technology.	6
	Ford job posting	24	I have been trained in WiFi Technology.	6
				124
			Comments:	
CommCollProg9 - nominal		38 connect to 25i	**Pre-Engineering/Physics/Chemistry**	

Table 24 (cont'd)

	OCC ENGR 1000 (used description but no degree prog)	1	I have been trained in engineering problems and methods of finding solutions, manipulation and computation of data and results, and applied engineering concept.	4
	LCC MATH 151	2	I have been trained in calculus, which includes limits, continuity, and derivatives of algebraic, trigonometric, exponential and logarithmic functions; linear approximation; L'Hopital's rule; Riemann sums; integration using substitution; and the fundamental theorem of calculus.	7
	LCC MATH 152	3	I have been trained in intermediate calculus, which includes techniques and applications of integration, improper integrals, sequences and infinite series, power series representation of functions, vectors, lines, planes, and 3D rectangular system.	8
	LCC MATH 253	4	I have been trained in advanced calculus, which includes multivariable calculus and vector analysis. I can solve problems with vector algebra, curves and surfaces in 3D-space, vector valued functions, partial derivatives, multiple integrals, vector fields, line integrals, and surface integrals.	9
	LCC MATH 254	5	I have been trained in differential equation, which includes the methods of undetermined coefficients, variation of parameters, series, Laplace transforms, and numerical methods.	10
	LCC MATH 260	6	I have been trained in linear algebra includes the study of systems of linear equations, matrix algebra, vector spaces, linear transformations, eigenvalues and eigenvectors, with applications.	10
	LCC CHEM 125	7	I have been trained in general chemistry from classroom instruction and laboratory course(s), which includes measurement, aqueous reactions, stoichiometry, thermochemistry, atomic structure, bonding, and acids and bases.	9
	MCC CHEM 1180	8	I have been trained in kinetics, chemical equilibrium of gaseous and aqueous environments, acid-base interactions, electrochemistry, nuclear chemistry, and coordination compounds.	9
	MCC CHEM 2260	9	I have been trained in the structure, nomenclature, preparation, and reactivity of aliphatic and aromatic compounds, including reaction mechanisms, stereochemistry, conformational analysis, and bonding theories. I also have knowledge of carbocation chemistry, functional groups and the principles of organic synthesis.	10
	MCC CHEM 2260	10	I have been trained in electrophilic and nucleophilic aromatic reactions. I have knowledge of the chemistry of the functional groups (alcohols, aldehydes, ketones, acids, acid derivatives, ethers, amines, thiols, etc.) with a continuing emphasis on mechanisms and organic synthesis, including the role of carbanions.	10
	LCC PHYS 260	11	I have been trained in the understanding of principles through the solution of problems in analysis of vectors, torques, trusses, resultants, machines, force systems, centroids and center gravity, equilibrium and friction.	10

Table 24 (cont'd)

	MCC ECON 1160	12	I have been trained in basic principles of economics with an emphasis on macroeconomic theory, which includes an analysis of national income, employment, and prices, and concludes with a discussion of monetary and fiscal policies.	4
	FCA job posting	13	I have been trained in C++ program language.	6
	FCA job posting	14	I have been trained in C program language	6
	FCA job posting	15	I have been trained in Python language.	6
	FCA job posting	16	I can develop software in Linux.	7
	FCA job posting	17	I have been trained in object-oriented development.	6
	FCA job posting	18	I have been trained with test driven SW methodology (unit test, Nunit, Gunit, Gtest)	6
	FCA job posting	19	I have the ability to interface with HiL testing, vehicle integration and validation engineering organizations.	6
	WCC CPS 121	20	I have passed the LPI Linux Essentials Certificate.	10
	LCC PHYS 251	21	I have been trained in forces and motion, momentum, work and energy, conservation laws of energy and momentum, rotational motion, static equilibrium, gravitation, and oscillations.	9
	LCC PHYS 252	22	I have been trained in electric and magnetic forces and fields, electromagnetic energy, currents and circuits, electromagnetic oscillations and waves, mechanical waves and sound, light waves, physical and geometrical optics.	10
	LCC PHYS 251	23	I have studied in a lab for 48 hours or more.	6
				178
			Comments:	
CommCollProg10 - nominal		39 connect to 25j	**Computer Information Systems - Programming in C++**	
	WCC CPS 171	1	I have been trained in programming using the C++ language, which includes sequential, decision and iterative control structures, functions, basic data structures and an introduction to classes.	6
	WCC CPS 171	2	I can write and execute approximately eight C++ programs.	6
	WCC CPS 121	3	I have been trained in the UNIX/Linux file system, communication with other users, editors, file manipulation and processing, basics of pipes and redirection, simple shell programming, and a basic introduction to Linux.	6

Table 24 (cont'd)

	WCC CPS 271	4	I have been trained in C++ by learning the object-oriented features of the language, which include classes, constructors and destructors, operator overloading, pointers, dynamic allocation of memory, inheritance, polymorphism, file manipulation, templates, and exceptions.	7
	WCC CPS 272	5	I have been trained in the C++ sequence and know more advanced computer science features as implemented in C++, which include advanced data structures, complexity/efficiency of algorithms, recursion and problem-solving.	7
	WCC CPS 276	6	I have been trained in building dynamic database-driven Web applications using PHP and MySQL.	7
	WCC CPS 298	7	I have simulated industrial experience of working in teams using version control software (GIT, GitHub) to manage projects, which includes the advantages and disadvantages of leading programming approaches like Agile Programming, Waterfall approach, Top-down programming and Paired developers.	7
	LCC CITP 110	8	I have been trained in Python as well. I know the fundamental techniques for understanding, designing, developing, and testing object-oriented programs through the use of scientific method, which include: structured program design; basic programming control structures; algorithm and logic design; functions; classes; methods; random number generators; user interface design; and working with data in files.	6
	LCC CITP 150	9	I have been trained in Visual Basic.NET programming as well. I can develop business applications by designing and creating a user interface and writing the necessary procedures.	6
	LCC CITP 180	10	I have been trained in Microsoft Visual Studio .NET as well. I know the C# .NET programming language by designing, implementing, and testing programming projects, which include creating and using methods and classes; inheritance; exception handling, and using controls.	6
	WCC CPS 121	11	I have passed the LPI Linux Essentials Certificate.	10
	WCC CPS 276	12	I have knowledge of Hyper Text Markup Language (HTML).	5
	WIN Report	13	I have been trained in MATLAB.	5
				84
			Comments:	

Table 24 (cont'd)

CommCollProg11 - nominal		40 connect to 25k	**Computer Information Systems - Programming in Java**	
	WCC CPS 161	1	I have been trained in Java programming language, which includes looping, conditional logic and string manipulation, and object-oriented concepts such as objects and classes, constructors, inheritance, and polymorphism.	6
	WCC CPS 261	2	I have been trained in Java concepts that include input/output, graphical user interfaces associated with AWT/Swing, data structures, networking, and multitasking (Threads).	7
	WCC CPS 276	3	I have been trained in building dynamic database-driven Web applications using PHP and MySQL.	7
	WCC CIS 282	4	I have been trained in contemporary database theory and practice, which includes terminology, database structures, SQL (structured query language), and NOSQL concepts and application.	7
	WCC CPS 278	5	I have been trained in Java Servlets, Java Server Pages (JSP), JSTL, Expression Language, Tag Libraries and Java Database Connectivity (JDBC).	7
	WCC CPS 121	6	I have been trained in the UNIX/Linux file system, communication with other users, editors, file manipulation and processing, basics of pipes and redirection, simple shell programming, and a basic introduction to Linux.	6
	WCC CPS 251	7	I have been trained Java to run on an Android smart phone or tablet, which includes Graphical User Interfaces, data storage, audio, databases, GPS and Google Maps.	7
	WCC CPS 298	8	I have simulated industrial experience of working in teams using version control software (GIT, GitHub) to manage projects, which includes the advantages and disadvantages of leading programming approaches like Agile Programming, Waterfall approach, Top-down programming and Paired developers.	7
	LCC CITP 110	9	I have been trained in Python as well. I know the fundamental techniques for understanding, designing, developing, and testing object-oriented programs through the use of scientific method, which include: structured program design; basic programming control structures; algorithm and logic design; functions; classes; methods; random number generators; user interface design; and working with data in files.	6
	LCC CITP 150	10	I have been trained in Visual Basic.NET programming as well. I can develop business applications by designing and creating a user interface and writing the necessary procedures.	6
	LCC CITP 180	11	I have been trained in Microsoft Visual Studio .NET as well. I know the C# .NET programming language by designing, implementing, and testing programming projects, which include creating and using methods and classes; inheritance; exception handling, and using controls.	6
	WCC CPS 121	12	I have passed the LPI Linux Essentials Certificate exam.	10

Table 24 (cont'd)

	WCC CPS 276	13	I have knowledge of Hyper Text Markup Language (HTML).	6
				88
			Comments:	
CommCollProg12 - nominal		41 connect to 25l	**Automotive Technology - Vehicle Development**	
	MCC AUTO 1000	1	I have been trained in the basic automotive components and general maintenance necessary for vehicle operation and have an understanding of Hybrid Electric Vehicle technology.	4
	MCC TMTH 1150	2	I have been trained in basic algebra, formula transposition, scientific notation (powers of 10), trigonometry, special products and factoring; application of algebra and formulas to solving network simplification; simultaneous equations; resistive D.C. circuits and reactive A.C. circuits (inductive and captive).	7
	MCC ELEC 1161	3	I have been trained in the theory and practical experimentation in the following areas as applied to D.C. circuits: Series, Parallel, and Series-Parallel circuits. I can use meters to measure and evaluate signals and operating voltages; identify basic electronic components as they relate to actual and schematic symbols, Ohm's Law, Watt's Law, Kirchhoff's Laws, and the Superposition Theorem.	6
	MCC ELEC 1171	4	I have been trained in the theory and experimentation in the following areas as applied to A.C. circuits: alternators, sine waves, capacitance, inductance, RC, RL and RCL series and parallel circuits, phase shift and filter, phase lead and lag circuits.	6
	MCC ELEC 1171	5	I can use meters, the oscilloscope, and the function generator.	5
	MCC ITCS 1140	6	I have been trained in computer programming and the detailed logic used to develop them. I am knowledgeable of various programming techniques, constructs, debugging methods and object-oriented concepts.	5
	MCC AUTO 1040	7	I have been trained in basic Electrical fundamentals including terminology, electrical circuits, Ohm's law, DVOM use, and wiring schematics.	4

Table 24 (cont'd)

	MCC AUTO 1200	8	I have been trained in rebuilding engines using engines, parts, precision measuring tools, and other related tools.	4
	MCC ELEC 1211	9	I have been trained in the knowledge required to understand and troubleshoot digital electronic circuits; number systems, codes, logic gates, Boolean statements, combinational logic, flip-flops, counters, shift registers, memory and storage, and integrated circuit technologies.	7
	MCC ELEC 1221	10	I have been trained in the knowledge required to understand, program, and apply microcontrollers (pic chips) to robotic applications using the Basic Stamp.	7
	MCC AUTO 1050	11	I have been trained in electrical testing tools, basic electronics,electric motors, and starting and charging systems.	4
	MCC AUTO 1130	12	I have been trained in automotive steering, suspension and alignments as well as diagnosis and service procedures	4
	MCC ELEC 2150	13	I can use the LabVIEW graphical system design platform.	5
	MCC ITNT 1500	14	I have been trained in basic principles and concepts of networking, which focuses on the terminology and technologies found in current networking environments and includes internetworking protocols and communication methods, network media, troubleshooting and configuration utilities, basics of network design and network management.	4
	MCC AUTO 1100	15	I have been trained in principles and theory of both disc and drum brake designs, with emphasis placed on inspection, parts replacement, diagnosis, use of specifications, special tools and machining operations.	4
	MCC PRDE 1250	16	I have been trained in the ability to read and interpret engineering drawings at the entry level, which include drawing terminology; title block; revision column; notes; dimensions and tolerances applications in types of lines; basic symbols; conventions; symmetry of assembly; detail working drawings; and isometric/3D, orthographic, auxiliary, and section views.	4
	MCC ELEC 2310	17	I have been trained in applied knowledge and hands-on skills in vehicle experimental testing, which include how to set up test procedures, wire up sensors for measurements, conduct experimental tests, record calibrated experimental data, and write test reports.	5

Table 24 (cont'd)

	MCC AUTO 2000	18	I have been trained in various technologies and systems that will enable automating various driving functions, connecting the automobile to sources of information that assist with this task, and allowing the automobile to make autonomous intelligent decisions concerning future actions of the vehicle that potentially impact the safety of the occupants.	6
	MCC ELEC 1161	19	I have been trained in an electronic software program applied in various circuits.	6
	MCC ELEC 1161	20	I can use scientific calculators.	5
	MCC ELEC 1211	21	I can use virtual circuit software.	6
	MCC ELEC 2010	22	I can use Electronics Workbench to simulate electronic circuits and instrumentation.	6
	MCC ELEC 2150	23	I can use the LabVIEW graphical system design platform.	5
	Wash ELE 134	24	I have passed the State of Michigan Journeyman Electrician Licensing exam.	10
	FCA job posting	25	I have passed the International Society of Certified Technician exam.	10
	GM job posting	26	I have been trained in industrial workplace local, state and federal safety regulations.	4
	FEV- HEV & EV job posting	27	I can build High-Voltage and Low-Voltage electrical wiring.	9
	FEV- HEV & EV job posting	28	I can build junction boxes, power distribution boxes and fuse boxes.	9
	FEV- HEV & EV job posting	29	I am well-versed in designing electrical wiring schematics for safe system integration.	8
	FCA job posting	30	I can manage test vehicle or dynamometer modifications, including electrical systems, design modifications, installations and commissioning/de-bug.	8
	FCA job posting	31	I can demonstrate programming and using RP systems for prototype I/O and control.	6
	FCA job posting	32	I have experience with vehicle & dynamometer development, including vehicle controls support, calibration tools, RP tools, data collection, complex system trouble shooting.	7
	FEV- HEV & EV job posting	33	I have strong knowledge in E-motor and battery systems.	9
	FEV- HEV & EV job posting	34	I have knowledge of vehicle control system requirements.	6
	FEV- HEV & EV job posting	35	I have knowledge of engine and vehicle controls interface.	7
	FEV- HEV & EV job posting	36	I have intermediate level knowledge of Microsoft office.	5

Table 24 (cont'd)

	FCA job posting	37	I have intermediate level knowledge of Google Suite software.	5
				222
			Comments:	
		42 connect to 25m	**Mechanical Systems**	
CommCollProg13 - nominal	LCC ELTE 108	1	I have been trained in direct current electrical theory, which covers series, parallel and combination circuits.	4
	LCC ELTE 131	2	I have been trained in wiring three-phase motor control circuits utilizing two- and three-wire control and machine control circuits utilizing limit and proximity switches, timers, relays, etc. I can identify correct symbols and standard construction of wiring and ladder diagrams.	4
	LCC METD 150	3	I have been trained in industrial blueprint reading and concepts in orthographic projection, with emphasis on interpretation of engineering drawings that include measurement systems, technical sketching, dimensioning, sectional and auxiliary views, and tolerancing.	4
	LCC METM 108	4	I have been trained in machine tool principles used in industry.	4
	LCC METS 102	5	I have been trained in industrial workplace local, state and federal safety regulations.	5
	LCC METS 110	6	I have been trained in theory and industrial application of power transmission gear drive systems, chain drive systems, belt drive systems, couplings, clutch and brake and more.	4
	LCC METS 120	7	I have been trained in the concepts, principles, and components of industrial pneumatic systems, which include gas laws, theory of air compression, regulators, filters, valves, actuators, electro-pneumatic and pneumatic circuits with emphasis on pneumatic diagrams and circuit design.	5
	LCC METS 130	8	I have been trained in industrial hydraulics, which includes the theory of fluid power and circuits covering pumps, pressure valves, flow valves, cylinders, filters and motors, etc.	5
	LCC METS 160	9	I have been trained in industrial robot fundamentals with regards to safety, types, applications, programming, operation, and troubleshooting	6
	LCC WELD 103	10	I have been trained in the safe operations and applications of oxyacetylene welding, torch cutting, plasma cutting, brazing and shielded metal arc welding.	4

Table 24 (cont'd)

	GM job posting	11	I have been trained in industrial workplace local, state and federal safety regulations.	4
	LCC METS 120 & LCC METS 160	12	I have at least 64 lab hours in pneumatic systems, robotics.	6
	LCC ELTE 260	13	I can operate Allen Bradley control technology.	9
	LCC ELTE 260	14	I can operate Siemens control technology.	9
	Ford job posting	15	I can operate Square D control technology.	9
	Ford job posting	16	I can operate Control Logix control technology.	9
	Ford job posting	17	I can operate Fanuc robotic systems and equipment.	9
	Ford job posting	18	I can operate ABB robotic systems and equipment.	9
	Ford job posting	19	I can operate Kawasaki robotic systems and equipment.	9
	FCA job posting	20	I can operate Comau robotic systems and equipment.	9
	FCA job posting	21	I have passed the International Society of Certified Technician exam.	10
	FEV- HEV & EV job posting	22	I have intermediate level knowledge of Microsoft office.	5
	STELLANTIS job posting	23	I have intermediate level knowledge of Google Suite software.	5
				147
			Comments:	
CommCollProg14 - nominal		43 connect to 25n	**Welding and Fabrication Technology**	
	LCC METM 190	1	I have been trained in the science of metallurgy, a domain of materials science that studies the physical and chemical behavior of metallic elements. I have the working knowledge of the properties, uses and heat treat processes of commonly used metals and alloys.	4
	LCC METM 190	2	I am knowledgeable about local, state and federal safety regulations.	6
	LCC WELD 102	3	I have been trained in the safe operations and applications of oxyacetylene welding, torch cutting, plasma cutting, brazing and shielded metal arc welding.	6

Table 24 (cont'd)

	LCC WELD 103	4	I have been trained in advanced welding to produce quality multiple pass fillet and groove welds on steel plates. I can use conventional and low hydrogen electrodes in preparation of passing performance tests in all positions. I am knowledgeable of destructive testing methods, weld profiles and welding symbols as related to arc welding.	7
	LCC WELD 105	5	I have been trained in the technical understanding and applications of gas metal arc welding and flux cored arc welding to include fundamentals, safety, equipment adjustments, metal transfers and shielding gases.	7
	LCC WELD 110	6	I have been trained with the skills, principles and applications of gas tungsten arc welding, which includes knowledge of the different thickness of ferrous and non-ferrous metals in all positions, proper material cleaning, fit up and safety.	5
	LCC WELD 111	7	I have been trained on a MIG welding robot through a teach pendant, edit programs, set weld schedules, and basic fixture building skills.	6
	LCC WELD 115	8	I am an expert in blueprint and welding symbols, metallurgy, welding processes, consumables and strict code enforcement.	6
	LCC WELD 125	9	I am an expert in **tool and die welding** theory and practice methods involved in welding various alloyed metals, preheating and postheating of metals, recognition of materials, alloying elements and their effects, the proper usage of air, oil and water hardening steels.	4
	LCC WELD 201	10	I have been trained in theory, cutting, fit up and practiced on different sizes of pipe using shielded metal arc welding. I know varied weld and base metal testing methods used to the strict code requirements and low hydrogen type electrodes in groove welds in the 2G, 5G, and 6G positions.	9
	LCC WELD 205	11	I am knowledgeable of the American Welding Society Structural Welding Code D1.1 applications and requirements.	6
	LCC	12	I have passed the Welding Certification exam.	10
	LCC	13	I have at least 64 lab hours utilizing welding techniques.	6
	All LCC WELD	14	My lab time included the use of a robot.	6
	LCC WELD 115	15	I can set-up and operate Poke-yoke apparatus.	9
	Venteion10 job posting	16	I can operate a lathe machine.	9
	Dowding Ind. Posting	17	I can change welding wire when required.	9
	Dowding Ind. Posting	18	I have intermediate level knowledge of Microsoft office.	5
	FEV- HEV & EV job posting	19	I have intermediate level knowledge of Google Suite software.	5

Table 24 (cont'd)

				125
			Comments:	
CommCollProg15 - nominal		44 connect to 25o	**IT- Cloud Computing/Applied Data Science**	
	MCC ITCS-1010	1	I have been trained in up-to-date information about hardware, software, the Internet, telecommunications and network systems, databases, commerce and transaction processing, and information and decision support systems.	4
	MCC ITNT-1500	2	I have been trained in the basic principles and concepts of networking, which include internetworking protocols and communication methods, network media, troubleshooting and configuration utilities, basics of network design and network management.	4
	MCC ITCS-1140	3	I have been trained in various programming techniques, constructs, debugging methods and object-oriented concepts.	4
	MCC ITOS-1710	4	I have been trained in the basic structure, functions, and tools of the Linux operating system, which include basic Linux commands, files and directories, text editing, pipes and filters, shell environment, and scripting.	4
	MCC ITCC-1000	5	I have been trained in the overall understanding of cloud computing concepts, which include cloud terminology, cloud service and deployment models, cloud security principles and the fundamentals of application deployment and operation in the cloud.	4
	MCC ITIA-1200	6	I have been trained in various elements of information systems security, which include information security planning, logical and physical security design, security plan implementation and administration, and legal and liability issues surrounding information systems.	4
	MCC ITIA-1200	7	I have knowledge in various security threats and know how to protect an organization against malicious attacks through processes that ensure confidentiality, availability, and data integrity.	4
	MCC ITCS-1250	8	I have been trained in syntax, input/output layout, testing, debugging, documentation, problem definition, loops, and decisions.	4
	MCC ITCS-1250	9	I have been trained in Microsoft C# program language.	6
	MCC ITWP-1000	10	I have been trained in the fundamental understanding of HTML for web page development, the utilization of CSS for web page layout and formatting, and the use of JavaScript for interactivity and covers current industry standards, processes and techniques.	6

Table 24 (cont'd)

	MCC ITCC-2000	11	I have been trained in how to provision compute, network, and storage web services.	5
	MCC ITCC-2000	12	I have knowledge of cloud security, high-availability, and automation tools used to manage cloud applications.	5
	MCC ITCC-2100	13	I have been trained in the fundamentals of cloud application development with an emphasis on web application communication and service-oriented architectures, which include microservice design, creation and consumption.	5
	MCC ITCC-2200	14	I have been trained in how to use various tools to create and deploy new and existing applications to the cloud and to use cloud monitoring tools to assess application performance.	5
	MCC ITCC-2300	15	I have been trained in cloud messaging services, Functions as a Service (FaaS), and continuous application integration and delivery.	5
	WCC CIS 285	16	I have been trained in the fundamental concepts of "Big Data" management and data science analytics, and know the challenges faced in dealing with massive volumes of available data as well as in proposing scalable solutions for them.	5
	MCC ITOS-1710	17	I have passed the Linux+ industry certification exam.	10
	FCA job posting	18	I have knowledge of Palantir Technologies.	9
	FCA job posting	19	I have knowledge of SQL Server Management Studio & Integration Services.	9
	FCA job posting	20	I have knowledge of DAX query & Power Pivot in Microsoft Excel.	5
				107
			Comments:	
CommCollProg16 - nominal		45 connect to 25p	**Computer Information Systems - Cybersecurity**	
	OCC CIS 1200	1	I have been trained on the fundamentals of database systems, which include the basics of database vs. file management systems; functions, components, and personnel involved in a database; database, client-server, and transaction processing architectures; and relational data models and operations.	4
	OCC CIS 1200	2	I have been trained in business requirements analysis, perform data definition, manipulation, and queries using basic SQL, create forms and reports; and can analyze macros, procedures and triggers.	4

Table 24 (cont'd)

	OCC CIS 1200	3	I have been trained in concepts of database planning, design, and administration fundamentals, data warehousing, and data mining.	4
	OCC CIS 1300	4	I have been trained in communications hardware and the interconnection of servers and clients within LANs and WANs that include network architectures, standards, protocols and access methods used within intranets and the Internet.	4
	OCC CIS 1300	5	I have been trained on the functions of network operating systems such as Windows Server, Unix, and Novell NetWare, centralized computing, client/server and peer-to-peer environments, their services and their program-to-program communication protocols , data security and system component protection.	4
	OCC CIS 1550	6	I have been trained in analyzing software risks, understanding likely points of application attack, and making preliminary decisions about how software applications mitigate attack.	4
	OCC CIS 1550	7	I can identify systemic threats in any deployment environment, understand the vulnerabilities of common software applications, and construct software that are responsive to identified vulnerabilities.	4
	OCC CIS 1610	8	I have been trained to make an analysis of database-related malware; data system architecture; database system installation and configuration; data access controls and authentication; data security tools and devices; and security testing and auditing.	4
	OCC CIS 1620	9	I have been trained in basic number theory and finite field arithmetic used in cryptography; symmetric ciphers; asymmetric ciphers; block and stream ciphers; implementation of popular encryption algorithms (e.g., AES); hash algorithms; digital signatures; and key management and distribution.	4
	OCC CIS 1630	10	I have knowledge of the security policies and frameworks, their organizational implications, to the psychology, ethics, and legal considerations of their implementation.	4
	OCC CIS 2111	11	I have been trained in the techniques used by system analysts and programmers in the analysis and design of computer-based business information systems with focus on the Unified Modeling Language (UML), which include system and object-oriented development life cycles (SDLC and ODLC) and subjects in computer-aided software engineering (CASE) such as project management, requirements modeling, data flow and entity relationship diagrams (DFD and ERD) and data dictionaries.	6
	OCC CIS 2434	12	I can install and administer a Linux/Unix operating system using a virtual machine software product.	9

Table 24 (cont'd)

	OCC CIS 2535	13	I have been trained on the Microsoft Windows Server operating system, which includes installation of network operating system, setup of users and groups, files and folder trustee rights, and console management.	7
	OCC CIS 2838	14	I have been trained to understand defenses against Reconnaissance, Scanning, Gaining Access, maintaining access and covering tracks. I also have knowledge of computer ethics.	7
	OCC CIS 2845	15	I have knowledge of forensic techniques and tools for both Windows and Linux investigations.	7
	OCC CIS 1600	16	I have passed the Security+ Exam.	10
	MCC website	17	I have passed the Certified Ethical Hacker (CEH) Exam.	10
	MCC website	18	I have passed the Symptoms Security Certified Practitioner Exam (SSCP)	10
				86
			Comments:	
CommCollProg17 - nominal		46 connect to 25q	**Plastics-Polymer Engineering Technology**	
	Penn PPT115	1	I have knowledge of the plastics industry, including materials and processes. Also, the nature of plastic product manufacturers, including size, work environment, and typical processes used.	4
	Penn PPT118	2	I have been trained in polymer processing techniques, including injection molding, extrusion, blow molding, rotational molding, and thermoforming.	4
	Penn PPT128	3	I have been trained in the principles of the structure, properties and applications of polymer materials, which include the nature of polymers, synthesis, formulation, and structure property relationships.	4
	Penn PPT129	4	I have been trained in the application of polymer testing methods and procedures, which include mechanical testing, rheological testing, and material identification. ASTM test methods were used as the basis for test procedures.	4

Table 24 (cont'd)

	Penn PPT160	5	I have been trained in thermoset and thermoplastic composite materials, polymers, reinforcements, processing techniques, tooling, properties, and emerging nanocomposite materials with applications in various markets such as sports, automotive, marine, construction, aircraft, medical, and electronics.	4
	GRCC MN 217	6	I have been trained in the fundamentals of moving fluid and hydraulic power, design of hydraulic pumps, operation of hydraulic valves, selection of cylinders, motors, accumulators, reservoirs, filters and the design of hydraulic circuits.	6
	Penn PPT248	7	I have been trained in plastics extrusion processing, including the fundamentals of extruder hardware and operation. Additionally, different extrusion types such as profile, pipe/tubing, blown film, co-extrusion, and twin-screw extrusion are covered.	6
	Penn PPT248	8	I can downstream equipment for take-off, cooling and calibration.	9
	Penn PPT251	9	I have been trained in the plastics blow molding processes that includes different molding methods such as extrusion, stretch blow, injection, and co-extrusion are detailed.	6
	Penn PPT251	10	My lab work included hands-on study of process and parison control, mold design, automation controls, and auxiliary equipment.	5
	Penn PPT220	11	I have hands-on skill application, performing maintenance on molds and dies used in plastics processing based on established procedures, which include the proper techniques for mold maintenance, print reading, documentation of wear, and the proper use of measuring and metrology equipment.	5
	Penn PPT235	12	I have knowledge of the theory and application of injection molding of consumer goods, which include development of part microstructure, the molecular level process from pellet to part, and the analysis of current trends in technology and consumer preference.	6
	Penn PPT235	13	I can set up and operate injection molding machines and troubleshoot part defects and dimensional problems.	9
	Penn PPT260	14	I have knowledge of the theory and application of rotational molding technology, which include rotational molding equipment, materials, part design, molds and tooling, and processing.	6

Table 24 (cont'd)

	Penn PPT260	15	I can set-up and basic troubleshoot rotational molding process equipment.	9
	Penn PPT270	16	I have knowledge of the theory and application of thermoforming technology, which include thermoforming equipment, materials, part design, and processing.	6
	Penn PPT270	17	I can set-up and basic troubleshoot thermoforming process equipment.	9
	Perf Plastics job posting	18	I can operate Fanuc robotic systems and equipment.	9
	Perf Plastics job posting	19	I can operate ABB robotic systems and equipment.	9
	Perf Plastics job posting	20	I can operate Kawasaki robotic systems and equipment.	9
	Perf Plastics job posting	21	I can operate Comau robotic systems and equipment.	9
				111
			Comment:	
CommCollProg18 - nominal		46 connect to 25r	**Other**	
			Please specify your program: _____	
	GM job posting	1	I have been trained in industrial workplace local, state and federal safety regulations.	4
	LCC METS 120 & LCC METS 160	2	I have at least 64 lab hours in pneumatic systems, robotics.	6
	LCC ELTE 260	3	I can operate Allen Bradley control technology.	9

Table 24 (cont'd)

	LCC ELTE 260	4	I can operate Siemens control technology.	9
	Ford job posting	5	I can operate Square D control technology.	9
	Ford job posting	6	I can operate Control Logix control technology.	9
	Ford job posting	7	I can operate Fanuc robotic systems and equipment.	9
	Ford job posting	8	I can operate ABB robotic systems and equipment.	9
	Ford job posting	9	I can operate Kawasaki robotic systems and equipment.	9
	FCA job posting	10	I can operate Comau robotic systems and equipment.	9
	FCA job posting	11	I have passed an industry certification in my field such as the International Society of Certified Technician exam.	10
	FEV- HEV & EV job posting	12	I have intermediate level knowledge of Microsoft office.	5
	STELLANTIS job posting	13	I have intermediate level knowledge of Google Suite software.	5
				102
			Comment:	
GenStudies1 - nominal			**General Studies**	
		47	**Chemistry**	
	LCC CHEM 125	1	I am studying/am proficient in **general chemistry** from classroom instruction and laboratory course(s), which includes measurement, aqueous reactions, stoichiometry, thermochemistry, atomic structure, bonding, and acids and bases.	9
	LCC CHEM 161	2	I am knowledgeable of advanced chemistry from classroom instruction and laboratory course(s) designed to stress basic laboratory techniques, writing lab reports, and critical thinking exercises, which include density determination, synthesis, empirical formulas, molecular geometry, gas laws, pH, chemical equilibrium, and water hardness.	10
	LCC CHEM 161	3	I have studied in a chemistry lab for 48 hours or more.	5

Table 24 (cont'd)

GenStudies2 - nominal		48	**English**	
	OCC ENG 1450	1	I am knowledgeable of writing and reading for problem solving that identifies and defines problems, establishes criteria for effective decision-making, generates solutions, implements plans and evaluates outcomes. I can use specific, appropriate written, graphic and/or oral forms of communication.	4
	LCC ENGL 124	2	I am knowledgeable of technical writing in a variety of formats for select audiences, which include writing instructions, mechanism descriptions, technical definitions, as well as business letters, persuasive memos, job application materials, and basic research techniques.	4
GenStudies3 - nominal		49	**Math**	
	LCC MATH 105	1	I am knowledgeable of the skills needed for introductory math, which includes numeracy, mathematical thinking & investigations, proportional reasoning, basic algebraic concepts, functions (linear & exponential), and basic statistical concepts.	2
	LCC MATH 112	2	I am knowledgeable of immediate algebra, which includes emphasis on graphing and diverse, real-life applications. Also, can solve functions & relations, polynomial, rational, radical, and quadratic expressions and equations, rational exponents, and absolute value equations and inequalities with an introduction to complex numbers.	3
	LCC MATH 120	3	I am knowledgeable of the skills needed for college algebra, which includes properties and graphs of linear, quadratic, polynomial, rational, exponential and logarithmic functions, with an emphasis on applications including finance, business/industry, life and social sciences.	4
	LCC MATH 114	4	I am knowledgeable of algebra for technical programs, with trigonometry. I can solve problems with algebraic expressions, powers, roots, ratio and proportion, variation, linear and quadratic equations, formulas, systems of equations, graphing, area, volume, Pythagorean Theorem, and right triangle trigonometry.	5
	LCC MATH 121	5	I am knowledgeable of precalculus, which includes polynomial, rational, radical, exponential, and logarithmic functions; solving equations/inequalities algebraically and graphically; and mathematical modeling in problem solving.	6
	LCC MATH 122	6	I am knowledgeable of advanced precalculus that includes right triangle trigonometry, trigonometric functions, graphs, identities and equations, inverse trig functions, laws of sines/cosines, polar coordinates, vectors, systems of linear equations, matrices, sequences, series, conic sections, parametric equations, permutations, combinations, and binomial theorem.	7

Table 24 (cont'd)

	LCC MATH 151	7	I am knowledgeable of calculus, which includes limits, continuity, and derivatives of algebraic, trigonometric, exponential and logarithmic functions; linear approximation; L'Hopital's rule; Riemann sums; integration using substitution; and the fundamental theorem of calculus.	7
	LCC MATH 152	8	I am knowledgeable of intermediate calculus, which includes techniques and applications of integration, improper integrals, sequences and infinite series, power series representation of functions, vectors, lines, planes, and 3D rectangular system.	8
	LCC MATH 253	9	I am knowledgeable of advanced calculus, which includes multivariable calculus and vector analysis. I can solve problems with vector algebra, curves and surfaces in 3D-space, vector valued functions, partial derivatives, multiple integrals, vector fields, line integrals, and surface integrals.	9
	LCC MATH 105 & 112 & others	10	I can use a Graphing calculator.	5
	LCC MATH 105	11	I can create Excel spreadsheets.	5
GenStudies4 - nominal		50	**Statistics**	
	LCC STAT 170	1	I am knowledgeable of introductory concepts and methods of statistics, with an emphasis on data analysis, which include methods for collecting data, graphical and numerical descriptive statistics, correlation, simple linear regression, basic concepts of probability, confidence intervals and hypothesis tests for means and proportions, and chi-square tests.	9
	LCC STAT 125	2	I am knowledgeable of introductory probability and statistics, which include descriptive statistics, probability, random variables, normal distribution, t distribution, chi-square distribution, F distribution, confidence intervals, hypothesis testing, correlation, and linear regression.	9
GenStudies5 - nominal		51	**Communications**	
	LCC COMM 130	1	I have been trained in the skills and confidence needed for **public speaking**. I know the proper techniques for researching, developing, organizing, outlining, and delivering effective informative, panel and persuasive presentation and have learned interpersonal concepts that affect my work in group presentations.	4
GenStudies6 - nominal		52	**Physics**	

Table 24 (cont'd)

	LCC PHYS 251	1	I am knowledgeable of forces and motion, momentum, work and energy, conservation laws of energy and momentum, rotational motion, static equilibrium, gravitation, and oscillations.	9
	LCC PHYS 252	2	I am knowledgeable of electric and magnetic forces and fields, electromagnetic energy, currents and circuits, electromagnetic oscillations and waves, mechanical waves and sound, light waves, physical and geometrical optics.	10
	LCC PHYS 251	3	I have studied in a chemistry lab for 48 hours or more.	6
GenStudies7 - nominal		53	**Philosophy**	
	OCC PHI 1710	1	I am knowledgeable of deductive and inductive reasoning; what distinguishes good from bad arguments; common mistakes in reasoning; and the use of language, definition, and explanation.	4
GenStudies8 - nominal		54	**Economics**	
	MCC ECON 1160	1	I am knowledgeable of basic principles of economics with an emphasis on macroeconomic theory, which includes an analysis of national income, employment, and prices, and concludes with a discussion of monetary and fiscal policies.	4
Barrier1 - nominal		55	**Barrier**	
			Is there a reason/barrier that may prevent you from continuing your program or graduating on time?	
			No, I do not have any barriers.	
			- or-	
			(Check all that apply)	
			I can't afford the tuition.	
			I am having academic challenges in my class(es).	
			I am having childcare issues.	
			I am having transportation issues.	
			I am had housing stability issues in the last 12 months.	
			I will have to take more credits to graduate.	
			I have decided to transfer to another school.	
			Other (please specify) _____	
			Comments:	
FutResidence - nominal		56	Now that you are on a career track with more earning potential, how likely are you to remain in your current place of residence or move to a different city?	

Table 24 (cont'd)

			(Check the appropriate one)	
			I plan to remain in my current home/apartment.	
			I plan to move into a new apartment in my city.	
			I plan to move to a new apartment in another city in Michigan.	
			I plan to move to a new apartment outside of Michigan.	
			I plan to move to a new home in my city.	
			I plan to purchase a new home in another city in Michigan.	
			I plan to move to a new home outside of Michigan.	
ViewofProg - nominal		57	Overall comment about program or changes that you would like to see policymakers make to help you complete your studies? (optional)	

APPENDIX B

E-MAIL TO STUDENTS

This is the first e-mail message to students.

You have been selected by the Institutional Research and Analytics at Washtenaw Community College to participate in a research study by a Michigan State University Ph.D. student titled, "The Implications That Change in Manufacturing Will Have on Employment of Michigan Workers". It is a dissertation study of how Michigan workers will be impacted by the technological changes in advanced manufacturing such as more automation that includes robotics, mechatronics, material composition, and predictive analytics. It is believed that community colleges are instrumental in preparing workers for high-demand jobs of the future.

Michigan's economy has always centered on the manufacturing industry. You are being asked to take this survey to assess the training in your academic program to determine if changes in manufacturing will make Michigan businesses competitive in the global economy. If you are not planning to work in manufacturing, your input is still needed to assess if Michigan can start to focus on other industries to boost the state's economy. Please answer all open-ended and multiple-choice questions. The questions pertain to your school enrollment, demographics, courses, and plans after graduation. Your program is 1 of 18 programs listed and should be selected to load all relevant questions. The survey will take approximately 10 minutes to complete and can be viewed on a computer or cell phone. Please respond by (three-week deadline).

The results of the survey will be used to assist in setting policies on the local, state, and federal level for workforce and economic development improvements.

Your participation is voluntary, you may choose not to participate at all, or you may cease participation at any time, and you may refuse to answer any question without consequence. You can exit at any time without consequence.

For review of the consent form, please click on the link. The consent form also appears as the first screen of the survey. HRP-507 Consent Form to Students. You consent to taking the survey once you start and complete the questions. You can exit at any time without consequence.

Please click on the link to start the survey. https://msu.co1.qualtrics.com/jfe/form/SV_bjFuurBNsII4cRL

Thank you for participating in this study.

Gina M. Jackson

E-mail to Students (cont'd)

After 1 ½ weeks from the initial e-mail going out, this reminder e-mail was sent to students with the following text:

This e-mail serves as a reminder that you have been selected by the Institutional Research and Analytics at Washtenaw Community College to participate in a research study by a Michigan State University Ph.D. student titled, "The Implications That Change in Manufacturing Will Have on Employment of Michigan Workers". If you have already taken the survey, please disregard this message. If not, please know that this is a dissertation study of how Michigan workers will be impacted by the technological changes in advanced manufacturing such as more automation that includes robotics, mechatronics, material composition, and predictive analytics. It is believed that community colleges are instrumental in preparing workers for high-demand jobs of the future.

Michigan's economy has always centered on the manufacturing industry. You are being asked to take this survey to assess the training in your academic program to determine if changes in manufacturing will make Michigan businesses competitive in the global economy. If you are not planning to work in manufacturing, your input is still needed to assess if Michigan can start to focus on other industries to boost the state's economy. Please answer all open-ended and multiple-choice questions. The questions pertain to your school enrollment, demographics, courses, and plans after graduation. Your program is 1 of 18 programs listed and should be selected to load all relevant questions. The survey will take approximately 10 minutes to complete and can be viewed on a computer or cell phone. Please respond by (1 ½ week deadline).

The results of the survey will be used to assist in setting policies on the local, state, and federal level for workforce and economic development improvements.

Your participation is voluntary, you may choose not to participate at all, or you may cease participation at any time, and you may refuse to answer any question without consequence. You can exit at any time without consequence.

For review of the consent form, please click on the link. The consent form also appears as the first screen of the survey. HRP-507 Consent Form to Students. You consent to taking the survey once you start and complete the questions. You can exit at any time without consequence.

Please click on the link to start the survey. https://msu.co1.qualtrics.com/jfe/form/SV_bjFuurBNsII4cRL

Thank you for participating in this study.

Gina M. Jackson

APPENDIX C

E-MAIL TO INSTRUCTORS

E-mail to Instructors:

You have been selected by the Institutional Research and Analytics at Washtenaw Community College to participate in a research study by a Michigan State University Ph.D. student titled, "*THE IMPLICATIONS THAT CHANGE IN MANUFACTURING WILL HAVE ON EMPLOYMENT OF MICHIGAN WORKERS*". It is a study of how Michigan workers will be impacted by the technological changes in advanced manufacturing such as more automation that includes robotics, mechatronics, material composition, and predictive analytics.

You have been selected to answer questions to assess the training in your academic program to make Michigan workers skilled for future advanced manufacturing jobs. If your academic program is not in manufacturing per se (e.g., computer information systems), please take time to answer the questions because a student may choose to work in the manufacturing industry with the skill set that you are teaching. A separate e-mail with a survey link will go to selected students to assess their skills. Both your answers will assist the researcher in making policy recommendations on the local, state, and federal level on how community colleges can prepare and graduate more Michigan workers in the high-demand advanced manufacturing field.

Your participation is voluntary, you may choose not to participate at all, or you may cease participation at any time, and you may refuse to answer any question without consequence. You can exit at any time without consequence.

For review of the consent form, please click on the link. The consent form also appears as the first screen of the survey. Consent Form to Instructors. You consent to taking the survey once you start and complete the questions.

Please click on the link to start the survey. Deadline is Friday, August 28, 2020.
Instructor Survey

Thank you for participating in this study,

Gina M. Jackson, Researcher

APPENDIX D

STATISTICAL TABLES

Table 25: Reliability

Case Processing Summary

	N	%
Valid	172	72.6
Excluded[a]	65	27.4
Total	237	100.0

a. Listwise deletion based on all variables in the procedure.

Table 26: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.855	.843	317

Table 27: Academic Program and Academic Score

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1965.705[a]	1872	.065
Likelihood Ratio	728.239	1872	1.000
Linear-by-Linear Association	21.388	1	.000
N of Valid Cases	181		

a. 2006 cells (100.0%) have expected count less than 5. The minimum expected count is .01.

Statistical Tables (cont'd)

Table 28: Symmetric Measures

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Interval by Interval	Pearson's R	-.345	.062	-4.913	.000[c]
Ordinal by Ordinal	Spearman Correlation	-.318	.070	-4.489	.000[c]
N of Valid Cases		181			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Table 29: Score and CTE Program (One-Way ANOVA)

Descriptives

Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	67	102.34	50.899	6.218	89.93	114.76	14	213
2	113	91.19	53.765	5.058	81.16	101.21	3	244
99	1	50.00	.	.	.	.	50	50
Total	181	95.09	52.811	3.925	87.34	102.83	3	244

Table 30: ANOVA

Score

			Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)		7280.384	2	3640.192	1.310	.272
	Linear Term	Weighted	2493.522	1	2493.522	.897	.345
		Deviation	4786.862	1	4786.862	1.722	.191
Within Groups			494740.202	178	2779.439		
Total			502020.586	180			

APPENDIX E

JOB POSTINGS

Job Postings

Mechatronics Technician Apprentice

FEV North America, Inc is a global engineering services leader providing full vehicle support to the automotive community as well as the heavy-duty and commercial engine industry. If you are interested in joining a team of experienced engineers creating advanced engines to address future fuel economy and emissions requirements, FEV is where you want to be.

- Mechatronics technicians combine electrical, mechanical, and electronic competencies to identify, analyze and solve systems-based problems.
- A mechatronics technician is skilled individual who combines these competencies to solve systematic problems.
- At the same time, he/she uses a holistic approach to provide basic solutions.
- A mechatronics technician must be able to support engineers, modify machines, make minor changes and repair, test and maintain related equipment.

Responsibilities:

- Support instrumentation, setup/debug of components and vehicles
- Disassemble engines, transmissions, driveline components and other vehicle systems
- Generate detailed manufacturing Bill of Material representing the disassembly of the hardware
- Support construction and unification of BOMs used during teardowns
    - Naming convention, measurements, material analysis, etc.
- Take detailed, informative and consistent photographs of parts during and after disassembly
- Upkeep photo area(s), camera equipment, editing software, etc.
- Build and photograph exploded views of disassembled assemblies and modules during teardowns
- Measure and record necessarily component attribute data on components and assemblies supporting design, manufacturing, value engineering and cost studies
- Keep shop area clean and presentable for customer events
- Develop standards manuals for teardowns, photographing, parts measurements, etc.
- Repair and maintain teardown tools and equipment
- Research and recommend benchmarking hardware and software (e.g. 3D scanning equipment, material analysis equipment, etc.)
- Maintain and track customer hardware and disposal of hardware

FEV North America, Inc offers a complete range of engineering services, providing support across the globe to customers in the design, analysis, prototyping, powertrain and transmission development, as well as vehicle integration, calibration and homologation for advanced internal combustion gasoline-, diesel-, and alternative-fueled powertrains. FEV also designs, develops and prototypes advanced vehicle / powertrain electronic control systems and hybrid-electric engine concepts that address future emission and fuel economy standards. The company has expanded its engineering capabilities to include full vehicle systems and now offers broad expertise in electronics, telematics and infotainment system engineering. The FEV Test Systems division is a global supplier of advanced test cell, instrumentation and test equipment; energy technology and conventional, electric and alternative vehicle drive systems. We are also a major supplier of advanced testing and instrumentation products and services for some of the world's largest powertrain OEMs.

FEV is focused on meeting our customers' requirements for rapid development schedules, high quality standards and reduced costs.

The FEV Group employs a staff of over 5,500 highly skilled specialists at advanced technical centers on three continents. FEV, Inc. employs approximately 450 personnel at FEV's North American Technical Center in Auburn Hills, MI.

For more about FEV please visit our website at www.fev.com

EOE M/F/Disability/Vet

Welder Apprentice

FEV North America, Inc is a global engineering services leader providing full vehicle support to the automotive community as well as the heavy-duty and commercial engine industry. If you are interested in joining a team of experienced engineers creating advanced engines to address future fuel economy and emissions requirements, FEV is where you want to be.

Welders use hand-welding or flame-cutting equipment to weld or join metal components, or to fill holes, indentations or seams of fabricated and metal products.

- Fits and assembles machined parts into complete units, applying knowledge of machine shop theory and procedures, shop mathematics, machinability of materials, and layout techniques
- Studies blueprints, sketches, drawings, manuals, specifications, or sample part to determine dimensions and tolerances of finished workpiece, sequence of operations, and setup requirements
- Measures, marks, and scribes dimensions and reference points on material or workpiece as guides for subsequent machining
- Selects, aligns, and secures holding fixtures, cutting tools, attachments, accessories, and materials on machines, such as mills, lathes, jig borers, grinders, and shapers
- Calculates and sets controls to regulate machining factors, such as speed, feed, coolant flow, and depth and angle of cut, or enters commands to retrieve, input, or edit computerized machine control media
- Starts and observes machine operation to detect malfunctions or out of tolerance machining, and adjusts machine controls or control media as required
- Verifies conformance of finished workpiece to specifications, using precision measuring instruments
- Sets up and operates machine on trial run to verify accuracy of machine settings or programmed control data
- Fits and assembles parts into complete assembly, using jigs, fixtures, surface plate, surface table, hand tools, and power tools
- Verifies dimensions and alignment of assembly, using measuring instruments, such as micrometers, height gauges, and gauge blocks
- Installs machined replacement parts in mechanisms, machines, and equipment, and test operation of unit to ensure functionality and performance
- Operates welding equipment to cut or weld parts
- Develops specifications from general description and draw sketch of part or product to be fabricated
- May confer with engineers, production personnel, programmers, or others to resolve machining or assembly problems

Skills:

- Skilled with manual operation lathes
- Skilled with manual mills
- Skilled with axis machines
- Extensive understanding of machine tooling use
- Ability to understand complex Engineering drawings

FEV North America, Inc offers a complete range of engineering services, providing support across the globe to customers in the design, analysis, prototyping, powertrain and transmission development, as well as vehicle integration, calibration and homologation for advanced internal combustion gasoline-, diesel-, and alternative-fueled powertrains. FEV also designs, develops and prototypes advanced vehicle / powertrain electronic control systems and hybrid-electric engine concepts that address future emission and fuel economy standards. The company has expanded its engineering capabilities to include full vehicle systems and now offers broad expertise in electronics, telematics and infotainment system engineering. The FEV Test Systems division is a global supplier of advanced test cell, instrumentation and test equipment; energy technology and conventional, electric and alternative vehicle drive systems. We are also a major supplier of advanced testing and instrumentation products and services for some of the world's largest powertrain OEMs.

FEV is focused on meeting our customers' requirements for rapid development schedules, high quality standards and reduced costs.

The FEV Group employs a staff of over 5,500 highly skilled specialists at advanced technical centers on three continents. FEV, Inc. employs approximately 450 personnel at FEV's North American Technical Center in Auburn Hills, MI.

For more about FEV please visit our website at www.fev.com

EOE M/F/Disability/Vet

CAD Technician

Autodie LLC - Grand Rapids, MI

Autodie LLC, a wholly owned subsidiary of Fiat Chrysler Automobiles, is a leader in the design and build of metal forming tooling for the automotive industry as well as a supplier of large-scale machined products. Our world class climate-controlled facility is centrally located just north of downtown Grand Rapids. Autodie is a company with more than 50 years of experience in fulfilling customer needs and offering local expertise for project management, engineering, machining, die construction & tryout, engineering change incorporation, buy-off and launch support.

We are currently seeking a qualified candidate to fill the position of CAD Technician.

This position requires knowledge in die design and surfacing geometry in CAD and will prepare die designs for manufacturing in a World Class Manufacturing environment while fostering a spirit of cooperation between and within departments.

DUTIES AND RESPONSIBLITIES:

- Surfacing for inner and outer body panels
- Design dies in castings and boiler plate construction
- Work with die construction, tryout, sales, purchasing and project management as part of a team, communicating issues and providing solutions to support other departments

EDUCATION, WORK EXPERIENCE AND SKILLS:

- Minimum of 3 years of experience in Die design
- Minimum of 2 years surfacing Class "A" large surface panels
- Demonstrated understanding of die mechanics
- Knowledge of die construction tools and machinery
- Excellent communication skills to address issues or concerns on designs as they arise
- Must be able to work in a fast-paced environment while producing accurate data
- Requires a self-starter with a strong work ethic, organizational skills and an aptitude for problem solving

We offer an excellent compensation and complete benefit program in a supportive work environment. Our global commitment to technological advancement offers opportunities for personal growth and development.

Qualified candidates should send their resume of accomplishments with salary history.

Job Type: Full-time

Experience:

- surfacing class A large surface panels: 2 years (Required)
- die design: 3 years (Required)

Benefits:

- Health insurance
- Dental insurance
- Vision insurance
- Retirement plan
- Paid time off

Company's website:

- www.autodie-llc.com

H.B. Fuller
Lab Technician - Nights
Grand Rapids, MI
$12-$21 Per Hour(Glassdoor est.)

H.B. Fuller is a leading global adhesives provider focusing on perfecting adhesives, sealants and other specialty chemicals across all industries throughout the world. While our products are virtually invisible, they play a vital role in ensuring the quality of modern life and we are committed to connecting what matters to solve some of the world's biggest adhesion challenges.

H.B. Fuller's Engineering Adhesives segment develops technologically advanced adhesive solutions for the electronics, automotive, clean energy, medical and other, related industries. As these dynamic markets continue to change, and consumers demand lighter, safer, greener, more reliable products, we partner with our customers to improve performance and lives.

Lab Technician - Night Shift

Grand Rapids, MI

Experienced Lab Technician from a manufacturing environment

Description:

Reporting to the Facility Technical Manager, the selected candidate will support all safety and quality assurance for production. Direct liaison between production and the quality of our products.

Taking on this position you will perform quality checks of raw materials, submit daily batch release reports and enter all quality assurance test results while keeping up with production. You will be working real time with production.

Employees receive full benefits, including medical, dental, insurance, 401k contribution, paid time off and paid Holidays. All employees qualify for an annual cash bonus, based on business performance. Annual raises are based on company and individual performance.

Requirements:

High School diploma or GED + 2 year Community college or equivalent AA degree in chemistry or biochemistry, coupled with up to 12 months of and up to 12 months as a Quality laboratory Technician.

Three + years of experience in Microsoft Office, Excel, Access, and Word is required.

One + years of experience in a controlled lab environment

Able to work 12 hour shifts on nights. 6pm-6am.

As Lab Technician, you will be fully engaged with our standards and will become a technology expert. You will work directly with timing of production and have the ability to be involved in multiple processes. We are looking for innovative influencers that are able to enthuse others be independent and drive quality products.

H.B. Fuller is an Equal Opportunity Employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, veteran or disability status.

Electronic Technician
DEPARTMENT OF THE AIR FORCE

Overview

open & closing dates: 01/01/2019 to 12/31/2020

- **Service**

  Competitive

- **Pay scale & grade:** GS 5 - 14
- **Salary:** $33,394 to $157,663 per year
- **Appointment type:** Multiple Appointment Types
- **Work schedule:** Multiple Schedules

Locations: Few vacancies in the following locations: Maxwell AFB, AL; Norman, AR, Davis Monthan AFB, AZ; Show more locations (37)

Relocation expenses reimbursed: No

Telework eligible: No

This job is open to: The public

Clarification from the agency

This public notice is to gather applications that may or may not result in a referral or selection.

Announcement number

AFPC-CYBERDHA-10381352-0856

Control number

520425600

Duties

Summary

Click on "Learn more about this agency" button below for **IMPORTANT** additional information.

The primary purpose of this position is to provide technical expertise to install, operate, and maintain theater air and space operations center's RF communications, and associated equipment.

Responsibilities

- Maintains and operates assigned systems and subsystems to ensure compliance with established standards and safety requirements. Determines when equipment malfunctions warrant shutdown of various systems.
- Provides technical guidance, training, and assistance to other technicians and conducts on-the-job (OJT) training to apprentices in all phases of work.
- Utilizes safety practices and procedures following established safety rules and regulations and maintains a safe and clean work environment.

Travel Required: Occasional travel - You may be expected to travel for this position.

Supervisory status: No

Promotion Potential: 15

- **Job family (Series):** 0856 Electronics Technical

Similar jobs: Mechanics, Radio; Radio Equipment Repairers; Radio Mechanics; Repairers, Radio Equipment

Requirements

Conditions of Employment

- Please read this Public Notice in its entirety prior to submitting your application for consideration.
- U.S. Citizenship is required
- Males must be registered for Selective Service, see www.sss.gov
- Total salary varies depending on location of position

- PCS expenses if authorized will be paid IAW JTR and Air Force Regulations
- Recruitment incentives may be authorized
- Position may be subject to random drug testing
- Employee may be required to work other than normal duty hours, to include evenings, weekends and/or holidays
- Shift work and emergency overtime may be required
- Employee must maintain current certifications
- A security clearance may be required
- Disclosure of Political Appointments
- This position is subject to provisions of the DoD Priority Placement Program
- Per National Defense Authorization Act (NDAA) of fiscal year FY 2017, Section 1111 modifies 5 United States Code (USC) 3326; Veterans who are retiring within 180 days of appointment effective date may require a 180 day waiver package.

Qualifications

FOR GS-05: One year of specialized experience to at least the GS-04 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes knowledge of basic principles of Electronics Technician or related field.

OR

Successful completion of all the requirements for a bachelor's degree in electrical engineering, electronics engineering, or electronics technology

OR

3 years of study in an accredited (by the Accreditation Board of Engineering and Technology, Inc. (ABET) curriculum in electronics

OR

a full 4-year course of study leading to a bachelor's degree that included major study

OR

at least 24 semester hours in any combination of courses. At least 12 of the 24 semester hours must have been in electronics courses. FOR GS-06: One year of specialized experience to at least the GS-05 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes practical knowledge of technical methods to perform

assignments such as carrying out limited projects that involve use of specialized complicated techniques.

OR

have one year of graduate level education directly related to the work of the position
OR

have a combination of education and specialized experience

FOR GS-07: One year of specialized experience to at least the GS-06 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes knowledge a wide range of occupational theories, principles, concepts, and practices in the technical area of electronics technology and practices, operating parameters, capabilities, and limitations of electronics systems associated calibrated, precision measuring, and test, equipment; and of systems and component design, capabilities, configurations, limitations, and functional operation and of various types of electronics logic.

OR

have one year of graduate level education directly related to the work of the position

OR

have a combination of education and specialized experience

FOR GS-08: One year of specialized experience to at least the GS-07 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes knowledge of moderate complex electronic concepts and ability to convert theoretical idea to functional components and systems.

OR

have a master's or equivalent graduate degree directly related to the work of the position

FOR GS-09: One year of specialized experience to at least the GS-08 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes practical knowledge of electronic theory, circuit, elementary physics, and engineering mechanics, and ability to apply knowledge to the design modification and repair of ground-air UHF radio communication system, satellite communication equipment, terminal(s), ground radios and peripheral equipment.

OR

have a master's or equivalent graduate degree directly related to the work of the position

FOR GS-10: One year of specialized experience to at least the GS-09 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes knowledge of principles and practices of team building of the method and techniques of fact finding, analysis and resolution of complex problems.

NOTE: There is no substitution of education for specialized experience at the GS-10 level.

FOR GS-11: One year of specialized experience to at least the GS-10 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes knowledge of electronics concepts, standards, principles, methods, and techniques to ensure work is in compliance with applicable regulations and quality standards. NOTE: There is no substitution of education for specialized experience at the GS-11 level.

FOR GS-12: One year of specialized experience to at least the GS-11 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes knowledge of aircraft hardware, software, technical orders, specifications, computer systems and test systems. NOTE: There is no substitution of education for specialized experience at the GS-12 level.

FOR GS-13: One year of specialized experience to at least the GS-12 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes knowledge of operational test and evaluation organization and structure, concepts, principles, practices and applicable code, regulations, policy, and issues.
NOTE: There is no substitution of education for specialized experience at the GS-13 level.

FOR GS-14: One year of specialized experience to at least the GS-13 grade level under the General Schedule (GS) or other pay systems. Examples of specialized experience includes knowledge of the agency, squadron, LG, AFFTC policies, regulations, and directives. NOTE: There is no substitution of education for specialized experience at the GS-14 level.

OR

To view qualifying educational requirements and/or combination of education and specialized experience click on the following link: https://www.opm.gov/policy-data-oversight/classification-qualifications/general-schedule-qualification-standards/0800/electronics-technicalseries-0856/

KNOWLEDGE, SKILLS AND ABILITIES (KSAs): Your qualifications will be evaluated on the basis of your level of knowledge, skills, abilities and/or competencies in the following areas:

1. Experience with of 721S, PSC-5D, PRC-117F, PRC-117G, PRC-150, URG-III, LVT-11, PRC-152, PRC-112G, EPLRS, Combat Track II, and GBS radio systems. Experience with of private IP network management. Knowledge of/experience with Radio over IP and E&M principles/systems.

2. Knowledge of a wide range of electronic principles and practices, operating parameters, capabilities, and limitations of electronic systems associated with air and space operations centers, and of systems and component design, capabilities, configurations, limitations, and functional operation; and of various types of electronics logic.

3. Knowledge of safety regulations, procedures, and practices.

4. Skill in the interpretation of technical data such as drawings, schematics, blueprints, and specifications of complete electronic systems; in analyzing problems in integrated/interfacing systems involving numerous complex circuits; and in using complex electronic and electromechanical test and measuring equipment using integrated test functions for different purposes.

5. Ability to modify standard procedures, adapt equipment or techniques, and make departures from previous approaches to solve technical problems or improve system performance for highly complex electronic systems; to trace electronics logic from one system to another; and to establish and maintain effective working relationships to represent the organization in a professional manner.

6. Ability to use computer terminals to enter and extract data to maintain records and document actions.

PART-TIME OR UNPAID EXPERIENCE: Credit will be given for appropriate unpaid and or part-time work. You must clearly identify the duties and responsibilities in each position held and the total number of hours per week.

VOLUNTEER WORK EXPERIENCE: Refers to paid and unpaid experience, including volunteer work done through National Service Programs (i.e., Peace Corps, AmeriCorps) and other organizations (e.g., professional; philanthropic; religious; spiritual; community; student and social). Volunteer work helps build critical competencies, knowledge and skills that can provide valuable training and experience that translates directly to paid employment. You will receive credit for all qualifying experience, including volunteer experience.

Education

IF USING EDUCATION TO QUALIFY: You **MUST** provide transcripts to support your educational claims. Education must be accredited by an accrediting institution recognized by the U.S. Department of Education.

FOREIGN EDUCATION: Education completed in foreign colleges or universities may be used to meet the requirements. You must show proof the education credentials have been deemed to be at least equivalent to that gained in conventional U.S. education program. It is your responsibility to provide such evidence when applying.

Additional information

This is a Direct Hire Public Notice and is being used to fill under the Direct Hire Authority for Cyber Workforce Positions up to grade GS-15. Under this recruitment procedure applications will be accepted for each location/ installation identified in this Public Notice and selections are made for vacancies as they occur. There may or may not be actual/projected vacancies at the time you submit your application. Positions may be filled as permanent, temporary or term with a full-time or part-time work schedule. Pay will vary by geographic location.

Duties and responsibilities vary and may increase according to grade level.

This public notice may be used to fill target grades (GS-05 Target GS 15). There may be promotion potential up to the GS-15 or equivalent.

Interagency Career Transition Assistance Program (ICTAP): For information on how to apply as an ICTAP eligible click here. To be well-qualified and exercise selection priority for this vacancy, displaced Federal employees must be rated in the "Highly Qualified" or "Best Qualified" Category on the rating criteria for this vacancy. You must submit a copy of the agency notice, your most recent performance rating, and your most recent SF-50 noting position, grade level, and duty location.

Employed Annuitants (Reemployed Annuitants): Applicants in receipt of an annuity based on civilian employment in the Federal Service are subject to the DoD Policy on The Employment of Annuitants. Click here for more information.

Temporary and Term Appointments: If you are selected for a temporary or term position in the competitive service, your appointment may be extended to the maximum period allowed by law without further competition. Additionally, if you are serving on a term appointment in the competitive service, you may be converted to a career or career-conditional appointment without further competition. NOTE: Current federal civilian employees may apply for this position and if selected, a break in service of at least 3 days may be required prior to appointment to this position.

Selective Service: Males born after 12-31-59 must be registered or exempt from Selective Service. For additional information, click here.

Direct Deposit: All federal employees are required to have direct deposit.

If you have questions regarding this announcement and have hearing or speech difficulties click here.

Tax Law Impact for PCS: On 22-Dec-2017, Public Law 115-97 - the "Tax Cuts and Jobs Act of 2017 suspended qualified moving expense deductions along with the exclusion for employer reimbursements and payments of moving expenses effective 01-Jan-2018 for tax years 2018 through 2025. The law made taxable certain reimbursements and other payments, including driving mileage, airfare and lodging expenses, en-route travel to the new duty station, and temporary storage of those items. The Federal Travel Regulation Bulletin (FTR) 18-05 issued by General Services Administration (GSA) has authorized agencies to use the Withholding Tax Allowance (WTA) and Relocation Income Tax Allowance (RITA) to pay for "substantially all" of the increased tax liability resulting from the "2018 Tax Cuts and Jobs Act" for certain eligible individuals. For additional information on WTA/RITA allowances and eligibilities, please visit: https://www.gsa.gov/cdnstatic/FTR%20Bulletin%2018_05%20Relocation%20Allowances_0.pdf

Read more

How You Will Be Evaluated

You will be evaluated for this job based on how well you meet the qualifications above.

Your latest resume will be used to determine your qualifications.

Your application package (resume, supporting documents, and responses to the questionnaire) will be used to determine your eligibility, qualifications, and quality ranking for this position. Please follow all instructions carefully. Errors or omissions may affect your rating or consideration for employment.

Your responses to the questionnaire may be compared to the documents you submit. The documents you submit must support your responses to the online questionnaire. If your application contradicts or does not support your questionnaire responses, you will receive a rating of "not qualified" or "insufficient information" and you will not receive further consideration for this job.

Applicants who disqualify themselves will not be evaluated further.

Read more

Background checks and security clearance

Security clearance: Secret

Drug test required: No

Required Documents

The following documents are required and must be provided with your application for this Public Notice:

- Online Application - Questionnaire
- Resume - must include beginning and ending month and year for each employment period
- Transcripts - if you are basing your qualifications on education or if the position requires education, you must submit copies of your transcripts
- Registration/License - active, current registration/license **if applicable** for the position
- Veterans' Preference - If you are claiming veterans' preference, you must submit a copy of your DD Form 214, which must include character of service or a Statement of Service/Proof of Service which must include service dates and character of service. In addition, if claiming 10-point preference you must submit a VA Letter or a disability determination from a branch of the Armed Forces (or documentation of Purple Heart, if applicable) and a SF 15 (Application for 10-point veteran preference).

ACTIVE DUTY SERVICE MEMBERS: The VOW Act Chapter 21 of Title 5, United States Code (U.S.C.), Section 2108a, requires Federal agencies treat active duty service member as veterans, disabled veterans, and preference eligible, when they submit, at the time they apply for a Federal job, a "certification" of active service in lieu of a DD-214, assuming the service member is otherwise eligible. A "certification" letter should be on letterhead of the appropriate military branch of the service and contain (1) the military service dates including the expected discharge or release date; and (2) the character of service. The service member's military service dates are necessary in order to determine whether he or she meets the definition of "veteran" under 5 U.S.C. 2108(1). The "certification" must reflect the service member is expected to be discharged or released from active duty service in the armed forces under honorable conditions **not later than 120 days after the date of submission**. The "certification" must be signed by, or by direction of, the adjutant, personnel officer, or commander of your unit or higher headquarters and must indicate when your terminal leave will begin (if applicable), your rank, dates of active duty service, the type of discharge and character of service (i.e. honorable). Further, under paragraph (h) of the rule, agencies are required to verify a qualifying separation from military service prior to appointment, through the DD-214 or other appropriate documentation. Your preference and/or appointment eligibility will be verified prior to appointment. Active duty members that fail to provide a valid "certification" of service with their initial application will be found "not eligible." Military members may be appointed before the effective date of their military retirement/separation if member is on terminal leave.

If you are relying on your education to meet qualification requirements:

Education must be accredited by an accrediting institution recognized by the U.S. Department of Education in order for it to be credited towards qualifications. Therefore, provide only the attendance and/or degrees from schools accredited by accrediting institutions recognized by the U.S. Department of Education

Failure to provide all of the required information as stated in this vacancy announcement may result in an ineligible rating or may affect the overall rating.

- Benefits

A career with the U.S. Government provides employees with a comprehensive benefits package. As a federal employee, you and your family will have access to a range of benefits that are designed to make your federal career very rewarding. Learn more about federal benefits.

Review our benefits

Eligibility for benefits depends on the type of position you hold and whether your position is full-time, part-time, or intermittent. Contact the hiring agency for more information on the specific benefits offered.

- How to Apply

How to Apply

The complete Application Package must be submitted by 11:59 PM (ET) on 12/31/2020.

To preview the Application Questionnaire, please click the following link: https://apply.usastaffing.gov/ViewQuestionnaire/10381352

To begin the process, click the **Apply Online** button to create an account or log in to your existing USAJOBS account. Follow the prompts to complete the application questionnaire. Please ensure you click the **Submit My Application** button at the end of the process.

To apply for this position, you must provide a complete Application Package which includes:

1. Your Resume (your latest resume will be used to determine your qualifications). If you submit more than one copy of your resume, only the most recent (latest) version will be reviewed. The latest timestamp will be used to determine which version of your resume is "most recent."

    - It is your responsibility to check the status and timestamp of all documents you submit as part of your application.
    - If your resume includes a photograph or other inappropriate material or content, you will not be considered for this vacancy.
    - For qualification determinations your resume must contain hours worked per week and dates of employment (i.e., hours per week and month/year to month/year or month/year to present). If your resume does not contain this information, your application may be marked as insufficient and you will not receive consideration for this position.

2. A complete Application Questionnaire

3. Additional Required Documents (see Required Documents section). Ensure all submitted documents contain your full name.

If you are unable to apply online, view the following link for information regarding Alternate Application.

PLEASE NOTE: It is the applicant's responsibility to verify that information entered and/or uploaded, (i.e., resume) is received, accurate, and submitted by the closing date. You may verify your documents have been processed with your application package successfully. You can access your USAJOBS account to do so by clicking here. Uploaded documents may take up to one hour to clear the virus scan.

Human Resources **WILL NOT** modify or change any answers submitted by an applicant.

Agency contact information

Total Force Service Center

Phone

1-800-525-0102

Email

DO.NOT.EMAIL@CALL.ONLY

Address

EHA DHA
550 C Street W
JBSA Randolph AFB, TX 78150
US

Learn more about this agency

Next steps

After you submit your application, you will be contacted if further evaluation or interviews.

APPENDIX F

CURRICULUM VITAE

GINA MARCELLA JACKSON
jackso39@msu.edu

EDUCATION

Ph.D. in Urban and Regional Planning
Michigan State University, East Lansing, Michigan
Began fall 2017; Graduation date: 5/2021
Dissertation title: *The Implications that Change in Manufacturing Will Have on Employment of Michigan Workers*.
Specializations: workforce development, manufacturing communities, post-secondary education, and advanced manufacturing

Certificate in Infrastructure Engineering
Illinois Institute of Technology, Chicago, Illinois
2007

Certificate in Construction Management
Illinois Institute of Technology, Chicago, Illinois
2006

Master of Arts Degree in Urban Planning and Policy
University of Illinois at Chicago, Illinois
2000
Master's Project title: *The Economic Impact of Casino Gaming in Detroit*
Specializations: community and economic development, workforce development, and affordable housing

Bachelor of Arts Degree in Public Administration (transfer student from Oakland Community College)
Michigan State University, East Lansing, Michigan
1994

PROFESSIONAL EXPERIENCE

Michigan State University School of Planning, Design, and Construction 2018
Academic program that specializes in four built environment disciplines. My focus is urban and regional planning.
Research Assistant

- Performed research for MSU Extension that evaluated the programs offered in comparison with other land grant institutions (e.g., community sustainability and food systems).

PROFESSIONAL EXPERIENCE continued

Detroit Public Schools Foundation **2016**

An independent 501 (c)(3) that raises money from the private sector to support students in Detroit Public Schools.

Volunteer

- Researched potential donors for the organization.
- Researched and drafted a summary of Michigan legislation in fiscal year 2016 that affected Detroit Public Schools school financing.
- Created a budget and donor solicitation to fund a pre-kindergarten program in all elementary schools.
- Completed other projects as assigned by the Executive Director.

Detroit Land Bank Authority **2014-2016**

Senior Sales and Program Specialist

The land bank is a public authority dedicated to returning Detroit's vacant, abandoned, and foreclosed property to productive use.

- Managed the Disposition programs for vacant land and set-priced homes (side lots, direct sales, commercial lots, and land lease). Coordinated with the legal team and helped compose sales documents that protected the agency and buyer according to local, state, and federal laws.
- Implemented the Buy Back Pilot Program to allow occupants in foreclosed DLBA owned homes the ability to buy them back. Created processes for nonprofit counselors, occupants, and consultants to navigate through the buyback period. Developed outcome measures to evaluate the effectiveness of the program after a 6-month and 12-month period.
- Served as lead for communicating with potential buyers both via phone and in-person; sought approval from property staff for high demand properties to become available for sale; coordinated with other departments and outside agencies. Responded to sales requests from the city's district and assistant managers.
- Was successful in selling and processing 2,069 properties totaling over $297,000.
- Created financial records for Disposition programs and created weekly sales reports for all programs.
- Served as lead for Disposition sales team.

Cook County Bureau of Economic Development **2010-2011**

Planner III

The Bureau of Community Development is responsible for planning and community and economic development throughout the Chicago metropolitan region.

- Managed redevelopment projects of foreclosed and abandoned properties under the Neighborhood Stabilization Program.

PROFESSIONAL EXPERIENCE continued

- Responsible for working with subrecipients/developers through the planning, financing and construction phases. Reviewed appraisals, site plans, architectural plans & specifications, environmental reviews, and cost analyses.
- Reviewed general contractor applications.

Highland Park Illinois Community Land Trust (HPICLT) 2007-2009

Project Manager/Interim Executive Director

The first community land trust formed in Illinois. This not-for-profit organization provides affordable housing throughout the metropolitan Chicago area.

- Assisted with closing on the financing for a mixed-income 14-unit town home and rental apartment project totaling $4.1 million. The workforce and transit-oriented development was a joint venture between the HPICLT, the City of Highland Park, and private developers.
- Acted as construction manager by working with the general contractor and subcontractors during construction or rehabilitation phases. Reviewed contracts awarded by general contractors for compliance with hiring diversity. Conducted on-site inspections of construction progress with owner's representative.
- Acted as asset manager for rental apartments and scattered-site homes in portfolio.
- Prepared agenda, packets, and minutes for the HPICLT board and homeowners' association meetings.
- Conducted a monthly orientation session for potential applicants. Assisted with marketing the program to eligible residents. Updated website.
- Applied for and submitted quarterly and annual subsidy filings for state and federal programs (HOME, AHP, & Low-income Housing Tax Credits).
- Performed accounting, budgeting, and created monthly operating reports.

Campbell Tiu Campbell Architects 2006

Project Manager

50-year design firm that specializes in site design, public facilities, and construction administration in Chicago, Illinois.

- Researched the demographics and replacement housing opportunities available for the City of Chicago's Englewood neighborhood by the installation of a new freight rail line under the federal and state CREATE project. Researched other ancillary economic development opportunities according to the City of Chicago's zoning ordinance, neighborhood plans, and financing mechanisms. Assisted in the identification of project stakeholders (alderman and city commissions, community organizations, state legislators, and homeowners) to institute proper approval channels.

PROFESSIONAL EXPERIENCE continued

- Maintained database of permit issues on projects such as the University of Chicago's new residence hall. Coordinated any corrections with lead architectural firm to keep project on schedule.

Community Economic Redevelopment Corporation **1999-2001**

Project Manager

Real estate organization that centered on urban planning and developing multifamily housing and retail in the city of Chicago and northwest Indiana.

- Conducted the due diligence (reviewed appraisals, architectural plans and specifications, environmental reviews, construction budget, and cost analyses) and final acquisition of a 224-unit apartment complex in Fort Wayne, Indiana utilizing tax-exempt bond financing that totaled $7.6 million.
- As general contractor, managed the rehabilitation of the apartment complex by hiring subcontractors, setting up construction draws, scheduling unit renovations, establishing and maintaining a comprehensive project budget showing the current status and any perceived issues that may impact costs. Was successful in leasing up the property by 30%. Served as asset manager.
- Supervised interns.

United Automobile Workers Union **1995-1996**

Research Intern

UAW-represented workplaces ranging from multinational corporations, small manufacturers and state and local governments to colleges and universities, hospitals and private non-profit organizations.

- Researched issues pertaining to collective bargaining.
- Participated in collective bargaining for the State of Michigan and City of Inkster and Romulus.

State Senator Debbie Stabenow **1993-1994**

Research Intern/Gubernatorial Campaign Deputy Field Director

Michigan legislator that ran for governor.

- Researched issues for the drafting and passage of legislative bills that pertained to education and property taxes.
- Headed the Detroit office for the State Senator's gubernatorial campaign.

FUTURE RESEARCH

Project: *Examining Tax Increment Financing as a Solution for Distressed Urban Neighborhoods in Michigan Cities*

FUTURE RESEARCH continued

An assessment will look at whether neighborhood tax-increment financing districts is economically viable for urban neighborhoods that have been distressed for decades. It will be determined if it is a good solution to spur new housing and commercial revitalization in blighted neighborhoods.

SERVICE AND PROFESSIONAL MEMBERSHIPS

East Lansing Hannah Community Center Commission, 2019
Served as a special advisory committee member on future improvements and programming

Michigan Economic Developers Association, member, 2019 - present

American Planning Association, member, 2019 - present

AWARDS

Keith Hernandez Family Scholarship, 2019

MSU Education Opportunity Fellowship, 2018 - 2019

MSU Education Opportunity Fellowship, 2019 - 2020

Malcolm C. Drummond-Shunichi Hagiwara Fellowship, 2018 - 2019

Malcolm C. Drummond-Shunichi Hagiwara Fellowship, 2019 - 2020

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