PRINCIPALS' PERCEPTIONS ON THE NECESSITY TO PREPARE STUDENTS FOR CAREERS IN ADVANCED MANUFACTURING

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ABSTRACT

The United States (U.S.) is undergoing a paradigm shift in manufacturing as it progresses from an era of low skill employees who stood in one place controlling machines that drilled, stamped, cut, and milled products that passed through the effective and efficient assembly line, to one that is derived from scientific inquiry and technological innovation referred to as advanced manufacturing (PCAST, 2011). Presently, manufacturing firms employ ten percent of the nation's employees directly and impact numerous organizations along its supply chain and financial sector (Giffi et al., 2015). The U.S. currently has a manufacturing base that comprises twenty percent of its total gross domestic product and is expected to continue to grow (PCAST, 2011; NSTC, 2012; Giffi et al., 2015). Specifically, Giffi et al. (2015) predicts more than two million jobs will go unfilled in advanced manufacturing by 2020 due to the inability to find qualified employees and the increasing demand for customized products.

The purpose of this study was to identify principals' perceptions on the necessity to prepare students for careers in advanced manufacturing in public high schools in New York State, excluding New York City, with student populations of 600 or fewer students. Specifically, this study examined high school principal leadership actions for incorporating 21st century skills and the use of tools and machines (hard skills) in technology education classrooms to support a student career pathway for careers in advanced manufacturing.

Findings showed that principals believe advanced manufacturing is a viable career opportunity and have increased technology education offerings aligned to careers in advanced manufacturing. However, the data suggest principal leadership actions supporting the development of hard skills is not consistent with the needs identified by advanced manufacturing organizations. In regards to principal leadership of 21st century skills, findings show that significant positive relationships exist in the incorporation of these skills in technology education courses and through their principal leadership actions. However, principal leadership actions were not significantly correlated to assessing student development and mastery of 21st century skills.

Key words: advanced manufacturing, hard skills, principal, 21st century skills

CHAPTER I: INTRODUCTION

In a speech to the joint session of congress on February 24, 2009, President Barack Obama stated (Obama, 2009):

> Tonight, I ask every American to commit to at least one year or more of higher education or career training. This can be community college or a four-year school; vocational training or an apprenticeship. But whatever the training may be, every American will need to get more than a high school diploma. And dropping out of high school is no longer an option. It's not just quitting on yourself, it's quitting on your country; and this country needs and values the talents of every American.

Statement of the Problem

The turn of the 20th century marked the United States (U.S.) as the global leader in education, despite only nine percent of the population possessing a high school diploma (Symonds, Schwartz, and Ferguson, 2011; Ferguson & Lamback, 2013). The educational achievement of America's youth, due in part to the expectation that all students would attend high school catapulted the U.S. as the global leader in educational attainment and intellectual capital by 1940 (Ferguson & Lamback, 2013). With each decade, the academic rigor and educational expectations for America's children increased to help meet the intellectual capital needed by businesses and organizations (Symonds et al, 2011; Ferguson & Lamback, 2013). Today, nearly 70 percent of high school graduates attend college but only 40 percent obtain an associate's or bachelor's degree by the age of twenty-five. Less than 30 percent of students who enroll in community college complete a degree within three years (Symonds et al., 2011).

Carnevale, Smith, and Strohl (2013) state there will be 55 million new jobs created between 2010 and 2020. For the jobs created, 65 percent will require some form of education beyond high school. Additionally, the authors identified the most new jobs will be created in the financial services (10 million), then wholesale and retail (7 million), followed by Government and public education services (6.7 million), and manufacturing (3.5 million).

In the field of manufacturing, Giffi et al. (2015) identified advanced manufacturing facilities were unable to fill 600,000 skilled positions because of an inherent skills gap in the industry in 2011, and expect the number to swell to 2 million jobs due to consumer demand of specialized products.

The goal of several government and private agencies is to position the U.S. as a global leader in the production of products and processes derived from scientific discovery and technological innovation, referred to as advanced manufacturing (PCAST 2011, 2014; NSTC, 2012; Manyika et al., 2011; Shipp et al., 2012; Banchiu et al., 2013; Giffi et al., 2015). These organizations include:

- The President's Council of Advisors on Science and Technology [PCAST, 2011 & 2014], is an advisory group of scientists and engineers appointed by the President to provide advice and make policy recommendations on a wide range of issues pertaining to science and technology.
- The National Science and Technology Council [NSTC, 2012], operates under the executive branch of the U.S. government and coordinates research and developmental strategies to form investment packages aimed at accomplishing national science and technology goals and funding related to the Environment, Natural Resources and Sustainability; Homeland and National Security; Science, Technology, Engineering, and Math (STEM) Education; Science; and Technology.

- The Institute for Defense Analyses (IDA) is a non-profit organization that operates three federally funded research and development centers to provide analyses of national security issues pertaining to science and technology while conducting related research on other national challenges (Shipp et al., 2012),.
- The Mckinsey Global Institute (MGI) is the business and economic research arm of McKinsey and Company. MGI operates under the mission to help leaders in the commercial, public, and social sectors develop a deeper understanding of the global economy and the information to derive decisions on management and policy issues. Recent research has focused on productivity, competitiveness, and growth; the evolution of global financial markets; and the economic impact technology has on the growth of productivity (Manyika et al., 2011).
- The Manufacturing Institute (MI) is an affiliate of the National Association of Manufacturers that is committed to delivering information and services to manufacturers in the U.S. and is the authority on attracting qualified talent to support the manufacturing industry (Giffi et al., 2015).

Importance of an Advanced Manufacturing Pathway

In a meta-analysis conducted by the IDA in 2012, Shipp et al. (2012) identified 23 definitions of the term “advanced manufacturing.” Through their review of the literature and interviews with more than 90 industry leaders and collegiate professors, they defined advanced manufacturing as:

> Manufacturing that builds on and encompasses the use of science, engineering, and information technologies, along with high-precision tools and methods integrated with a

> high-performance workforce and innovative business or organizational models, to improve existing or create entirely new materials, products, and processes (p. 19).

This definition will be used throughout the remainder of this document.

The U.S. has long thrived on its ability to produce goods and sell them in the global marketplace. The 20th century mantra of "build it here and sell it everywhere" enabled the U.S. to create a framework that provided economic growth while being the leading producer of manufactured goods in the world from 1895 to 2009 (PCAST, 2011). Presently, manufacturing firms employ approximately 10 percent of the nation's employees directly, and indirectly impact numerous organizations along its supply chain and financial sector (p. 2). Giffi et al. (2015) states, "Every dollar spent in manufacturing adds $1.37 to the U.S. economy, and every 100 jobs in a manufacturing facility creates an additional 250 jobs in other sectors. In short, manufacturing matters" (p. 2).

In 2010, the manufacturing industry generated nearly $1.7 trillion in Gross Domestic Product (GDP) and led all firms in the U.S. with exports of $1.1 trillion, or 86 percent of all U.S. goods shipped overseas in 2009 (NSTC, 2012). However, manufacturing as a product of GDP, declined from 27 percent in 1957 to 11 percent in 2009 (p. 4). Employment has fallen from 17.6 million jobs in 1998 to 11.6 million jobs in 2010 due to the movement of production facilities to other countries (PCAST, 2011). PCAST (2011) and Giffi et al. (2015) identified the skills and talents of employees, rather than the cost of labor, as the reason most frequently identified by manufacturing organizations to move production facilities offshore. What began with the loss of jobs in furniture, clothing, and textiles has resulted in the loss of high technology industries including, but not limited to, laptop computers, solar cells, semiconductors, flat panel displays, robotics, interactive electronic games, and lithium-ion batteries (Pisano & Shih, 2009). This resulted in a trade deficit of $17 billion in 2003, which widened to $81 billion in 2010 (PCAST, 2011). The trade deficit is staggering when considering that all of the high technology industries lost by the U.S. were invented in the U.S. (Pisano & Shih, 2009)

Compounding the challenge of manufacturing jobs being sent overseas, is the fact that the manufacturing trade itself has changed. Within the past few decades, manufacturing has evolved from a labor-intensive set of mechanical processes that consisted of workers standing in one spot controlling machines that drilled, cut, stamped, or milled products as they passed through the assembly line to a sophisticated set of information and technology based processes (Thomas, Barton, & John, 2007; Mital, et al., 2009; Shipp, et al., 2012). In a joint research effort conducted by the Manufacturing Institute and Deloitte (Giffi et al, 2015), they found that the public perceived manufacturing as an essential component of the nation’s economy, but only 37 percent of respondents said they would encourage their child to enter the field due to the dirty environment and lack of job security (Giffi et al., 2015).

Shipp et. al. (2012) identified three areas that highlight why the U.S. should adopt an advanced manufacturing framework to produce goods despite the negative public perception regarding advanced manufacturing: (1) advanced manufacturing provides the opportunity for high-quality, good-paying jobs in the U.S.; (2) a strong manufacturing sector enables research & development to synergize and create new products and design processes to further technological advancements; (3) domestic manufacturing using advanced technologies are vital to national security and; (4) an advanced workforce will require higher degrees of intellectual capital which also helps top strengthen society.

Research suggests the best model to foster a strong manufacturing sector is through collaborative partnerships with federal and state governments, industry, and secondary and higher education (Manyika et al., 2011; PCAST, 2011, 2014; NSTC, 2012; and Shipp et al., 2012; Banchiu, et al., 2013; Giffi et al., 2015). Therefore, focusing research on secondary education to help identify the strengths of relationships between the leadership actions of building principals and the skills students are learning to prepare them for careers in advanced manufacturing is a valid relationship to study at the micro level. This research may foster collaborative conversations among building and system leaders, industry, and state and federal government initiatives to support the development of advanced manufacturing skills in secondary education to help cultivate the intellectual capital needed by the industry.

Noted Gaps in the Research

The literature was rich in information indicating the importance of advanced manufacturing for the economy, society, national security. However, there was limited research regarding leadership to help expose and develop student skills in the field of advanced manufacturing. Specifically, literature was scarce regarding principal leadership of curricula programs that engaged the use of key hard skills required by advanced manufacturing organizations. Coates (2006) defined hard skills as skills that are, "Technical or administrative procedures related to an organization's core business" (p. 1). Small (2006), identified through his research of advanced manufacturing organizations that the most essential hard skills were computer aided design (CAD), computer numeric control (CNC) machines, and computer aided manufacturing (CAM). Despite limited literature related to the the opportunities secocndary students have to develop hard skills needed in advanced manufacturing, the literature was abundant with research that identified an overall skills gap between the advanced manufacturing industry and current applicants (Symonds et al., 2011; Manyika et al., 2011; PCAST, 2011, 2014; Shipp et. al., 2012; NSTC, 2012; Banchiu et al., 2013; Giffi et al., 2015).

Symonds et al. (2011) further identifies there is a21st century skills gap. Whether it is because of mathematical, oral and written expression, critical thinking, professionalism, or specific skills needed, high school graduates lack critical soft or 21st century skills for employment. The Glossary of Education Reform (2015) encompasses the definition of soft and 21st century skills as:

> A broad set of knowledge, skills, work habits, and character traits that are believed-by educators, school reformers, college professors, employers and others-to be critically important to success in today's world, particularly in collegiate programs and contemporary careers and workplaces. Generally speaking, 21st century skills can be applied in all academic subject areas and in all educational, career, and civic settings throughout a student's life.

For the remainder of this document, soft and 21st century skills will be combined into the term 21st century skills and will be defined by the definition provided by the Glossary of Education Reform (2015).

The lack of skilled employees (hard and 21st century) has taken a toll on the industry according to Giffi et al. (2015). They found advanced manufacturing firms were unable to fill 600,000 jobs in 2011 due to a skills gap between applicants and the needs of advanced manufacturing organizations. Current growth projections identify more than 2 million jobs will go unfilled in advanced manufacturing organizations by 2020.

Significance of the Study

This study provides valuable information for building and system leaders as they work to ensure all students are college and career ready, particularly in regard to obtaining the skills and knowledge correlated with careers in advanced manufacturing. The information obtained in this research will help enable school leaders to have knowledge on the significant impacts advanced manufacturing has on society, the economy, national security, and the expected job outlook for the future.

In a letter to congress dated February 15, 2012, the NSTC (2012) states, “Advanced manufacturing is a matter of fundamental importance to the economic strength and national security of the United States” (p. vii). Shipp et al. (2012) predicts that by 2032, advanced manufacturing will likely replace traditional manufacturing as it is known today. Within this shift, “an advanced manufacturing workforce will be needed to develop and maintain these advances in manufacturing” (Shipp et al., 2012, p. vii).

This research has the potential to guide system and building level leadership in secondary schools, to help ensure students possess the skills and knowledge to obtain careers in advanced manufacturing. The creation of a pipeline of intellectual capital needed by the advanced manufacturing industry may help facilitate regional efforts to attract advanced manufacturing organizations by having employees who possess the skills needed by the industry. The results of this study may empower principals to effectively implement curricula and instructional strategies in technology education courses to help ensure high school students are exposed to the appropriate curricula and necessary skill development needed by the advanced manufacturing industry.

Purpose of the Study

The purpose of this study was to explore the relationship between high school principals’ leadership actions and their perceptions on preparing students for careers in advanced manufacturing. This quantitative study, surveyed building principals with a responsibility of 600 or fewer students in grades 9-12, through an online survey using Survey Monkey. Specifically, the study investigated the software, tools, machines, and 21st century skills students are exposed to, and expected to master in technology education programs. This exploratory study investigated building principal self-reported information in leadership strategies and actions that support student development and mastery of the knowledge and skills needed by the advanced manufacturing industry.

The study was designed to address the following research questions regarding principal leadership actions to support student development and mastery of skills supporting student careers in advanced manufacturing:

1. What is the strength of the relationship between building principal support for preparing students for careers in advanced manufacturing and student use of tools and machines associated with the advanced manufacturing industry?
2. What is the strength of the relationship between building principal support of 21st century skills in high school technology education classes and the incorporation of those skills by technology teachers?

Limitations of the Study

The scope of this study was limited in the following ways. The population was limited to public high schools in New York State that contain 600 or fewer students based on the economy of scales research applied to secondary school settings by Lee and Smith (1997). Their research indicated that the ideal size of a high school building in regard to course offerings and student achievement occurred in buildings with student populations between 600 and 900 students (p. 3). In their research, high school populations below this threshold had fewer course offerings and less bureaucratic influence on the building and course offerings. This resulted in building principals having more control of the instructional program (p. 18-19). Conversely, in schools with 600 or more students, principals were much less likely to have a curricular role. This leadership was often the responsibility of a department chair or assistant superintendent of curriculum and instruction in schools of this size with more than 600 students. New York City principals were excluded from the study because the governance structure was substantively different from the rest of the state at the time research for this study was conducted (Schools, 2015).

The researcher sent out the survey to high school principals in New York State and had reason to believe a total of 378 principals received it and were afforded an opportunity to participate. The initial goal was for the survey to be sent to 389 building principals, but the opt-out feature in Survey Monkey prevented five principals from receiving the email through Survey Monkey and an additional six emails were bounced back due to undeliverable addresses. Between January 9, 2015 and March 23, 2015, an introductory email and five subsequent emails were sent to the total population of 378 principals describing the survey's purpose along with a link to complete the survey. The final email sent resulted in zero responses after a seven-day period. A total of 92 principals initiated responses to the survey, representing a response rate of 24 percent. Of the 92 respondents, eight were responsible for more than 600 students in their respective buildings and seven had not offered a technology education class since the 2009-2010 school year. Due to not meeting the requirements of the design of the study, these participants were thanked for their time and energy, were exited from the survey, and ultimately excluded from the sample. The final sample size was 77 respondents; representing a response rate of 20 percent.

Researcher limitations are inherent to this study with regard to the population that was chosen. The researcher made a deliberate decision to limit the population of this study to principals with 600 or fewer students in their respective high school. Additionally, New York City was excluded due to its vastly different governance structure at the time this study was conducted (Schools, 2015). However, studying high schools with 600 or fewer students is worthwhile because, according to the economies of scale research by Lee and Smith (1997), schools of this size are reflective of fewer course offerings and electives, and greater control of the academic program by the building principal. That being said, although comparing program opportunity across high school size is beyond the scope of this study, a limitation was established in the scope of the research to specifically look at a subset of high schools in New York State solely based on their student enrollment.

Key Terms and Definitions

Advanced Manufacturing: "Advanced manufacturing improves existing or creates entirely new materials, products, and processes via the use of science, engineering, and information technologies, high precision tools and methods, a high performance workforce, and innovative business or organizational models" (Shipp et al., 2012, p.4) .

Computer Numeric Control (CNC): "Computer Numerical Control (CNC) is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data. CNC can control the motions of the work piece or tool, the input parameters such as feed depth of cut, and speed" (Computer Numeric Control (CNC), 2015).

Hard Skill: "Technical or administrative procedures related to an organization's core business" (Coates, 2006, p. 1)

Middle-Skill Jobs: PCAST (2014) defines middle-skill level jobs as, "…those requiring the equivalent of a two-year degree, occupational license, or certification, typically with wages in the range of $40,000 and up" (p. 2).

Small Schools: "Schools that enroll less than 600 students" (Lee & Smith, 1997, p. 3).

Technology Education: The Commissioner's Regulations under Part 100.4 defines technology education, "as a program of instruction designed to assist all students in meeting State intermediate standards for technology" (NYSED, 2015).

21st Century Skills: "A broad set of knowledge, skills, work habits, and character traits that are believed-by educators, school reformers, college professors, employers and others-to be critically important to success in today's world, particularly in collegiate programs and contemporary careers and workplaces. Generally speaking, 21st century skills can be applied in all academic subject areas and in all educational, career, and civic settings throughout a student's life" (Glossary of Education Reform, 2015).

Summary

This chapter provided the background and overview of advanced manufacturing and the benefits and advantages it can provide for manufacturing organizations and the U.S. The significance of the study and the definition of terms used were provided to create a uniform understanding for the reader. Limitations of the study were also briefly described.

A review of the literature pertaining to advanced manufacturing comprises Chapter Two. This chapter provides a review of scholarly literature examined to create a clear understanding about how advanced manufacturing can benefit the society, economy, and national security of the U.S., the skills needed by advanced manufacturing employers to help the industry meet the most optimistic growth scenarios, and how high school principals can help play a role in ensuring students are exposed to the hard and 21st century skills needed by advanced manufacturing organizations.

The methodology used for this study is detailed in Chapter Three. This chapter describes the quantitative research design used in this study. High school principals in New York State, excluding New York City, who service 600 or fewer students were invited to participate in this study. This chapter focuses on the purpose of the study, research design, population and sample, sampling method, instrumentation used for data collection, organization and analysis of the data, ethical considerations, and limitations of the study.

Chapter Four is comprised of an analysis of the data collected by respondents (n = 77) through a multi-measurement survey instrument completed on the online survey site, Survey Monkey (www.surveymonkey.com). This chapter reveals the major findings related to the leadership actions of building principals to support the hard and 21st century skills required by the advanced manufacturing industry in which students are being exposed to in technology education classes.

Chapter Five consists of a discussion of the findings for the leadership actions of principals supporting student development of hard and 21st century skills related to advanced manufacturing, recommendations for policy and practice, and future research in the field of advanced manufacturing.

CHAPTER II: REVIEW OF THE RELEVANT LITERATURE

Introduction

Manufacturing systems are considered essential for the creation and propagation of wealth by most nations (NSTC, 2012). The U.S. currently has a manufacturing base that comprises 20% of its total gross domestic product and also provides for 30% of all traded goods (PCAST, 2011). Much of the world's low skill manufacturing once existed in the U.S. but now occurs in Asia and India. The U.S. has found it is not cost productive to produce the products that rely on low skill labor in the U.S. (Tassey, 2014).

The U.S. is undergoing a paradigm shift in manufacturing as it progresses from the post-World War II era of low skill employees who controlled machines that drilled, cut, stamped, or milled products as they passed through the effective and efficient assembly line, to one that is derived from scientific inquiry and technological innovation (PCAST, 2011). This shift in manufacturing processes improves production efficiency, quality and diversity of products, and helps prevent a potential loss of competitive advantage in the global marketplace through new technologies, high precision tools, and advanced materials (Mital, et al., 1999; Thomas et al., 2007; PCAST, 2011; Manyika et al., 2011; NSTC, 2012; Shipp et al., 2012).

For the benefits of advanced manufacturing to be fully realized, a more skilled workforce is needed to operate the technological systems and computers that will power and control the manufacturing processes (Shani, Krishan, & Thompson, 1992; Shipp et al., 2012). Employees will need at least a post-secondary credential or certificate or an associate's degree to obtain a job with a pay rate approximately 22 percent higher than traditional manufacturing (PCAST, 2011). The advanced manufacturing sector is currently creating jobs and is expected to sustain job growth (PCAST, 2011; Banchiu et al., 2013; Giffi et al., 2015). The lack of skilled employees has taken a toll on the industry according to Giffi et al. (2015). They found advanced manufacturing firms were unable to fill 600,000 jobs in 2011 due to a skills gap between applicants and the needs of advanced manufacturing organizations. Within the K-12 framework, building and system level leaders will need to ensure students have access to acquire the skills needed by the advanced manufacturing industry to earn a credential, associate's degree, or bachelor's degree after completing high school (PCAST, 2011; Banchiu et al., 2013; Giffi et al., 2015).

Current growth projections, identify more than 2 million jobs will go unfilled in advanced manufacturing organizations by 2020. Additionally, President Obama has pledged $500 million dollars each year since 2009 to help support advanced manufacturing recommendations made to him by NSTC and PCAST (Martino, 2011; Banchiu et al., 2013; Manyika et. al., 2011).

The purpose of this study is to explore the relationship between high school principals' leadership actions and their perceptions on preparing students for careers in advanced manufacturing. Specifically, this study will examine high school principals' support for incorporating 21st century skills and the use of tools and machines to support students for careers in advanced manufacturing in technology education programs.

The review of the literature is comprised of three sections. The first section will define advanced manufacturing and why it is important to the society, economy, and national security of the U.S. The second section will identify the technical (hard) and 21st century skills needed by employees in advanced manufacturing to ensure the industry can grow to meet the most optimistic high-growth scenario. The third section will identify the principal's role in creating localized pathways for students to pursue a career in advanced manufacturing.

Creating a Pathway to Advanced Manufacturing

According to the Organisation for Economic Cooperation and Development [OECD, 2014], the U.S. is ranked 13th out of 36 first world countries in high school graduation rates. Every year, at least one million students exit school before earning their high school diploma. For those who failed to graduate in 2010, the total lost lifetime earnings in wages, taxes, and work productivity will equate to approximately $337 billion (Perry & Wallace, 2012). The most common reason why students withdrew from school is because they felt classes were not interesting and were not going to prepare them to achieve their future goals (Symonds et al., 2011).

In addition, only 56 percent of students enrolling in a four-year college obtain their bachelor's degree within six years, and less than 30 percent of students enrolling in a community college successfully complete their associate's degree within three years (Symonds et al., 2011). "Our current system places far too much emphasis on a single pathway to success: attending and graduating from a four-year college after completing a program of study in high school" (Symonds et al., 2011, p. 24). By 2020, the U.S. will need to create 21 million jobs by 2020 to place unemployment at the government's level of acceptable unemployment (less than 5 percent) while supporting its growing population (Manyika et al., 2011).

According to Manyika et al. (2011), the best opportunity to lower unemployment rates is to focus on six sectors that have been identified as high growth for jobs in this decade (2010-2020): health care, business services, leisure and hospitality, construction, manufacturing, and retail. The combined employment of these sectors accounted for 66 percent of employment in 2010 and is expected to account for 85 percent of new jobs created by 2020 (p. 1). Within these sectors, approximately 12 million job-openings will be middle skill level jobs that will need to be filled by individuals with an associate's degree or occupational certificate (Carnevale et al., 2013). Middle skills jobs, as defined by PCAST (2011) are "…those requiring the equivalent of a two-year degree, occupational license, or certification, typically with wages in the range of $40,000 and up" (p. 2).

It is predicted by the year 2020, two out of three jobs created will require a post-secondary degree or credential (Symonds et al., 2011). Despite the expected number of job openings, Manyika et al. (2011) estimates an employee shortage of 1.5 million workers with bachelor's degrees or higher by the end of the decade while approximately 6 million Americans without a high school diploma will be unable to find a job. "The message is clear: in 21st century America, education beyond high school is the passport to the American Dream" (Symonds et. al., p. 2). Most importantly, an education beyond high school does not have to be a bachelor's degree. Associate's degrees and certificate programs can lead to future employment and success in numerous industries with middle-skill shortages (p. 3).

The goal of several government and private agencies is to focus on the high growth area of manufacturing in an effort to position the U.S. as a global leader in the production of products and processes derived from scientific discovery and technological innovation, referred to as advanced manufacturing (PCAST, 2011; Manyika et al., 2011; Shipp et al., 2012; NSTC, 2012; Banchiu et al., 2013; Giffi et al., 2015). Furthermore, these organizations claim that by combining new technologies, high precision tools and machines, and advanced materials, the U.S. can become a global leader in the field (PCAST, 2011; Shipp et. al., 2012; NSTC, 2012; Manyika et al., 2011; Banchiu et al., 2013; Giffi et al., 2015). To support this ambitious, but attainable goal, the U.S. will need to strengthen the relationship between federal and state governments, the manufacturing industry, and secondary and higher education to help ensure future employees possess a higher skill set than what has been needed in traditional manufacturing (PCAST, 2011; Shipp et al., 2012; Banchiu et al, 2013; Giffi et al., 2015).

Defining Advanced Manufacturing

The definition of advanced manufacturing, as it is used in this dissertation, was defined through a meta-analysis of the literature by Shipp et al. (2012). Through the authors research of the literature and interviews of more than 90 people in academia, government, and industry, a total of 23 different definitions ranging from holistic to extremely technical were identified. Reviewed definitions included “manufacturing techniques that use microelectronic technology” (Castrillon, & Cantorna, 2004); “advanced manufacturing is a computer-aided process that involves robotics, computer-aided design, computer-aided engineering, computer-aided manufacturing, computer-integrated process planning and computer numerical control machining” (Duffy & Salvendry, 2000); PCAST (2011) defined advanced manufacturing as:

> a family of activities that (a) depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or (b) make use of cutting edge materials and emerging capabilities enabled by the physical and biological sciences, for example nanotechnology, chemistry, and biology. This involves new ways to manufacture existing products, and especially the manufacture of new products emerging from advanced technologies (p. ii).

Through their analysis, Shipp et al. (2012) created the following definition that will be used for the remainder of this document:

> Advanced manufacturing builds on and encompasses the use of science, engineering, and information technologies, along with high precision tools and methods integrated with a

> high-performance workforce and innovative business or organizational models, to improve existing or create entirely new materials, products, and processes (p. 19).

The most significant difference between the definition created by the Shipp et al. (2012) and the other definitions was the necessity to have a high-performance workforce to support advanced manufacturing. Advanced manufacturing cannot exist without a talented and competent workforce (PCAST, 2011; NSTC, 2012; Shipp et al., 2012; Giffi et al, 2015). Therefore, the definition derived by Shipp et al. (2012) was the most encompassing and fully representative of the advanced manufacturing industry in the literature.

The Resurgence of Manufacturing in the U.S.

In 2011, PCAST (2011) argued the importance of transitioning the U.S. manufacturing sector from low-skill, inexpensive products, in which the U.S. is not capable of competing, to manufacturing that is derived from scientific innovation (p. 9). PCAST (2011) believed placing an emphasis on manufacturing that required advanced machinery and higher skill and knowledge level from the operator, is how the U.S. may become a global leader in manufacturing (p. 3). Successfully transitioning to an advanced manufacturing environment will require employees to possess a higher skill set than traditional manufacturing (p. 9).

Industry leaders see the potential for manufacturing to make an extensive comeback in the U.S., especially when advanced manufacturing technologies are implemented (NSTC, 2012; Manyika et al., 2011; PCAST, 2011, Banchiu et al., 2013; Giffi et al., 2015). Between 2001 and 2010, more than 64,000 factories nationwide closed their doors resulting in nearly 5.7 million employees losing their jobs (Molnar, 2014). However, Giffi et al. (2015) discovered that employers in the U.S. were unable to fill 600,000 skilled positions in advanced manufacturing since 2011 due to an inherent gap of hard and 21st century skills. Two theories by Banchiu et al.

(2013) regarding the shortage of employees were: (1) regions did not align training credentials and certifications to industry needs and; (2) the elimination of high school manufacturing courses during the recent recession did not expose students to the field as it had traditionally (p. 2). These factors, in addition to manufacturing being perceived as dangerous and dirty, have helped to create a perception that careers in the field are not sustainable and should not be pursued (Giffi et al., 2015).

Despite the reduction of employees in the manufacturing sector, U.S. exports have risen five times faster than those of other advanced nations and three times faster than emerging Asian nations (Tassey, 2014). The five traditional manufacturing sectors (chemicals, machinery, electrical equipment, plastics and rubber, and fabricated metals) had a 23 percent reduction in productivity while the five large research and development sectors that encompass advanced manufacturing (semiconductors, communications equipment, computers, pharmaceuticals, and medical devices) had an average growth of 27 percent (p. 28).

Tassey (2014) predicts a positive future outlook in jobs, long-term growth, and salaries for employees in advanced manufacturing. Manufacturing organizations are beginning to move their manufacturing operations from offshore locations back to the U.S. to improve quality control and better serve their customers (p. 10). According to Manyika et al., (2011), the manufacturing sector was hit the hardest during the recession, losing nearly 2 million jobs due to automation, process redesign, and offshoring. Since the most recent recession ended, the manufacturing sector has increased employment by 1.8 percent each year to create more than 300,000 jobs. This is the strongest growth for the manufacturing since the 1980’s (Manyika et al., 2011).

Two bright spots for the U.S. in advanced manufacturing growth are in New England and Michigan. New England is on the cusp of creating 7,500 to 8,500 jobs each year with an average salary of $80,000 if the advanced manufacturing sector in the region can recruit employees with the skills needed by the industry (Jackson, 2015). In Michigan, advanced manufacturing growth has been promising as an estimated 65 percent of the state's manufacturing jobs in 2007 and 72 percent in 2009 were in advanced manufacturing (PCAST, 2011).

A parallel increase to the growing demand for advanced manufacturing will be for the U.S. to employ more robotic operations to increase its competitive advantage against several nations including Japan, Germany, Switzerland, and Sweden (Shani et al., 1992). A more skilled workforce will be needed to operate the new technological systems and computers that will power and control the advanced manufacturing industry in order to create and maintain a competitive advantage with other industrialized nations (Shani et al., 1992; Shipp et al., 2012).

Advanced Manufacturing as an Economic and Societal Driver in the United States

DeRuntz and Turner (2003) note advanced manufacturing is a critical competitive tool in the global economy to infiltrate new product markets, shorten product life cycles, and increase the amount of customer customization for a product. According to the authors, the benefits of advanced manufacturing can be classified as tangible and intangible (p. 6). The tangible benefits, which are quantifiable, include inventory savings, increased efficiency of floor space, increase of a corporation's return on investment, and reduced unit costs (p. 6). The intangible benefits, which are difficult to quantify, include an enhanced competitive advantage, increased flexibility, improved product quality, and faster response to customized customer demands (p. 7).

As manufacturing continues to grow at its fastest pace in more than a decade, creating more economic value for each dollar spent than any other sector in the U.S., products will be required to come to market faster (Gershenfeld, 2014). One advanced manufacturing technology that is bringing products to market faster is 3-Dimensional printing. This process enables manufacturers to have the ability to bring production concepts to small-scale production and testing in minutes instead of months. One analyst has projected the economic impact of this emerging technology as the fourth industrial revolution (Tassey, 2014).

If advanced manufacturing organizations bring more products to market faster, the standard of living will increase because more goods and services are being produced (Bevins et al., 2012). The role of advanced manufacturing is continuing to strengthen the world's economy while accounting for 16 percent of the global Gross Domestic Product (GDP) and 14 percent of employment (Tassey, 2014). Advanced manufacturing has enabled organizations to increase their flexibility, reduce lead time on production runs, increase machine utilization, reduce unit costs, and reduce labor costs which have led to increases in production capacity (Zammuto & O'Connor, 1992; Thomas, et al., 2007).

Future Growth of Advanced Manufacturing

Shipp et al. (2012) has identified four advanced manufacturing sectors which they believe will have the greatest impact on improving existing materials, products, and processes or creating entirely new materials, products, and processes. The four areas are semiconductors, including nanotechnology; advanced materials; additive manufacturing; and biomanufacturing, with a focus on synthetic biology (p. 19). Shipp et al. (2012) selected these categories because they have the potential to fundamentally change how we use and integrate products into our lives by the year 2030. Each of these areas represent the overarching themes of advanced manufacturing through mass customization platforms upon which other technologies or processes can be built, are crucial to national security, and have a high level of research and development capital already invested (p. iv).

Semiconductors and Nanotechnology

Semiconductors are essential for information technology and generate $300 billion in revenue annually with manufacturing occurring in over twenty countries (Shipp et al., 2012). As the keystone of the information technology economy, semiconductors support the $2 trillion electronics market and an additional $6 trillion in the service industry (p. 24). Shipp et al. (2012) predicts advances in mobile computing and cloud based connectivity will enable trillions of devices to be connected by embedded sensors. This will enable intelligent and adaptive cyber environments to exist and impact every aspect of our lives (p. 25). A significant component in semiconductor manufacturing is in the area of nanotechnology.

Nanotechnology is expected to impact everything we, as humans, use in our daily lives. It has expanded past the discovery phase and into the application and commercial production phase requiring a knowledgeable and skilled workforce capable of supporting and furthering its developmental potential (Jiao & Barakat, 2012). In 1959, a theoretical physicist named Richard Feymann challenged fellow scientists to consider the possibility of manipulating matter at the molecular and atomic levels to build ultra-small machines and information storage devices (Holley, 2009).

Jiao and Barakat (2012) accurately predicted the nanotechnology field to require 2 million workers in the United States by 2015. Their estimate was based upon the growth model in which the U.S. government has invested $21 billion since 2001, with $1.5 billion being spent since 2008 in the president’s budget on the National Nanotechnology Initiative. The National Nanotechnology Initiative [NNI, 2015] was established in 2000 as part of the United States

Government’s research and development initiative supporting nanotechnology-related activities of 20 departments and independent agencies, including, but not limited to, Department of Defense (DOD), Department of Justice (DOJ), Department of Transportation (DOT), Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), Department of Energy (DOE), and Department of Homeland Security (DHS).

The vision of NNI (2015) is a future in which the ability to understand and control matter at the nanoscale level leads to a revolution in technology and industry that benefits society. NNI (2015) serves as the catalyst to, “expedite the discovery, development, and deployment of nanoscale science, engineering, and technology to serve the public good through a program of coordinated research and development aligned with the missions of the participating agencies” (NNI, 2015). The goals of NNI (2015) are to (1) “advance a world-class nanotechnology research and development program; (2) foster the transfer of new technologies into products for commercial and public benefit; (3) develop and sustain educational resources, a skilled workforce, and a dynamic infrastructure and toolset to advance nanotechnology; and (4) support responsible development of nanotechnology.”

Holley (2009) defines nanotechnology as, “...an empowering catalyst that unlocks latent and unique properties in existing elements through molecular manipulation using scanning probe microscopy, crystalline growth, and high temperature processes” (p. 17). Most importantly, Holley (2009) states new materials that result from nanotechnology have a “general purpose” utility for combining with other materials to optimize their “physical, thermal, magnetic, electrical, and optical properties and for creating devices that operate the cellular level for biological and medical purposes” (p. 17). Holley (2009) further believes that due to the “general purpose” utility of nanotechnology, it will redefine nearly everything we use in our daily lives.

Advanced Materials

Advanced materials represent new or innovative structures upon which new products can be developed or existing products may be significantly improved upon (Shipp et al.,2012). From the dawn of bronze and iron in ancient times to Kevlar, advanced materials continue to be invented and incorporated into everything from household products to defensive applications for the armed forces (p. 23). Advanced materials are invested heavily among manufacturing research and development departments due to the extremely high payoff they can have by being the first to market while simultaneously creating or maintaining a competitive advantage in the global marketplace (p. 31).

Additive Manufacturing

Traditional manufacturing often involves subtractive properties to develop a product by removing unwanted material by cutting or drilling to achieve the desired results (Shipp et al., 2012). Additive manufacturing works in the opposite manner. The process of building a product by additive manufacturing requires manufacturers to use advanced manufacturing machines to build products without the creation of waste. A popular method to complete the additive manufacturing process is through 3-dimensional printers (Tassey, 2014). Through the use of 3-dimensional printers, manufacturers have the ability to bring production concepts from small-scale production and testing in minutes instead of months without wasting material. Tassey (2014) has projected the economic impact of additive manufacturing, through 3-dimensional printing, will bring about the fourth industrial revolution. In 2010, additive manufacturing equipment sales were approximately $1.2 billion, but the small industry is rapidly growing to meet industrial demands of creating customized components in a fraction of the time of subtractive manufacturing, while reducing production waste (p. 37).

Biomanufacturing

Biomanufacturing represents the largest and most distinguishable area of advanced manufacturing. It has the potential to revolutionize the entire medical industry and transform how an individual perceives and receives medical treatment. Shipp et al., (2012) defines biomanufacturing as, "...harnessing living systems to produce desired products by purifying a natural biological source (e.g., penicillin from mold) or by genetically engineering an organism or plant to produce a byproduct" (p. 43). When bringing products to market to treat patients, especially with pharmaceuticals, products are designed on a case-by-case basis through trial and error (p. 44). Synthetic biology is a derivative of biomanufacturing and builds upon the current nature of genetic engineering and metabolic engineering through the incorporation of information technology to wire biological parts together. This creates a circuit that allows the control and function of cells for a specified entity (p. 46). If successful, synthetic biology will factor into several manufacturing sectors including pharmaceuticals, biofuels, environmental sensors, agriculture, biological computing, and materials production (p. 44).

Research and Development

PCAST (2011) states, "Aside from providing jobs, a strong manufacturing sector is essential if the United States is to remain the world's leader in knowledge production and innovation" (p. 11). In research conducted by Deloitte and the Manufacturing Institute (Giffi et al., 2015), the skills and talents of employees, rather than the cost of labor, was the reason most frequently identified by manufacturing organizations to move production facilities offshore, as reported by 400 CEOs and senior manufacturing executives. What began with the loss of low jobs in furniture, clothing, and textiles has resulted in the loss of high skills jobs in technology industries including, but not limited to, laptop computers, solar cells, semiconductors, flat panel displays, robotics, interactive electronic games, and lithium-ion batteries (p. 5). The loss of high skill jobs in the technology industry has helped to contribute to the trade deficit of $17 billion in 2003, which widened to $81 billion in 2010 (PCAST, 2011). The trade deficit is staggering when considering that all of the high technology industries lost by the U.S. were invented in the U.S. (Pisano & Shih, 2009).

There is a critical corporate link associated with the importance of having research and development and manufacturing in the same country (Tassey, 2014). Research and development is the backbone of advanced manufacturing as it accounts for 70% of all spending in the U.S. and 60% of the industry's scientists and engineers (Tassey, 2014; NSTC, 2012). Globally, the economy spent approximately $1.4 trillion dollars in research and development in 2013 (Tassey, 2014). As global competitiveness continues, it is expected that more spending will ensue to help maintain a company's competitive advantage in the marketplace.

As manufacturing organizations in the U.S. have shifted their production facilities offshore, the U.S. lost intellectual capital related to the product being produced, and therefore has fallen behind China, Korea, Taiwan, and Japan in innovative products related to high technology industries (NSTC, 2012). Pisano and Shih (2009) identified a domino effect that exists when manufacturing moves offshore from where research and development occur. In order to continually improve an existing product, engineers must have frequent interactions with the physical manufacturing department. When the engineers lose the ability to interact, they cannot create new processes. Without creating new processes, the product becomes stagnant and cannot be improved upon, and therefore is passed by its competitors. PCAST (2011) states, "The nation's long-term ability to innovate and compete in the global economy greatly benefits from co-location of manufacturing and manufacturing related research and development activities in the U.S. The loss of these activities will undermine the U.S.'s capacity to invent, innovate, and compete in global markets" (p. 12).

National Security

The NSTC (2012) found manufacturing to be a critical component for the U.S. on a strategic timescale during times of war. The NSTC (2012) states the U.S. cannot become dependent on a foreign industrial base of manufacturing during critical times that require an "effective and sufficient supply chain that is not vulnerable to foreign policies and demands" (p. 19). As noted in the importance of research and development in the creation of future products, national security is also at risk. PCAST (2011) states that relocating the U.S.'s intellectual capital and talent out of the country to manufacture goods will continue to expose technology and innovate practices to other nations which can be copied or stolen easily.

Advanced Manufacturing's Necessity for Intellectual Capital

In order for the high growth areas of semiconductors, advanced materials, additive manufacturing, and biomanufacturing to reach their full potential, they must have the necessary intellectual capital to help maximize the potential of these divisions of advanced manufacturing (Shipp et al., 2012; Tassey, 2014). Unlike the U.S., Germany has made it a priority to connect their government initiative of advanced manufacturing to secondary schools and higher education to help create a continuous supply chain of intellectual capital to the workforce (Molnar, 2014). An essential component to ensure that the U.S. is a global leader in advanced manufacturing is having a high performing workforce (PCAST, 2011; NSTC, 2012; Shipp et al., 2012; Giffi et al., 2015). Student exposure to the field of advanced manufacturing through curricula and hard skills training before graduating high school will be essential if growth in advanced manufacturing is to continue on its projected path (Bevins, et al., 2010).

Current literature recommends manufacturing organizations work with K-12 schools, higher education, and vocational or certificate programs to create curricula emphasizing manufacturing and the skills needed by the advanced manufacturing industry to help reach the most optimistic high growth projections (PCAST, 2011; Banchiu, 2013; Giffi et al., 2015).

Castrillon and Cantorna (2005) state advanced manufacturing organizations should support educational programs aligned to their needs for two important reasons. First, the industry is anticipating a shortage of two million employees by 2020 (Giffi et al., 2015). Second, a highly capable workforce will help increase a company's competitive advantage while enabling the organization to have greater flexibility in its operations. Additionally, costs may be reduced while the overall quality of products produced will increase (Castrillon & Cantorna, 2005).

Mital et al. (1999) identified industry leaders, such as IBM, Xerox, and General Motors, which have begun to, or have already identified personnel as an integral part of a highly skilled manufacturing workforce. The authors' research suggests employees must be capable of working in teams to increase collaboration and competitiveness internally and externally of an organization (p. 176). These organizations have shifted away from complete automation because they have learned the value of a highly skilled and cognitively capable manufacturing workforce (p. 175). They desire employees capable of interacting and programming advanced manufacturing equipment to increase their profitability. Despite the unique variations of every advanced manufacturing organization, most operate under an umbrella set of skills (Giffi et al., 2015). In a recent study investigating the most important hard skills used by advanced manufacturing firms, Small (2006) found 85 percent used CAD, 73 percent used CNC, and 74 percent used CAM.

The changes in advanced manufacturing technology require improved human skills in both cognitive and psychomotor areas (Mital, et al., 1999). Developments in technology have enabled organizations to produce goods at an increased rate with more automation. With an increase in automation, employees are relieved of basic, monotonous activities, leaving more complex and difficult tasks to be completed by an individual or a team as they are confronted with a continuous flow of significant amounts of information (p. 177). With the increase in the amount of information, employees must make active use of the computers controlling the machines and traditional hand tools to make adjustments and repairs as needed to maximize production and reduce down time (p. 179).

Thomas et al. (2007) states corporations should not be deterred from incorporating advanced manufacturing technologies because the costs of the systems in conjunction with training employees will be too much of a financial burden for corporations to sustain and remain competitive. Furthermore, the authors state the pressures of mass customization, globalization, and outsourcing, while maintaining quality is impossible to achieve without advanced manufacturing technologies (p. 156). Intellectual capital cannot, and must not, be the barrier to improving performance and productivity. An organization must always be willing to invest in its most valuable resource - intellectual capital (Mital et al., 1999). Training is an essential and necessary component of every organization, from schools to advanced manufacturing organizations. Employees need, "...specific, consistent, and standardized on-site training programs if an organization is going to remain competitive while meeting the demands and goals of the organization in which they are employed" (Mital et al. 1999, p. 175).

Banchiu et al. (2013) identified the need for corporations to make investments in educational institutions – high schools, community and four-year colleges, certificate programs, and vocational schools – to help foster the development of skills employees will need to obtain employment in the advanced manufacturing sector. Technology has long been viewed as a source of competitive advantage in the manufacturing industry when supported with an intellectually capable workforce (Mital et al., 1999). Therefore, Duffy and Salvendry (1999) recommend every employer make sure they have recruited the most cognitively capable employees in order to have the greatest likelihood of solving problems efficiently and effectively in order to maximize earnings through reducing production lead-times, facilitating mass customization, and becoming a global competitor (Mital et al., 1999).

Advanced manufacturing requires human support in order to work effectively. Employees must be cognitively engaged throughout their work cycle while paying substantial attention to detail (Wall et al., 1990; Koubek et al., 1999). Koubek et al. (1999) identified every advanced manufacturing process is unique in its own right. Each system requires employees to have a greater depth of skill and knowledge in order to solve problems and prevent errors from occurring, or immediately correct them as soon as they surface. Machines used in the advanced manufacturing industry require employees to be much more cognitively engaged throughout the production process than traditional manufacturing (Wall et al., 1990).

Employers noted the greatest challenge they will experience by not having a skilled workforce will be the inability to meet production needs of their customers (p. 10). Banchiu et al. (2013) conducted a survey of 150 advanced manufacturing employers in Oakland County, Michigan. The results identified three universal needs for educational institutions to address to help produce more qualified employees. The industry asked educational institutions to (1) increase student technical knowledge of advanced manufacturing processes; (2) focus on technical (hard) skills instead of personal competencies and 21st century skills and; (3) student knowledge of CNC machines is one skill that spans multiple occupations in advanced manufacturing and is an essential component to advanced manufacturing.

Manyika et al., (2012) states the U.S. spends more than $300 billion annually on postsecondary education and job training programs, yet employers still have a hard time finding employees with specific skills they require in the STEM fields, including advanced manufacturing.

21st Century Skills

The literature has identified a deficiency in the hard skills employees need for employment with advanced manufacturing organizations. Symonds et al. (2011) stated in order to close the skills gap, an equal emphasis needs to be placed on hard and 21st century skills. Several bodies of research have supported the statement by Symonds et al. (2011), noting it is equally important to have students career ready by fostering 21st century skill development as it is to possess hard skills needed by every industry, including advanced manufacturing (PCAST, 2011; Hodge & Lear, 2013; Banchiu et al., 2013; Carnevale et al., 2013; Rosenbaum & Rosenbaum, 2015; Giffi et al., 2015; Partnership, 2008). As mentioned previously, 21st century skills are defined by the Glossary of Education Reform (2015) as,

> A broad set of knowledge, skills, work habits, and character traits that are believed-by educators, school reformers, college professors, employers and others-to be critically important to success in today’s world, particularly in collegiate programs and contemporary careers and workplaces. Generally speaking, 21st century skills can be applied in all academic subject areas and in all educational, career, and civic settings throughout a student’s life.

As identified in the definition by the Glossary of Education Reform (2015), 21st century skills can be applied to all subject areas, careers, and civic settings during a student's progress from high school, college, and the world of work. The Partnership for 21st Century Learning (Partnership, 2008) began with a network of founding organizations that included Time Warner, SAP, Apple Computers, Microsoft, and Cisco. These organizations came together to create four student outcomes all students needed to master to be successful in the workplace and in life. These outcomes included (1) core subject knowledge; (2) learning and innovation; (3) information, media, and technology skills; (4) life and career skills.

In research conducted by Hodge and Lear (2011), they sought to determine if results of the research conducted by The Partnership for 21st Century Learning (2008), National Association of Colleges and Employers [NACE, 2009], and the American Management Association [AMA, 2010] would correlate to their survey of college professors and students rankings of the most important 21st century skills needed by organizations. The surveys conducted by the three aforementioned organizations and Hodge and Lear (2011) focused on entry-level employability across all sectors of employment. According to the surveys of the aforementioned organizations, teamwork, communication, and the ability to think critically were nearly synonymous across all of the data collected.

In 2015, in a partnership between Deloitte and the Manufacturing Institute (MI), Giffi et al. (2015) sought to find the skills most deficient in new employees by advanced manufacturing employers. Their research indicated the most serious skill deficiencies were (1) computers skills; (2) poor problem solving capability; (3) poor math skills and; (4) poor work ethic (attendance, timeliness, etc.). The data suggests a disconnect exists between the 21st century skills required by most sectors needed to gain successful entry into the workplace and those needed by advanced manufacturing organizations as seen in Table 2.1.

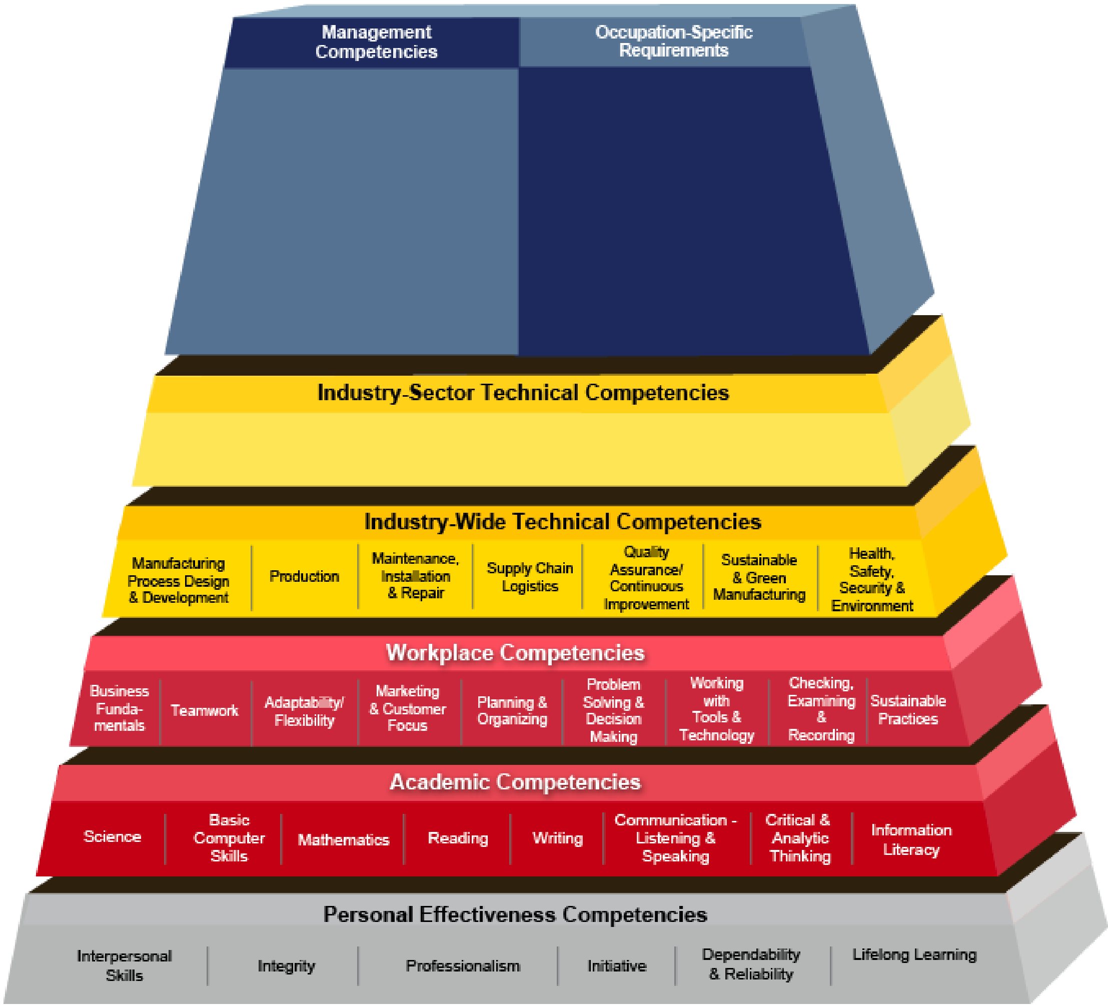
Table 2.1

Comparison of the Top Rated Skills of Six Surveys

21st Century Skills Survey (2008)	**NACE (2009)**	**AMA (2010)**	**Hodge & Lear Faculty (2011)**	**Hodge & Lear College Students (2008)**	**Deloitte & MI (2013)**
Communication	Communication	Communication	Communication	Management	Computer skills
Teamwork	Teamwork	Teamwork	Critical thinking	Communication	Problem solving
Ethics/Social Responsibility	Analytical	Critical thinking	Problem solving	Teamwork	Math skills
Professionalism	Technical	Creativity/ Innovation	Teamwork	Time management	Work ethic

The Manufacturing Institute (Giffi et al., 2015) set out to create a set of advanced manufacturing industry skills that would be synonymous across the entire industry. The pyramid model, developed by managers for managers, was first created in 2006 and then revised in 2012 with additional benchmarks. The pyramid is comprised of six levels. According to The Department of Labor (2012), the skills in the first two levels are necessary for all sectors of manufacturing that include, but are not limited to, dependability, willingness to learn, reading, writing, and math skills, effective oral and written communication, and basic computer skills. The third level represents a higher degree of skills than middle level skills needed to enter the advanced manufacturing sector. This level requires employees to have knowledge of accounting and corporate operations, teamwork, adaptability, marketing, planning, problem solving, and the implementation of the appropriate technology to solve a problem. The fourth and fifth levels of competencies are occupationally specific to the specific organization and require employees to hold advanced certificates in a specified field or bachelor’s degree. High-demand occupations are matched with specific industry certifications in areas including, but not limited to machinists, welders, fabricators, logistics engineers, and mechatronics. The focus at this level is to ensure the bottom line of the company remains strong through production development, maintenance, supply chain logistics, quality assurance, and health and safety. The final tier of the pyramid is related to managerial competencies and often requires higher levels of degrees including master's and doctorate's. The full pyramid can be seen in Figure 1.

Figure 1: Advanced Manufacturing Competency Framework



(Department of Labor, 2011, p. 1)

Principal Leadership In Creating an Advanced Manufacturing Pathway

Thus far the literature has identified the benefits advanced manufacturing has on the economy, society (DeRuntz & Turner, 2003; NSTC, 2012; Manyika et al., 2011; PCAST, 2011; Banchiu et al., 2013; Tassey, 2014; Giffi et al., 2015; Jackson, 2015) and, national security (PCAST, 2011; NSTC, 2012). This, coupled with the need to fill at least two million jobs by 2020 (Banchiu, et al., 2013; Giffi et al., 2015), and the recommendation for government, industry, and education to work together (PCAST, 2011; Banchiu et al., 2013; Giffi et al., 2015), means that building principals may be asked to play a role in the development of hard and 21st century skills in high school students in technology education classes to help meet the needs of the advanced manufacturing industry.

If high schools are going to help align their technology education curriculums with the needs of the advanced manufacturing industry and higher education change as recommended by PCAST (2011), Banchiu et al. (2013) and Giffi et al. (2015), school leaders will need be leaders throughout the change process. Leadership has been show to be essential to help ensure a successful change occurs (Dufour & Marzano 2011; Fullan, 2008; Kotter & Cohen, 2002; and Waters, Marzano, & McNulty, 2003). In the K-12 educational setting, principals are considered the lynchpin for student success and are a recurring variable in nearly every study regarding successful schools (Gano-Phillips et al., 2011; Campbell, 2012; Provost, Boscardin & Wells, 2010; Waters et al., 2003; Rogers, 2007; Wenig, 2004; White-Smith & White, 2009). The leadership of the building principal can create a positive and stimulating environment for students to learn or one that is detrimental to the building and district's mission and vision (Wenig, 2004).

In a meta-analysis of every study that measured the relationship between leadership and student achievement since the 1970's, Waters et al. (2003) found the building principal as the second most influential individual to impact a student's achievement after the student's classroom teacher. Ultimately, principals set the climate of the school while developing and fostering collaborative relationships to help an initiative succeed (Praisner, 2003; Rogers, 2007; Kelley, 2010).

Today's building principals are responsible for day-to-day operational challenges that include demands from a number of stakeholders, managing and implementing curricula changes, allocating resources, hiring, supporting, and maintaining faculty and staff, all while meeting the highest expectations for student achievement and teacher performance during the current standards movement (Gano-Phillips et al., 2011; Rogers, 2007; Provost, Boscardin, and Wells 2010; Wenig, 2004; NYSED, 2012). During this immensely challenging time for school leaders, White-Smith and White (2009) stress that principals must balance meeting the educational mission and vision of the district while following through on their own missions to help prepare all students to be college and career ready. Feller (2011) states that the growing emphasis on math and English scores, has created and inverse relationship with ensuring students possess the hard and 21st century skills required by professional organizations.

Technology Education in New York State

Furthering the challenges to provide all students with the hard and 21st century skills they need for the advanced manufacturing industry is the fact that New York State does not have have an advanced manufacturing pathway established. Dettelis (2011), states that New York has been operating under times of fiscal stress with a technology education department that could play a much larger role in helping students become more competitive in the global marketplace.

According to the New York State Education Department's Educational Framework for Technology Education, their long term strategic plan that was written in 2006, expired in 2010 and has yet to be updated (NYSED, 2006). The NYSED (2006) document states the following

> Various events over the last 10-15 years have combined to create an environment not friendly to technology education in schools…turnover by school district administrators has created administrators unaware of the potential and value of technology education programs. Recent changes to Commissioner's Regulations and revised graduation requirements have turned the system into a patchwork…Recent efforts to create awareness about and value for technology education have been less then successful…Not addressing the concerns of the school district and governmental agencies will lead to the demise and eventual extinction of these subjects that support the positive developmental aspects of every student (p. 1-4).

According to the document posted by NYSED (2006), there is little support at the state level for creating a pathway for advanced manufacturing. Therefore, localized system and building level leaders will be essential in helping to create a curriculum and pathway to provide students with the hard and 21st century skills they will need for to help make them college or career ready in the field of advanced manufacturing.

Summary

Advanced manufacturing is growing at a rate unseen for decades in the United States. PCAST (2011) has argued the importance of refocusing the U.S. manufacturing processes from a focus on low skill, inexpensive products, in which the U.S. is not capable of competing, to manufacturing that is derived from scientific innovation-more commonly referred to as advanced manufacturing. To accomplish this goal, a greater emphasis must be placed on preparing students for this career, especially in high school. More than 600,000 advanced manufacturing jobs were unfilled in 2011 in the U.S. This number is expected to grow to 2 million jobs by 2020 (Giffi et al., 2015).

To help prepare students for these careers, building principals will need to expand their focus from accountability measures of college and career readiness based upon math and English scores to a leveraging of practices that will expose and prepare students for careers in advanced manufacturing by placing a greater emphasis on the hard and 21st century skills most needed by advanced manufacturing organizations. Advanced manufacturing has the potential to positively impact the U.S. society and economy while enabling organizations to increase their competitive advantage by bringing products to market faster and creating more customized consumer products.

At the heart of advanced manufacturing is a well-trained, intelligent, and effective work force. The most cited reason by industry executives and Chief Executive Officers (CEO) for relocating manufacturing facilities offshore was due to a lack of skilled employees, not the cost of labor (Giffi et al., 2015). The loss of high technology industries including, but not limited to, laptop computers, solar cells, semiconductors, flat panel displays, robotics, interactive electronic games, and lithium-ion batteries (Pisano & Shih, 2009) resulted in a trade deficit of $17 billion in 2003, which widened to $81 billion in 2010 (PCAST, 2011). The trade deficit is staggering when considering that all of the high technology industries lost by the U.S. were invented in the U.S. (Pisano & Shih, 2009).

The trade gap that widened to $81 billion in 2010 must be addressed in a timely manner because the U.S. will continue to be under pressure from industrialized nations as they begin producing more products through advanced manufacturing technology as well. For building principals, this means not only ensuring accountability measures are met by all graduates. But also ensuring all students are exposed to the hard and 21st century skills that will be needed by the high growth industry of advanced manufacturing that is currently only being slowed down by an inability to find qualified employees.

CHAPTER III: METHODOLOGY

Introduction

The purpose of this study was to explore the relationship between high school principals' perceptions on the necessity to prepare students for careers in advanced manufacturing and the software, tools, machines, and skills students are exposed to in technology education classes. Specifically, this study examined high school principal leadership actions for incorporating 21st century skills, and the use of tools and machines to support a pathway for careers in advanced manufacturing for students.

The study was designed to answer the following research questions:

1. What is the strength of the relationship between building principal support for preparing students for careers in advanced manufacturing and student use of tools and machines associated with the advanced manufacturing industry?
2. What is the strength of the relationship between building principal support of 21st century and advanced manufacturing skills in high school and the incorporation of those skills by technology education teachers?

Research Design

The research design used two levels of analysis: A descriptive methodology to describe the holistic nature of the data set and a relational methodology to further examine relationships among variables. Creswell (2009) suggests the best way to determine the strength of the relationship between two variables is through a quantitative design, thus a quantitative methodology was employed. Variables were selected based on the literature regarding the skills, abilities, and knowledge needed by the advanced manufacturing industry. Specifically, this study examined:

1. The strength of the relationship between principal leadership and technology education classes that use computers, tools, and machines to prepare students for a career pathway aligned to the advanced manufacturing industry.
2. The strength of the relationship between principal leadership and technology education classes that incorporate 21st century skills aligned to a career pathway in the advanced manufacturing industry.

Sample and Sampling Procedures

The population for the study was defined as all New York State public high school principals responsible for students in grades 9-12 in New York State, excluding New York City, with building populations of 600 or fewer students.

Economy of scales research applied to secondary school settings by Lee and Smith (1997) indicated that the ideal size of a high school building in regard to course offerings and student achievement occurred in buildings with student populations between 600 and 900 students (p. 3). In their research, high school populations below this threshold had fewer course offerings and less bureaucratic influence on the building and course offerings. This resulted in building principals having more control of the instructional program (p. 18-19).

Based upon the research of Lee & Smith (1997), building principals with a responsibility for 600 or fewer students in grades 9-12 were selected for two primary reasons. First, building principals in schools with 600 or fewer students are more likely to have a close working relationship with the curriculum, instructional practices, and assessments teachers use when compared with buildings with more than 600 students. Buildings with student populations greater than 600 students will often have department leaders and/or an assistant superintendent for curriculum and instruction overseeing curricula changes instead of the building principal, thus creating a greater distance between principal knowledge of teacher practice. Second, schools with more than 600 students often have more electives and resources for students in high school than schools with 600 or fewer students. This enables schools with more than 600 students to provide more college and career pathway opportunities than schools with 600 or fewer students (Lee & Smith, 1997 and Nguyen, 2004). Given there is a positive relationship between an increase in high school building populations and the number of course offerings, it is this researcher's intent to investigate the curricula and availability of computer software, tools, and machines associated with careers in advanced manufacturing students have access to in schools with 600 or fewer students.

Ultimately, for principals to be included in the population, they had to meet three criteria: (1) the principal needed to be a principal in New York State, excluding New York City; (2) the principal needed to have responsibility for students in grades 9-12 and; (3) the principal could not have the responsibility for more than 600 students in his/her building. According to New York State's Education Department Public Access Data Site (NYSED, 2014) retrieved in October 2014, there were 389 New York State public school principals that met these criteria in the 2012-2013 school year (the most recent data on record).

Principals from New York City were excluded from the population because of the significant differences in governance structure from the rest of the state. During the research of this study, the governance structure of the New York City was set so that schools operated under the umbrella of one district in which building principals report to one of nearly 60 network teams for professional development and curricular needs (Schools, 2015). Therefore, building principals do not receive support or feedback from their respective superintendent of schools as they do for the rest of the state outside of NYC. Thus, many of the questions posed to respondents regarding governance structure and support would not be applicable to high school building principals in NYC.

Instrumentation

Data for this study was obtained from a researcher-designed and administered multi-measurement survey instrument (Appendix A). An introductory email (Appendix B) describing the study with an invitation to participate was sent to all principals who qualified to be included in the sample based on the aforementioned constraints. The email contained a link to the online survey site, Survey Monkey (www.surveymonkey.com) where respondents could complete the survey anonymously in their own time. Participants were invited to take the 14-question survey that was estimated to take 5-7 minutes to complete. To help increase the response rate, follow-up emails were sent seven, twenty-one, twenty-eight, thirty-five, and forty-nine days after the introductory email.

Anonymity was guaranteed by turning off the collection of IP addresses in the settings feature of Survey Monkey. Participants were also assured there were no known risks associated with the study, no names or schools would be identified in the results, and participants could opt-out of the survey at any time.

Reliability and Validity

To ensure survey tool validity, an in-depth literature review was conducted to guide the development of the instrument of the survey (Small, 2006; Symonds et al., 2011; PCAST 2011, 2014; Ferguson & Lamback, 2013; Carnevale et al., 2013; Giffi et al, 2015). All components of the instrument focused on respondents’ perceptions of advanced manufacturing and the hard and 21st century skills identified in the research as being essential for employees. Five high school principals within a regional Board of Cooperative Educational Services (BOCES) were selected as a beta sample to obtain feedback on the length of the survey, questions asked in the survey, and recommendations for improvement. They were informed of the purpose of the study, the corresponding research questions, and were asked to comment regarding the aforementioned areas. All input was used to make revisions to the instrument and to reword any confusing or poorly worded items. Changes were made to the survey based on the feedback from the beta sample. The beta sample reviewed the survey following the modifications and believed no further changes were necessary to obtain data in regards to the two research questions.

All data was transferred from Survey Monkey to SPSS for analysis through the Survey Monkey download feature. Cronbach's Alpha was used to check scale reliability, resulting in a rating of .78. According to Salkind (2014), a Cronbach's Alpha rating between .6 and .8 indicates a strong level of reliability (p. 92). Salkind (2014) further identifies the maximum level of validity is equal to the square root of the Cronbach's Alpha score for reliability (p. 126). Therefore, the validity of the data collection instrument was equivalent to .89, a highly reliable score.

Data Collection

Between January 9, 2015 and March 23, 2015, emails were sent to the total population of 389 principals describing the survey's purpose and a link to complete the survey after permission had been granted by The Sage Colleges Internal Review Board to ensure there would not be any inherent risk participants would be exposed to outside of the risk they would encounter in their daily lives (Appendix C). Of the 389 emails, 6 emails bounced back and 5 emails were linked to accounts of recipients who elected to opt-out of all emails from Survey Monkey, resulting in an available population of 378. A total of 92 principals initiated responses to the survey, representing a response rate of 24 percent. Of the 92 principals who responded, eight were responsible for more than 600 students in their respective buildings and seven had not offered a technology education class since the 2009-2010 school year. Due to not meeting the requirements of the design of the study, these participants were thanked for their time and energy, were exited from the survey and ultimately excluded from the sample. The final sample size after an introductory email and five subsequent reminders were sent was 77 principals; representing a response rate of 20 percent.

Data Analysis

The two levels of data analysis were used to address the research questions using SPSS (Version 22). The first level of analysis created a descriptive holistic profile of the data set. This included using SPSS for calculating the means, standard deviations, frequency counts, and percentages for all variables in the survey. The second level of analysis used SPSS to calculate Spearman’s rho correlational coefficients to identify the strength of the relationship between variables related to the research questions. Salkind (2014) recommends the use Spearman’s rho correlations to determine the strength relationships between ordinal variables (p. 96). All results of the survey are shown in chapter four.

Researcher Limitations and Bias

Research limitations are inherent to the study with regard to the population that was chosen to be included. As previously noted by the economy of scale research by Lee & Smith (1997), determining the population that would be used was a deliberate choice as an underlying assumption for inclusion in this research. Studying high schools with student populations of 600 or fewer students is worthwhile as they are often reflective of fewer elective course offerings and greater building principal control of the building’s academic program. That being said, although comparing program opportunity across high school size is beyond the scope of this study, a limitation was established in the scope of the research to specifically look at a subset of high schools in New York State solely based on their student enrollment.

The deliberate choice to reduce the size of the population resulted in an additional limitation in regards to the sample size (n = 77). The sample size was the result of a total of six emails being sent to the population describing the purpose of the study and a link to complete the survey. The final email sent resulted in zero responses during a seven-day period. A total of 92 principals responded to the survey, but eight were responsible for more than 600 students in their respective buildings and seven had not offered a technology education since the 2009-2010 school year. Due to not meeting the requirements of the design of the study, these participants were thanked for their time and energy, exited from the survey, and ultimately excluded from the sample.

An area of bias inherent in this study existed in the role of the researcher as a high school principal in a school with a student population below 600 students. The topic was of direct interest to the researcher, but the survey instrument was guided by the in-depth literature review process to guide the creation and validation of the survey instrument. To help eliminate any bias, the survey instrument was given to five high school principals at a regional BOCES to ensure the survey was not biased in the questioning or possible responses for respondents.

Summary

This chapter provided a description of the research design and methodology used in this study to gather and analyze data related to building principals' perceptions on the necessity to prepare students for careers in advanced manufacturing and their leadership actions to expose students to the hard and 21st century skills most needed by the industry. The following chapter provides an analysis of the data collected to answer each of the guiding research questions of this study.

CHAPTER IV: ANALYSIS

Introduction

Manufacturing is growing at a faster rate since the U.S.'s most recent recession than it has since the 1980s (Manyika et al., 2011). Manufacturing in the U.S. is in a paradigm shift. At one time, the U.S. was the global leader in low cost, low skill, and low wage manufactured goods. But the U.S. can no longer, nor wishes to, compete with Asian countries for production of these goods (PCAST, 2011). Instead, the U.S. is moving from traditional, labor-intensive manufacturing, to manufacturing that is derived from scientific inquiry and scientific discovery and technological innovation (PCAST, 2011). Supported by PCAST (2011 & 2014), NSTC (2012), Shipp et al. (2012), Manyika et al., (2012), and Giffi et al. (2015), advanced manufacturing provides economic and societal benefits that include high quality, good paying jobs, strong research and development departments to synergize and create new products and technological advancements, and helping to ensure the nation remains safe by maintaining all domestic military manufacturing. To help the economic and societal benefits to come to fruition, a skilled workforce will be needed to supply the necessary employees for the manufacturing sector in the U.S. To address the level of preparedness for careers in advanced manufacturing amongst high school students in New York State with 600 or fewer students, excluding New York City, data was used to address the following research questions:

1. What is the strength of the relationship between building principal support for preparing students for careers in advanced manufacturing and student use of tools and machines associated with the advanced manufacturing industry?

2. What is the strength of the relationship between building principal support of 21st century skills in high school technology education classes and the incorporation of those skills by technology teachers?

Chapter four provides two levels of analysis to address the research questions. The first level is descriptive in nature to create a holistic profile of the data set. Widely accepted descriptive statistics to analyze distribution and central tendency were used including means, standard deviations, frequency counts, and percentages for all variables in the survey. The second level is relational for examining if any relationships exist among variables, and if so, what the strength of the relationship signifies.

All correlation coefficients were calculated using Spearman's rho and interpreted by applying Davis' (1971) descriptors (negligible = 0.0 to .09; low = .10 to .29; moderate = .30 to .49; substantial = .50 to .69; and very strong = .70 to 1.00). In terms of significance of the relationship between variables, $p < .05$ was used as the standard minimum requirement for significance.

Study Respondents

Table 4.1 ($n = 77$) is a profile of respondent demographic information. The majority of respondents (22%) had 15-19 years of experience in education as a teacher and administrator, and 30 percent had 25 years or more of teaching and administration experience. The vast majority (99%) had more than nine years of experience in the field. Males comprised 58 percent of respondents, and 48 percent of respondents were between the ages of 35 and 44 years of age.

Table 4.1

Frequency Counts and Percentages of Respondent Demographics

Characteristic		Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Male	45	58.4	59.2	59.2
	Female	31	40.3	40.8	100
	Total	76	98.7	100	-
	Missing	1	-	-	-
Age	25-34	5	6.5	6.5	6.5
	35-44	37	48.1	48.1	54.5
	45-54	22	28.6	28.6	83.1
	55 or Older	13	16.9	16.9	100
	Total	77	100	100	-
Combined Years in Education as Teacher and Administrator	5-9	1	1.3	1.3	1.3
	10-14	17	22.1	22.1	23.4
	15-19	22	28.6	28.6	51.9
	20-24	15	19.5	19.5	71.4
	25-29	15	19.5	19.5	90.9
	30 or More Years	7	9.1	9.1	100
	Total	77	100	100	-

A profile of the respondent’s building information is presented in Table 4.2. As previously reported, all respondents must have responsibility for grades 9-12. Building configurations varied throughout the respondents. A 9-12 grade configuration represented 42 percent of all building configurations serving students in grades 9-12, followed by a 7-12 configuration, and K-12 configuration (24% and 18%, respectively). Fewer than 50 percent of respondents reported a student population between 201 and 400 students in the respondent’s building, and 43 percent of respondents reported a student population between 401 and 600 students. The percentage of students receiving a free or reduced lunch by at least 50 percent of the student population was the largest subgroup (22%) followed by 40 to 49 percent and 30 to 39 percent at 23 percent each, respectively.

Table 4.2

Frequency Counts and Percentage of School Demographics

Characteristic		Frequency	Percent	Valid Percent	Cumulative Percent
Building Configuration	K-12	14	18.2	18.2	18.2
	6-12	7	9.1	9.1	27.3
	7-12	24	31.2	31.2	58.5
	9-12	32	41.6	41.6	100
	Total	77	100	100	-
Total building student population	0-200	7	9.1	9.1	9.1
	201-400	37	48.1	48.1	57.1
	401-600	33	42.9	42.9	-
Percentage of students eligible for free or reduced lunch	0%-9%	2	2.6	2.6	2.6
	10%-19%	8	10.4	10.5	13.2
	20%-29%	8	10.4	10.5	23.7
	30%-39%	18	23.4	23.7	47.4
	40%-49%	18	23.4	23.7	71.1
	50% or Greater	22	28.6	28.9	100
	Total	76	98.7	100	-
	Missing	1	1.3		

Survey Results: Frequencies, Percentages, and Descriptive Statistics

Table 4.3 shows the frequency of respondent responses (n = 77) regarding increasing, decreasing, or sustaining technology education classes related to advanced manufacturing through incorporating 3-dimensional design software, 3-dimensional printing, CNC machining, or robotics since the 2009-2010 school year. Many of respondents (58%) reported increasing technology education classes related to advanced manufacturing. The most identified reason for increasing classes aligned to advanced manufacturing came from the respondent believing it was important to have a more computer based program (27%), followed by the respondent's teacher(s) believing it was important to go to a more computer based program (22%). Other variables were the increase of advanced manufacturing jobs in the U.S. (17%), increase in student demand for computer based technology education classes (15%), and an increase in advanced manufacturing jobs within a 50-mile radius of the building (14%).

Respondents who have seen a decline or no change in technology education class offerings related to advanced manufacturing were asked what they thought the reasons were. They reported a decrease in student enrollment (22%) as the primary reason for decreasing or not increasing course offerings followed by a lack of funding due to the Gap Elimination Adjustment (GEA) formula (20%) and property tax cap (20%). Five respondents (10%) identified the desire to increase course offerings, but could not recruit a qualified candidate to teach a more computer based curriculum aligned to advanced manufacturing. No respondents cited a lack of growth in advanced manufacturing in the U.S. or in a 50-mile radius of the respondent's respective building as a reason for not increasing advanced manufacturing course offerings.

This data suggests respondents have overcome financial challenges presented to them because they, or their technology education teachers, believed it was important to expose students to the hard skills related to advanced manufacturing. Most disturbing is the data reported by five respondents (10%) indicating they desired to increase their program offerings, but were unable to due to an inability to find a qualified candidate. This data aligns to the information provided by NYSED (2006) on their website which states, "Not addressing the concerns of the school district and governmental agencies will lead to the demise and eventual extinction of these subjects that support the positive developmental aspects of every student."

Table 4.3

Frequency Counts and Percentages for Advanced Manufacturing Course Offerings

	Characteristic	Frequency	Percent	Valid Percent	Cumulative Percent
Number of classes offered to students incorporating advanced manufacturing skills since the 2009-2010 school year	Increased	45	58.4	58.4	58.4
	Decreased	4	5.2	5.2	63.6
	Remained the Same	28	36.4	36.4	100
	Total	77	100	100	-
Reasons for increasing technology education course offerings related to advanced manufacturing	Increase in advanced manufacturing jobs in the U.S.	19	17.4	17.4	17.4
	Increase in advanced manufacturing jobs within a 50-mile radius of my building.	15	13.8	13.8	31.2
	Student enrollment has increased since the 2009-2010 school year.	0	0	0	31.2
	Increase in student demand to enroll in classes that are more computer based.	16	14.7	14.7	45.9
	My technology education teacher believed our classes needed to be more computer based.	24	22.0	22.0	67.9
	I believed our technology education classes needed to be more computer based.	29	26.6	26.6	94.5
	Other – Adoption of Project lead the Way Curriculum.	6	5.5	5.5	100
	Total	109	100	100	-
Reasons for decreasing or not increasing technology education course offerings related to advanced manufacturing	There has not been an increase in advanced manufacturing jobs in the U.S.	0	0	0	0
	There has not been an increase in advanced manufacturing jobs within a 50-mile radius of my building.	0	0	0	0
	Student enrollment has declined since the 2009-2010 school year.	11	22.4	22.4	22.4
	Reduction in course offerings due to the tax cap.	9	18.4	18.4	40.8
	Reduction in course offerings due to the GEA formula.	10	20.4	20.4	61.2
	Students have not requested technology education classes that are more computer based.	9	18.4	18.4	79.6
	Teacher(s) believe more traditional technology education classes involving wood and metal working are the essential skills students should know.	4	8.1	8.1	87.7
	I believe the essential skills students should learn are traditional wood and metal working.	0	0	0	87.7
	Other – Unable to find a qualified technology education teacher to teach courses aligned to advanced manufacturing.	5	10.2	10.2	97.9
	Other – Superintendent changed philosophy.	1	2.0	2.0	100
	Total	49	100	100	-

Table 4.4 shows the frequencies and percentages of responses (n = 77) regarding principal leadership actions to support increasing the opportunities for students to be exposed to curricula and/or use tools and machines aligned to the advanced manufacturing industry. In terms of principal leadership actions, 79 percent of respondents have read literature regarding advanced manufacturing and 80 percent have encouraged technology education teachers in their respective buildings to attend professional development opportunities aligned to advanced manufacturing.

In regards to student learning, 91 percent of respondents indicated their students prepared presentations to share with peers and 65 percent of their students were assessed on 21st century skills (work ethic, attitude, communication, time management, and teamwork). Many respondents (66%) reported students use 3-dimensional modeling software, 23 percent reported students used CNC machines, 49 percent reported students used a 3-dimensional printer, and 55 percent reported students built and programmed robots.

Regarding funding and purchases of tools and equipment aligned to advanced manufacturing since the 2009-2010 school year, 59 percent of respondents have requested funds from their superintendent, 54 percent of building principals have made a request for funds to their respective BOE, and 62 percent identified purchases of tools and machines supporting advanced manufacturing had been made in their building. This data aligns with the data from Table 4.3 in which respondents identified their ability to overcome financial challenges created by the property tax cap limit and GEA formulas to create course offerings aligned to advanced manufacturing.

Table 4.4

Frequencies and Percentages of Responses Regarding Leadership and Advanced Manufacturing Skills

Item	Yes		No		Unsure	
	N	%	N	%	N	%
11. I have requested funds from my superintendent or Board of Education to purchase tools and equipment related to advanced manufacturing since the 2009-2010 school year for students to use in technology education classes in grades 9-12.	36	59	22	36	3	5
12. I have requested my superintendent and Board of Education to offer classes regarding advanced manufacturing to students in grades 9-12.	33	54	25	41	3	5
13. I have read literature regarding the necessity to prepare students for careers in advanced manufacturing.	48	79	12	20	1	2
14. I have met with area businesses using advanced manufacturing technologies to help determine the skills my students need to be career ready upon graduating high school.	27	44	34	56	0	0
15. I have encouraged my technology education teachers in grades 9-12 to attend professional development opportunities aligned to advanced manufacturing.	49	80	10	16	2	3
16. I believe it is just as important for students to learn a trade as it is for students to go to college.	57	93	0	0	4	7
17. I believe the only pathway for student success is through a 4-year college degree.	1	2	60	98	0	0
18. I do not believe a career in advanced manufacturing is a viable opportunity for my students in New York State.	1	2	58	95	2	3
19. I believe it is important to introduce students to careers in nanotechnology in high school.	50	82	4	7	7	11
20. I have, or plan to work, with area advanced manufacturing organizations to create internship opportunities for my students.	32	53	17	28	11	18
21. Students use 3-dimensional modeling software, such as Autodesk Inventor, Pro-Engineer, Solidworks, Google SketchUp, or another 3-dimensional modeling program.	49	66	20	27	5	7
22. Students use a Computer Numeric Control (CNC) machine.	17	23	41	55	16	22
23. Students use a 3-dimensional printer.	36	49	36	49	12	1
24. Students design, build, and program robots for a specific purpose or competition.	40	55	33	45	0	0
25. Students create presentations to share information with their peers.	67	91	5	7	2	3
26. Students write papers to effectively communicate with their teacher(s).	57	77	13	18	4	5
27. Students can read mechanical blueprints.	41	55	14	19	19	26
28. Students have the opportunity to participate in internship programs.	37	51	34	47	2	3
29. Students have the opportunity to enroll in at least one Project Lead The Way class.	21	29	46	64	5	7
30. Students have the opportunity to enroll in at least one Engineering by Design class.	41	55	32	43	1	1
31. Purchases of new equipment or software related to CNC machines, 3-dimensional printers, 3-dimensional modeling software, or robotics have been purchased since the 2009-2010 school year.	46	62	26	35	2	3
32. Partnerships have been created with trade schools and/or community colleges to help provide graduates with opportunities to obtain employment in advanced manufacturing facilities.	28	38	41	55	5	7
33. Students receive instruction on 21st century skills (i.e. work ethic, attitude, communication, time management, teamwork, etc.).	59	80	14	19	1	1
34. Students are assessed on their 21st century skills (i.e. work ethic, attitude, communication, time management, teamwork etc.).	48	65	23	31	3	4

Table 4.5 shows how respondents (n = 70) ranked ordered ten 21st century skills identified in the literature as being essential skills for all individuals or specifically to advanced manufacturing (Symonds et al., 2011; Giffi et al., 2015). Respondents were asked to rank the

skills from the most important skill (1) to the least important skill (10). The only skill to not receive a most important rank (1) was the use of mathematics to solve problems. The mean scores for all of the items were calculated and reported from the most important to the least important. Overall, the three most important skills identified by respondents were (1) communicating effectively with others (*M* = 3.1), (2) thinking critically and problem-solve (*M* = 3.3), and (3) working in a cooperative team to complete a task on time (*M* = 4.0). The three least important skills identified by respondents were (8) maintaining a safe and healthy work environment (*M* = 6.9*)*, (9) maintaining a safe and healthy environment and using mathematics to solve problems (*M* = 7.1), and (10) adapting to a change in routine or schedule (*M* = 7.2).

This data does not perfectly align with the survey data presented by Giffi et al. (2015) in which the 21st century skills most needed by the advanced manufacturing industry were computer skills, followed by problem solving, math skills, and work ethic. Respondents ranked computer skills 6th, problem solving skills 2nd, math skills 8th, and work ethic 4th. This data suggests an emphasis is being placed on the skills identified by The Partnership for 21st Century Learning (2008), NACE (2009), and AMA (2010) which focused on universal skills needed for entry level employment across all industries, but not the skills directly related to the needs of the advanced manufacturing industry.

Table 4.5

Ranking of 21st Century and Advanced Manufacturing Skills

Item	*M*
Communicate effectively with others	3.1
Think critically and problem solve	3.3
Work in a cooperative team to complete a task on time	4.0
Conduct oneself in a respectable and professional manner	4.3
Utilize time effectively to complete a task	5.2
Use a personal computer and related applications to convey and retrieve information	6.8
Accept praise, setbacks, and criticism with positivity and an open mind	6.9
Maintain a safe and healthy work environment	7.1
Use mathematics to solve problems	7.1
Ability to adapt to a change in routine or schedule	7.2

Table 4.6 represents the frequency of respondent's perceptions on their leadership actions of integrating and measuring 21st century skills in technology education classes. The two responses with over 90 percent of respondents who agreed or strongly agreed with the statements were, "I am comfortable discussing 21st century skills with my technology education teachers", and "I encourage my technology education teacher(s) to participate in professional development opportunities related to developing 21st century skills in students in their class(es)."

Responses with 50 percent or fewer respondents who agreed or strongly agreed were for items: (41) "I work with local organizations to ensure students in technology education classes are meeting their expectations for 21st century skills upon graduating from high school"; (43) "In technology education department meetings, I review how to assess student mastery an application of 21st century skills"; (48) "Every activity's rubric assesses student mastery of specific 21st century skills; (49)"Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered them by the end of the class" and; (50) "Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered all of them by the end of the technology education sequence our high school offers."

This data suggests respondents' perceive themselves as proficient leaders in discussing 21st century skills with technology education teachers and technology education teachers value the conversations as well. In support of the data from Table 4.5 regarding the disconnect between the survey conducted by Giffi et al. (2015), only 49 percent agreed or strongly agreed to meeting with local organizations to help ensure students were coming to them with the skills necessary for employment. Further research may be needed to determine if the skills the respondents are discussing with their technology education teachers are the correct skills identified by advanced manufacturing organizations.

Table 4.6

Frequencies and Percentages of Principal Perceptions Regarding Leadership and 21st Century Skills

Item	Strongly Disagree		Disagree		Agree		Strongly Agree		Unsure	
	N	%	N	%	N	%	N	%	N	%
36. I am comfortable discussing 21st century skills with my technology education teacher(s).	3	4	1	1	40	54	29	39	1	1
37. My superintendent has supported my professional growth in leading 21st century skills for my teachers.	3	4	6	8	33	45	28	38	3	4
38. My technology education teacher(s) value my discussions with them regarding evaluating student mastery of 21st century skills.	2	3	2	3	33	46	27	38	8	11
39. I encourage my technology education teacher(s) to participate in professional development opportunities related to developing 21st century skills in students in their class(es).	2	3	2	3	28	38	40	54	2	3
40. I receive positive feedback from my superintendent regarding my leadership of incorporating 21st century skills into technology education classes.	2	3	13	18	30	41	18	25	10	14
41. I work with local organizations to ensure students in technology education classes are meeting their expectations of 21st century skills upon graduating from high school.	3	4	30	41	31	42	5	7	4	5
42. In technology education department meetings, I regularly discuss how to infuse 21st century skills into our daily lesson and unit plans.	1	1	29	39	25	34	13	18	6	8
43. In technology education department meetings, I review how to assess student mastery and application of 21st century skills.	1	1	32	44	25	35	7	10	7	10
44. My technology education teacher(s) view 21st century skills as a vital asset in which students are expected to have mastered before graduating from high school.	0	0	6	8	35	49	28	39	3	4
45. My technology education teacher(s) have planning time to incorporate 21st century skills into their curriculums and lesson plans.	0	0	14	19	35	48	22	30	2	3
46. My technology education teachers incorporate 21st century skills in every lesson.	3	4	20	28	30	42	13	18	5	7
47. My technology education teachers incorporate 21st century skills in every unit.	2	3	6	8	39	55	20	28	4	6
48. Every activity's rubric assesses student mastery of specific 21st century skills.	1	1	26	37	23	32	11	15	10	14
49. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered them by the end of the class.	3	4	25	36	23	33	10	14	9	13
50. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered all of them by the end of the technology education sequence our high school offers.	1	1	26	37	27	38	7	10	10	14

Relational Analysis of Study Respondents and Leadership Actions

Table 4.7 shows the relationship between years worked in education, the total student enrollment in the high school, percentage of students receiving free or reduced lunch, and whether or not high school technology education aligned to advanced manufacturing have increased, decreased, or remained the same since the 2009-2010 school year. The analysis resulted in five significant relationships ($p < .05$ or $p < .01$) when calculated using Spearman's rho correlational coefficients.

Significant relationships ($p < .05$) existed between items forty-one (41) "I work with local organizations to ensure students in technology education classes are meeting their expectations of 21st century skills upon graduating from high school" and the percentage of students who are eligible for free or reduced lunch ($r = -.259$, $p < .05$); items forty-five (45) "My technology education teacher(s) have planning time to incorporate 21st century skills into their curriculums and lesson plans" and the total student population in high school ($r = -.232$, $p < .05$); and items forty-five (45) "My technology education teacher(s) incorporate 21st century skills into every unit" and the years worked in education ($r = -.291$, $p < .05$).

Significant relationships ($p < .01$) existed between years worked in education and items thirty-nine (39) "I encourage my technology education teacher(s) to participate in professional development opportunities related to developing 21st century skills in students in their class(es)" ($r = .331$, $p < .01$); and forty (40) "I receive feedback from my superintendent regarding my leadership of incorporating 21st century skills into technology education classes" ($r = -.323$, $p < .05$).

The data suggests that as the years in education increase for the respondents, they are less likely to encourage teachers to participate in professional development opportunities related to

21st century skill development, receive positive feedback from their superintendent regarding their leadership of 21st century skills, and have technology education teachers incorporate 21st century skills into their curriculums. Further research will need to be conducted to help determine why these inverse relationships exist amongst the respondents' and their years in education.

Table 4.7

Relational Analysis of Leadership and Advanced Manufacturing and 21st Century Skills

Item	4. How many combined years, including this year, have you worked in the field of education as a teacher and administrator?	5. What is the total student enrollment in your building?	6. What is the percent of students eligible for free or reduced lunch in your building?
36. I am comfortable discussing 21st century skills with my technology education teacher(s).	-.214	-.136	-.217
37. My superintendent has supported my professional growth in leading 21st century skills for my teachers.	-.060	.083	-.098
38. My technology education teacher(s) value my discussions with them regarding evaluating student mastery of 21st century skills.	-.055	-.004	-.218
39. I encourage my technology education teacher(s) to participate in professional development opportunities related to developing 21st century skills in students in their class(es).	-.331**	.058	.069
40. I receive feedback from my superintendent regarding my leadership of incorporating 21st century skills into technology education classes.	-.323**	.025	.050
41. I work with local organizations to ensure students in technology education classes are meeting their expectations of 21st century skills upon graduating from high school.	-.134	.079	-.259*
42. In technology education department meetings, I regularly discuss how to infuse 21st century skills into our daily lessons and unit plans.	-.173	.102	-.126
43. In technology education department meetings, I review how to assess student mastery and application of 21st century skills.	-.120	.089	-.152
44. My technology education teacher(s) view 21st century skills as a vital asset in which students are expected to have mastered before graduating high school.	-.231	.064	-.105
45. My technology education teacher(s) have planning time to incorporate 21st century skills into their curriculums and lesson plans.	-.221	-.232*	.055
46. My technology education teacher(s) incorporate 21st century skills in every lesson.	-.086	.080	-.130
47. My technology education teacher(s) incorporate 21st century skills into every unit.	-.291*	-.028	-.228
48. Every activity's rubric assesses student mastery of specific 21st century skills.	-.184	.032	-.135
49. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered them by the end of the class.	-.133	.042	-.138
50. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered all of them by the end of the technology education sequence our high school offers.	-.060	-.027	-.102

* Correlation is significant at the .05 level (2 tailed)

** Correlation is significant at the .01 level (2 tailed)

Relational Analysis of Leadership Action Items Supporting Advanced Manufacturing Hard Skill Development Among Students in Technology Education Courses

The first research question sought to discover the strength of the relationship between building principal support for preparing students for careers in advanced manufacturing and student use of tools and machines associated with the advanced manufacturing industry. Tables 4.8, 4.9, and 4.10 indicate low to substantial significance ($p < .05$ and $p < .01$) among leadership items and hard skills related to preparing students for careers in advanced manufacturing when applying Davis' (1971) descriptors to measure levels of significance when using Spearman's rho to measure correlational relationships.

Table 4.8 was used to measure the relationship between leadership items related to creating and fostering advanced manufacturing skills. For the ten items measured for statistical significance, three items were statistically significant ($p < .05$ and $p < .01$) with at least five items. Items twelve (12) and fourteen (14) were each statistically significant with 6 items and item 31 was statistically significant with five items, respectively.

The strongest relationships existed between items thirteen (13), "I have read literature regarding the necessity to prepare students for careers in advanced manufacturing " and fourteen (14) "I have met with area businesses using advanced manufacturing technologies to help determine the skills my students need to be college and career ready upon graduating high school ($r = .384$, $p < .01$); items twelve (12) I have requested my superintendent and BOE to offer classes regarding advanced manufacturing to students in grades 9-12" and fifteen (15) I have encouraged my technology education teachers in grades 9-12 to attend professional development opportunities aligned to advanced manufacturing" ($r = .393$, $p < .01$) and; items fourteen (14) "I have met with area businesses using advanced manufacturing technologies to help determine the skills my students need to be college and career ready upon graduating high school" and twenty-nine (29) "Students have the opportunity to enroll in at least one Project Lead the Way class" ($r = .427$, $p < .01$).

The data suggest respondents are more likely to introduce students to advanced manufacturing if they have requested class offerings for advanced manufacturing from their superintendent or BOE and are more likely to purchase tools and machines to expose students to the hard skills needed by advanced manufacturing organizations. These relationships are also aligned to respondents who have met with area advanced manufacturing organizations to determine the skills their students need to be successful to gain entry level employment in advanced manufacturing.

Table 4.8

Principal Leadership Supporting Advanced Manufacturing

Item/Scale	**Item/Scale**									
	11	**12**	**13**	**14**	**15**	**20**	**29**	**30**	**31**	**32**
11. I have requested funds from my superintendent or BOE to purchase tools and equipment related to advanced manufacturing since the 2009-2010 school year for students to use in technology education classes in grades 9-12.	1.000									
12. I have requested my superintendent and BOE to offer classes regarding advanced manufacturing to students in grades 9-12.	.325*	1.000								
13.I have read literature regarding the necessity to prepare students for careers in advanced manufacturing.	.023	.155	1.000							
14. I have met with area businesses using advanced manufacturing technologies to help determine the skills my students need to be college and career ready upon graduating high school.	.175	.343**	.384**	1.000						
15. I have encouraged my technology education teachers in grades 9-12 to attend professional development opportunities aligned to advanced manufacturing.	.212	.393**	.030	.103	1.000					
20. I have, or plan to work with area advanced manufacturing organizations to create internship opportunities for my students.	.080	.173	-.026	.263*	-.012	1.000				
29. Students have the opportunity to enroll in at least one Project Lead the Way class.	.064	.274*	.117	.427**	.059	.096	1.000			
30. Students have the opportunity to enroll in at least one Engineering by Design class.	.254*	.344**	.047	.230	.187	.199	.379**	1.000		
31.Purchases of new equipment or software related to CNC machines, 3-dimesnional printers, 3-dimensional modeling software, or robotics have been purchased since the 2009-2010 school year.	.315*	.295*	-.040	.345**	.137	.125	.278*	.339**	1.000	
32. Partnerships have been created with trade schools and/or community colleges to help provide graduates with opportunities to obtain employment in advanced manufacturing facilities.	-.071	.085	-.033	.336**	.005	.080	.191	.214	.351**	1.000

* Correlation is significant at the .05 level (2 tailed)
** Correlation is significant at the .01 level (2 tailed)

Table 4.9 indicates moderate to substantial significance ($p < .05$ and $p < .01$) among items related to facilitating career development in advanced manufacturing and hard skills identified as being essential for a career in advanced manufacturing when calculated using Spearman’s rho correlational coefficient. Among the eight items measured for statistical significance, item twenty-one (21), “Students use 3-dimensional modeling software, such as Autodesk Inventor, Pro-Engineer, Solidworks, Google Sketch-Up, or another 3-dimensional modeling program," was the most statistically significant variable (p < .01) with three relationships that ranged from moderate to substantial. Item 21 was statistically significant with items: twenty-four (24), "Students design, build, and program robots for a specific purpose or competition" (r = .318, p < .01); twenty-seven (27), "Students can read mechanical blueprints" (r = .356, p < .01); and twenty-three (23) "Students use a 3-dimensional printer" (r = .501, p < .01).

These data are aligned to the research by Small (2006) and Tassey (2014). Small (2006) identified that 85 percent of advanced manufacturing organizations use 3-dimensional software and Tassey (2014) hypothesized the invention of the 3-dimensional printer will bring about a fourth industrial revolution. However, the use of CNC machines by students was not aligned well to the research by Small (2006) in which he indicated 74 percent of advanced manufacturers use this type of equipment. Further research will need to be conducted to determine why there is not a stronger relationship between the use of 3-dimensional modeling software and CNC machines as there is between 3-dimensional modeling software and 3-dimensional printers.

Table 4.9

Student Development of Hard Skills Related to Careers in Advanced Manufacturing

Item/Scale	**Item/Scale**					
	21	22	23	24	27	28
21. Students use 3-dimensional modeling software, such as Autodesk Inventor, Pro-Engineer, Solidworks, Google Sketch-Up, or another 3-dimensional modeling program.	1.000					
22. Students use a Computer Numeric Control (CNC) machine.	.178	1.000				
23. Students use a 3-dimensional printer.	.501**	-.020	1.000			
24. Students design, build, and program robots for a specific purpose or competition.	.318**	.083	.300*	1.000		
27. Students can read mechanical blueprints.	.356**	.111	.213	.154	1.000	
28. Students have the opportunity to participate in internship programs.	-.044	.040	.025	.041	-.057	1.000

* Correlation is significant at the .05 level (2 tailed)
** Correlation is significant at the .01 level (2 tailed)

Table 4.10 identifies the significant relationships (p < .05 or p < .01) among each of the variables that were measured independently in tables 4.8 and 4.9, respectively when calculated using Spearman's rho correlational coefficients. A total of 20 statistically significant relationships (p < .05 and p < .01) were calculated among the variables.

The most statistically significant variable (p < .05 and p < .01) was item twenty-one (21), "Students use 3-dimensional modeling software." It was statistically significant with seven leadership items. The two strongest relationships were items twenty-three (23), "Students use a 3-dimensional printer" and thirty-one (31), "Purchases of new equipment or software related to CNC machines, 3-dimesnional printers, 3-dimensional modeling software, or robotics have been purchased since the 2009-2010 school year" (r = .597, p < .01) and; twenty-one (21), "Students use 3-dimensional modeling software" and thirty-one (31), "Purchases of new equipment or software related to CNC machines, 3-dimesnional printers, 3-dimensional modeling software, or robotics have been purchased since the 2009-2010 school year" (r = .619, p < .01).

The data suggest students were more likely to be exposed to the hard skills related to advanced manufacturing if respondents' requested to have courses aligned to advanced manufacturing from their respective superintendent or BOE, purchased tools or equipment aligned to the skills needed for the development or hard skills, or offered at least one Project Lead the Way Course.

Table 4.10

Correlations Between Principal Leadership Actions and Advanced Manufacturing Hard Skills

	Advanced Manufacturing Skills				
Leadership Items	21. Students use 3-dimensional modeling software.	22. Students use a CNC machine.	23. Students use a 3-dimensional printer.	24. Students design, build, and program robots for a specific purpose or competition.	27. Students can read mechanical blueprints.
11. I have requested funds from my superintendent or BOE to purchase tools and equipment related to advanced manufacturing since the 2009-2010 school year for students to use in technology education classes in grades 9-	.235	.285*.	.181	-.004	.074
12. I have requested my superintendent and BOE to offer classes regarding advanced manufacturing to students in grades 9-12.	.298*	.188	.108	.367**	.376**
13. I have read literature regarding the necessity to prepare students for careers in advanced manufacturing.	.175	-.027	-.004	.231	.034
14. I have met with area businesses using advanced manufacturing technologies to help determine the skills my students need to be college and career ready upon graduating high school.	.410**	.175	.148	.121	.370**
15. I have encouraged my technology education teachers in grades 9-12 to attend professional development opportunities aligned to advanced manufacturing.	.268*	-.001	.107	.104	.236
16. I believe it is just as important for students to learn a trade as it is for students to go to college.	-.202	.096	-.155	-.120	-.240
17. I believe the only pathway for student success is through a 4-year college degree.	.099	.004	.139	.123	.117
18. I do not believe a career in advanced manufacturing is a viable opportunity for my students in New York State.	.276*	.111	.210	.077	.204
19. I believe it is important to introduce students to careers in nanotechnology in high school.	-.203	.071	.234	.174	-.017
20. I have, or plan to work with, area advanced manufacturing organizations to create internship opportunities for my students.	-.026	.088	.006	-.015	.173
28. Student have the opportunity to participate in internship programs.	-.044	.040	.025	.041	-.057
29. Students have the opportunity to enroll in at least one Project Lead the Way class.	.352**	.070	.245*	.234*	.426**
30. Students have the opportunity to enroll in at least one Engineering by Design class.	.380**	.121	.201	.289*	.326**
31.Purchases of new equipment or software related to CNC machines, 3-dimesnional printers, 3-dimensional modeling software, or robotics have been purchased since the 2009-2010 school year.	.619**	.050	.597**	.218	.253*
32. Partnerships have been created with trade schools and/or community colleges to help provide graduates with opportunities to obtain employment in advanced manufacturing facilities.	.085	.162	.113	.001	.206

* Correlation is significant at the .05 level (2 tailed)

** Correlation is significant at the .01 level (2 tailed)

Relational Analysis of Leadership Action Items Supporting and Advanced Manufacturing 21st Century Skill Development Among Students in Technology Education Courses

Research question two sought to determine the strength of the relationship between building principal support of 21st century skills in high school technology education classes and the incorporation of those skills by technology teachers. Using the same methodology as the first research question, research question two applied Spearman’s rho correlations coefficients to determine the level of significance ($p < .05$ or $p < .01$) for ordinal data responses. Tables 4.11, 4.12, and 4.13 show the relationships between principal leadership and teacher implementation of 21st century skills in high school technology education classes.

Table 4.11 shows that nearly all relationships among leadership associated with the development of 21st century and advanced manufacturing skills are significant. The three most significant relationships identified substantial to very strong correlations. The significant correlations existed between items thirty-seven (37), “My superintendent has supported my professional growth in leading 21st century skills for my teachers” and thirty-eight (38) “My technology education teacher(s) value my discussions with them regarding evaluating student mastery of 21st century skills” ($r = .546$, $p < .01$); (41) “I work with local organizations to ensure students in technology education classes are meeting their expectations of 21st century skills upon graduating from high school” and forty-two (42), “In technology education department meetings, I regularly discuss how to infuse 21st century skills into our daily lessons and unit plans” ($r = .554$, $p < .01$); and forty-two (42), “In technology education department meetings, I regularly discuss how to infuse 21st century skills into our daily lessons and unit plans” and forty-three (43), “In technology education department meetings, I review how to assess student mastery and application of 21st century skills” (r = .811, p < .01).

The data suggest nearly all of the relationships between leadership action items regarding 21st century skills are important. Respondents were comfortable discussing and leading conversations regarding the development and evaluation 21st century skills in technology education classes. The one variable that was not statistically significant among the leadership items was teachers valuing discussions with respondents regarding the implementation of 21st century skills.

Table 4.11

Correlations of Principal Leadership Actions and 21^{st} Century Skills

Item/Scale	Item/Scale							
	36	37	38	39	40	41	42	43
36. I am comfortable discussing 21^{st} century skills with my technology education teacher(s).	1.000							
37. My superintendent has supported my professional growth in leading 21^{st} century skills for my teachers.	.435**	1.000						
38. My technology education teacher(s) value my discussions with them regarding evaluating student mastery of 21^{st} century skills.	.459**	.546**	1.000					
39. I encourage my technology education teacher(s) to participate in professional development opportunities related to developing 21^{st} century skills in students in their class(es).	.518**	.416**	.266*	1.000				
40. I receive feedback from my superintendent regarding my leadership of incorporating 21^{st} century skills into technology education classes.	.301**	.435**	.459**	.298*	1.000			
41. I work with local organizations to ensure students in technology education classes are meeting their expectations of 21^{st} century skills upon graduating from high school.	.317**	.256*	.127	.264*	.389**	1.000		
42. In technology education department meetings, I regularly discuss how to infuse 21^{st} century skills into our daily lessons and unit plans.	.373**	.222	.110	.431**	.463**	.554**	1.000	
43. In technology education department meetings, I review how to assess student mastery and application of 21^{st} century skills.	.326**	.255*	.245*	.431**	.398**	.339**	.811**	1.000

* Correlation is significant at the .05 level (2 tailed)
** Correlation is significant at the .01 level (2 tailed)

Table 4.12 shows a moderate to very strong relationship ($p < .01$ and $p < .05$) existed between all variables regarding respondents’ perceptions of how their technology education teachers implement, and evaluate student progress of 21^{st} century skills and advanced manufacturing skills in their classes and department.

The three strongest relationships were all very strong. These relationships existed between items fourty-nine (49), “Technology education teachers have created 21^{st} century skills benchmarks to ensure all students have successfully mastered them by the end of the class" and forty-eight (48), "Every activity's rubric assesses student mastery of specific 21st century skills" (r = .775, p < .01); fifty (50), "Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered all of them by the end of the technology education sequence our high school offers" and forty-eight (48) (r = .787, p < .01) and; item forty-nine (49) and fifty (50) (r = .941, p < .01).

The data suggest respondents' positively reported the incorporation, instruction, and evaluation of 21st century skills in their classrooms. Further research will need to be identified on which 21st century skills they are fully implementing to determine if teachers are focusing on the advanced manufacturing 21st skills or the general 21st century skills identified by The Partnership for 21st Century Learning (2008), NACE (2009), or AMA (2010).

Table 4.12

Correlations of Teacher Implementation and Evaluation of 21st Century Skills

Item/Scale	**Item/Scale**						
	44	45	46	47	48	49	50
44. My technology education teacher(s) view 21st century skills as a vital asset in which students are expected to have mastered before graduating high school.	1.000						
45. My technology education teacher(s) have planning time to incorporate 21st century skills into their curriculums and lesson plans.	.363**	1.000					
46. My technology education teacher(s) incorporate 21st century skills in every lesson.	.422**	.434**	1.000				
47. My technology education teacher(s) incorporate 21st century skills into every unit.	.409**	.442**	.693**	1.000			
48. Every activity's rubric assesses student mastery of specific 21st century skills.	.416**	.512**	.624**	.527**	1.000		
49. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered them by the end of the class.	.454**	.435**	.679**	.479**	.775**	1.000	
50. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered all of them by the end of the technology education sequence our high school offers.	.346**	.429**	.622**	.453**	.787**	.941**	1.000

* Correlation is significant at the .05 level (2 tailed)
** Correlation is significant at the .01 level (2 tailed)

Table 4.13 identifies the significant relationships ($p < .05$ and $p < .01$) among each of the variables that were measured independently in tables 4.11 and 4.12, respectively when calculated using Spearman's rho correlational coefficients. All items, with the exception of one relationship, showed a moderate to very strong relationship existed between all items regarding respondents' perceptions of 21st century and advanced manufacturing skills and their respective teacher's implementation and evaluation of the skills in technology education classes and their building program.

The three strongest relationships were all substantial. These relationships existed between items: fifty (50), "Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered all of them by the end of the technology education sequence our high school offers” and forty (40), “I receive feedback from my superintendent regarding my leadership of incorporating 21st century skills into technology education classes” ($r = .546, p < .01$); forty (40) and forty-eight (48), “Every activity’s rubric assesses student mastery of specific 21st century skills” ($r = .568, p < .01$) and; forty-four (44), “My technology education teacher(s) view 21st century skills as a vital asset in which students are expected to have mastered before graduating high school” and forty-three (43), “In technology education department meetings, I review how to assess student mastery and application of 21st century skills” ($r = .583, p < .01$).

The data suggest respondent’s leadership and the implementation, instruction, and evaluation of 21st century skills in the classroom are positively correlated. As respondent leadership of 21st century skills increases, so does teacher implementation and evaluation of the same skills.

Table 4.13

Correlations Between Principal Leadership and Teacher Implementation of 21st Century Skills

	Item/Scale						
Item/Scale	44. My technology education teacher(s) view 21st century skills as a vital asset in which students are expected to have mastered before graduating high school.	45. My technology education teacher(s) have planning time to incorporate 21st century skills into their curriculums and lesson plans.	46. My technology education teacher(s) incorporate 21st century skills in every lesson.	47. My technology education teacher(s) incorporate 21st century skills into every unit.	48. Every activity's rubric assesses student mastery of specific 21st century skills.	49. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered them by the end of the class.	50. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered all of them by the end of the technology education sequence our high school offers.
36. I am comfortable discussing 21st century skills with my technology education teacher(s).	.419**	.278*	.401**	.432**	.359**	.404**	.385**
37. My superintendent has supported my professional growth in leading 21st century skills for my teachers.	.379**	.351**	.450**	.334**	.330**	.377**	.325**
38. My technology education teacher(s) value my discussions with them regarding evaluating student mastery of 21st century skills.	.496**	.409**	.380**	.374**	.422**	.513**	.470**
39. I encourage my technology education teacher(s) to participate in professional development opportunities related to developing 21st century skills in students in their class(es).	.514**	.435**	.362**	.374**	.312**	.295*	.246*
40. I receive feedback from my superintendent regarding my leadership of incorporating 21st century skills into technology education classes.	.394**	.326**	.391**	.368**	.568**	.535**	.546**
41. I work with local organizations to ensure students in technology education classes are meeting their expectations of 21st century skills upon graduating from high school.	.256*	.255*	.308**	.171	.434**	.439**	.455**
42. In technology education department meetings, I regularly discuss how to infuse 21st century skills into our daily lessons and unit plans.	.491**	.338**	.431**	.367**	.443**	.436**	.403**
43. In technology education department meetings, I review how to assess student mastery and application of 21st century skills.	.583**	.381**	.526**	.453**	.474**	.471**	.431**

* Correlation is significant at the .05 level (2 tailed)
** Correlation is significant at the .01 level (2 tailed)

Summary of the Data

The purpose of this study was to explore principals' perceptions regarding advanced manufacturing and the relationships between high school principal's leadership actions to prepare students for careers in advanced manufacturing and the software, tools, machines, and skills students are exposed to in technology education classes. Specifically, this study examined high school principal support for incorporating 21st century skills and the use of tools and machines to support a pathway for careers in advanced manufacturing for students by answering the following research questions:

1. What is the strength of the relationship between building principal support for preparing students for careers in advanced manufacturing and student use of tools and machines associated with the advanced manufacturing industry?
2. What is the strength of the relationship between building principal support of 21st century skills in high school technology education classes and the incorporation of those skills by technology teachers?

The response rate (n = 77) was a limitation to this study that was imposed based upon the selection criteria of the population. Determining the population that would be used was a deliberate choice as an underlying assumption for inclusion in this research. Studying high schools with student populations of 600 or fewer students is worthwhile as they are often reflective of fewer elective course offerings and greater building principal control of the building's academic program (Lee & Smith, 1997). The narrowed focus of the scope of this research was to focus on small schools as identified by Lee and Smith (1997) to specifically focus on principal leadership actions and perceptions on the necessity to prepare students for careers in advanced manufacturing who are less likely to be exposed to these classes when compared to high schools with more than 600 students.

Respondents Perceptions Regarding Advanced Manufacturing

The data suggested many respondents (58%) have overcome financial challenges presented to them by the property tax cap limit and GEA by increasing the number of courses related to advanced manufacturing. The most cited reasons for increasing course offerings related to advanced manufacturing were respondents believed it was important (27%) or their technology education teachers (22%), believed it was important to expose students course offerings aligned to manufacturing. Most disturbing is the data by five respondents (10%) indicating they desired to increase their program offerings, but were unable to due to an inability to find a qualified candidate. This data aligns to the information provided by NYSED (2006) on their website which states, "Not addressing the concerns of the school district and governmental agencies will lead to the demise and eventual extinction of these subjects that support the positive developmental aspects of every student."

Respondents Perceptions and Leadership Actions of Hard Skills

The data suggested students were more likely to be exposed to the hard skills related to advanced manufacturing if respondents requested to have courses aligned to advanced manufacturing from their respective superintendent or BOE, purchased tools or equipment aligned to the skills needed for the development or hard skills, or offered at least one Project Lead the Way Course.

The data also aligned to the research by Small (2006) and Tassey (2014) regarding the the importance of 3-dimensional modeling and use of 3-dimensional printers. Forty-nine respondents (66%) identified students used 3-dimensional modeling software in technology education classes and forty respondents (55%) identified students use a 3-dimensional printer. Small (2006) identified that 85 percent of advanced manufacturing organizations use 3-dimensional software and Tassey (2014) hypothesized the invention of the 3-dimensional printer will bring about a fourth industrial revolution. However, respondent use of CNC machines by students was not aligned well to the research by Small (2006) which indicated 74 percent of advanced manufacturers use this type of machine. Only seventeen respondents (23%) indicated students used a CNC machine in their technology education program.

Respondents Perceptions and Leadership Actions of 21st Century Skills

Respondents data suggested the positive relationship that existed between leadership action items and technology teacher incorporation and evaluation of 21st century skills in their classrooms. However, respondents data of ranking 21st century skills does not align well with the survey data presented by Giffi et al. (2015). The data conducted by Giff et al. (2015) indicated computer skills as the most needed skill, followed by problem solving, math skills, and work ethic. Respondents ranked computer skills 6th, problem solving skills 2nd, math skills 8th, and work ethic 4th. This data suggests an emphasis is being placed on the skills identified by The Partnership for 21st Century Learning (2008), NACE (2009), and AMA (2010) which focused on universal skills needed for entry level employment, but not directly related to the needs of the advanced manufacturing industry.

CHAPTER V: FINDINGS, RECOMMENDATIONS, AND CONCLUSIONS

Introduction

The purpose of this study was to explore the relationship between high school principals' perceptions on the necessity of preparing students for careers in advanced manufacturing and the software, tools, machines, and skills students are exposed to in technology education classes. Specifically, this study examined high school principal support for incorporating 21st century and advanced manufacturing skills, and the use of tools and machines to support a pathway for careers in advanced manufacturing for students.

To help determine the level of preparedness for careers in advanced manufacturing among high school students in New York State with 600 or fewer students, excluding New York City, an electronic survey was distributed to all building principals who met the aforementioned criteria to ascertain data and answer the following research questions:

1. What is the strength of the relationship between building principal support for preparing students for careers in advanced manufacturing and student use of tools and machines associated with the advanced manufacturing industry?
2. What is the strength of the relationship between building principal support of 21st century skills in high school technology education classes and the incorporation of those skills by technology teachers?

Discussion and Analysis of Findings

Finding One: Principals Believe Advanced Manufacturing is a Viable Career Choice

Today's building principals are consumed with day-to-day operational challenges that include demands from a number of stakeholders, managing and implementing curricula changes, allocating resources, hiring, supporting and maintaining faculty and staff, and meeting the highest expectations for student achievement and teacher performance during the standards movement (Rogers, 2007; Provost et al., 2010; Gano-Phillips et al.,, 2011; Wenig, 2004).

During this immensely challenging time as a school leader, high school principals must balance meeting the educational mission, vision, and goals of the district, student achievement goals on standardized assessments, and following through on their own missions to help ensure all students graduate college and career ready (White-Smith & White, 2009). The focus on college readiness has left a gap in helping to ensure students also graduate career ready. Leadership has never been more important for educational professionals to help provide students with the hard and 21st century skills required by professional organizations, in which so many students are ill-equipped (Feller, 2011).

Respondents were consistent regarding their beliefs and expectations about preparing students to be college or career ready and the role advanced manufacturing will have on career development in New York:

- 98 percent of respondents believed multiple pathways exist for students to be successful after graduating high school other than a bachelor’s degree.
- 85 percent believed a career in advanced manufacturing was a viable career opportunity for their students.
- 79 percent had read literature regarding the importance of preparing students for careers in advanced manufacturing.
- 80 percent have encouraged their technology education teacher to attend trainings related to advanced manufacturing.

To support these initiatives, 59 percent of respondents had requested funds from their superintendent or BOE to purchase tools and equipment related to advanced manufacturing and 54 percent had made requests to increase course offerings for students. Respondents were well aware of advanced manufacturing and the significant role it will play in ensuring the growth of the nation's economy despite the most recent curriculum and instructional changes implemented by the Common Core State Standards under the Regents Reform Agenda.

Finding Two: Principals Have Increased Technology Education Offerings Related to Advanced Manufacturing Since the 2009-2010 School Year

One of the most significant components of the data collected was that 58 percent of respondents (n = 45) had increased their technology education programs incorporating advanced manufacturing skills since the 2009-2010 school year, despite budgetary limitations created by the property tax cap limit and Gap Elimination Adjustment (GEA) formula. This finding is in stark contrast to the hypothesis made by Banchiu et al. (2013) in which the author believed a pipeline of employees graduating from high schools would not exist due to elective classes related to advanced manufacturing being cut from high schools during the most recent recession (p. 2). Only 5 percent (n = 4) of all respondents (n = 77) reported having decreased their curriculum offerings.

The top three reasons for increasing technology education courses incorporating advanced manufacturing were: (1) the respondents believed the classes needed to be more computer based (n = 29, 26%); (2) the technology education teacher(s) believed classes needed to be more computer based (n = 25, 22%) and; (3) the respondents cited an increase in advanced manufacturing jobs in the U.S. (n = 19; 17%). The top three reasons why schools had either decreased technology classes or did not increase the number of classes related to advanced manufacturing were: (1) reduction in student enrollment (n = 11, 22%); (2) reduction in course offerings due to the GEA formula (n = 10, 20%) and; (3) reduction in course offerings due to the property tax cap limit (n = 9, 18%).

More than half of respondents (58%) indicate they have been able to overcome the fiscal challenges created by the property tax cap limit and the GEA and have been able to increase technology education offerings to students. Schools were able to purchase curriculum programs, including PLTW and EbD, 3-dimensional modeling software, 3-dimensional printers, CNC machines, and robotics to support the development of hard skills aligned to advanced manufacturing. Infusing these skills in technology education classes cannot be overstated based upon the research completed by Tassey (2014), Mital et al. (1999), Feller (2011), and Small (2006).

Finding Three: Newly Certified Technology Education Teachers Have Reduced Dramatically Since 2007-2008

Beyond student enrollment and fiscal challenges, five respondents (10%) desired to increase their course offerings but were unable to find a qualified technology education teacher to teach courses related to advanced manufacturing. This finding is substantive in relation to the research conducted by Philip Dettelis, the Assistant in Instructional Services for Technology Education for NYSED. He confirmed the significant decline in new teachers being certified to teach technology education as noted in table 5.1 (P. Dettelis, personal communication, July 23, 2015).

Table 5.1

Number of Newly Certified Technology Teachers

Year	Number of Newly Certified Technology Teachers
2007 – 2008	304
2008 – 2009	306
2009 – 2010	237
2010 – 2011	201
2011 – 2012	183
2012 – 2013	178
2013 – 2014	65
2014 – 2015	6

This data aligns to the document that is available on New York State’s Technology Education Department’s webpage (2006) that states, “not addressing the concerns of the school district and governmental agencies will lead to the demise and eventual extinction of these subjects [technology education] that support the positive developmental aspects of every student.”

The reason regarding the significant decline in newly certified teachers is beyond the scope of this study. However, the data provided by Mr. Dettelis provides an opportunity for further research to determine if this trend will have a significant impact on technology education programs in the future.

Research Question 1: What is the strength of the relationship between building principal support for preparing students for careers in advanced manufacturing and student use of tools and machines associated with the advanced manufacturing industry?

Finding Four: Substantive Relationships Between Principal Support for Advanced Manufacturing and Students Development of Hard Skills Does Not Exist

As previously identified, respondents were very consistent regarding their beliefs and expectations about preparing students to be college or career ready. Most importantly, respondents (n = 58, 95%) identified the growing demand advanced manufacturing will have on career development in New York State as a viable career pathway.

In a recent study, Small (2006) investigated the type of technology used by advanced manufacturing firms in which he found, 85 percent used CAD, 73 percent used CNC, and 74 percent used CAM (Small, 2006). Additionally, the process of building a product through additive manufacturing used by 3-dimensional printers enables manufacturers to have the ability to bring production concepts to small-scale production and testing in minutes instead of months (Tassey, 2014). Tassey (2014) predicts this emerging technology will bring about the next industrial revolution.

However, the results of the survey are not substantively aligned with the research. Believing a career in advanced manufacturing is a viable career opportunity was not supported with the essential hard skills students must have in the advanced manufacturing industry. A total of 105 relationships were measured between principal leadership actions and student exposure to hard skills universally supported by the advanced manufacturing industry. Of these relationships, only 19 were found to be statistically significant ($p < .05$). The most significant variable related to student development of the hard skills students will need was the incorporation of at least one Project Lead The Way (PLTW) course. This variable was statistically significant with most of the hard skills universally documented in the literature by

Tassey (2014) and Small (2006). The only hard skill not to be statistically significant with PLTW was student use of a CNC machine.

The inherent lack of relationships related to student use of CNC machines, despite its noted importance to the advanced manufacturing industry, is beyond the scope of this study and will need to be explored further in future studies.

Research Question 2: What is the strength of the relationship between building principal support of 21st century skills in high school technology education classes and the incorporation of those skills by technology teachers?

Finding Five: 21st Century Skills are Important

Respondents (n =77) were asked to rank order ten various 21st century skills used under the 21st from the most important (receiving a rank of 1) to the least important (receiving a rank of 10). These skills included, but were not limited to, communicating effectively with others, thinking critically to solve a problem, working in cooperative teams, utilizing time effectively to complete a task, maintaining a safe working environment, and using mathematics to solve problems. Overall, the three most important skills identified by respondents were (1) communicating effectively with others (*M* = 3.1), (2) thinking critically and problem-solve (*M* = 3.3), and (3) working in a cooperative team to complete a task on time (*M* = 4.0). The three least important skills identified by respondents were (8) maintaining a safe and healthy work environment (*M* = 6.9*)*, (9) maintaining a safe and healthy environment and using mathematics to solve problems (*M* = 7.1) , and (10) adapting to a change in routine or schedule (*M* = 7.2).

This data does not perfectly align with the data presented by Giffi et al. (2015) in which the researchers identified the 21st century skills most needed by advanced manufacturers. Their research with advanced manufacturers indicated computer skills as the most needed skill, followed by problem solving, math skills, and work ethic. Respondents ranked computer skills 6th, problem solving skills 2nd, math skills 8th, and work ethic 4th. This data suggests an emphasis is being placed on the skills identified by The Partnership for 21st Century Learning (2008), NACE (2009), and AMA (2010) which focused on universal skills needed for entry level employment across all sectors, but not directly related to the needs of the advanced manufacturing industry. Further research will need to be conducted to determine exactly which 21st century skills students are being exposed to in technology education classes aligned to careers in advanced manufacturing.

Finding Six: Respondents Feel More Positively About Their Ability to Provide Leadership for Incorporating 21st century skills Than They Do Evaluating 21st century skills

Respondents felt positive in their leadership and oversight of 21st century skills in technology education classes. Respondents (n = 77) were asked fifteen questions regarding their perceptions and leadership actions regarding the development of 21st century skills in technology education classes on a likert scale ranging from strongly disagree to strongly agree. Respondents agreed or strongly agreed to feeling comfortable discussing 21st century skills with their technology education teachers (93%), having their technology education teachers value discussion on how to evaluate 21st century skills (84%), encouraging their technology education teacher to participate in professional development aligned to student development of 21st century skills (92%), and having their technology education teachers incorporate 21st century skills in every unit (83%).

Respondents agreed or strongly agreed to reviewing how students should be assessed on their soft skill acquisition (45%), creating 21st century skills benchmarks to ensure they had been mastered by the end of the class (47%) or by the end of the technology education sequence (48%), and by working with local organizations to ensure their graduates were meeting industry expectations for 21st century skills (49%).

Respondents demonstrated higher efficacy of leadership of 21st century skills than they did with the development of hard skills related to advanced manufacturing. However, much smaller percentages of respondents identified technology education teachers had created benchmarks or assessed student mastery of 21st century skills. Most importantly, forty-nine percent (49%) of respondents agreed or strongly agreed to meeting with local organizations to determine if graduates were demonstrating career ready 21st century skills.

The integration and evaluation of 21st century skills into technology education programs are not surprising. The Partnership for 21st Century Skills (2008) was founded in 2002 and The Advanced Manufacturing Competency Model was first created in 2006 with advanced manufacturing firms. The implementation of 21st century skills in high school technology education programs is less expensive than purchasing equipment for the development of hard skills for students and the subsequent professional development that would be needed by teachers to be trained in how to use the equipment. Symonds et al. (2011) stated critics may argue spending time on developing students' 21st century skills will dilute the rigor and the essential hard skills that are most needed by organizations. However, U.S. employers have openly stated that today's young adults do not possess oral and written communication, critical thinking, creativity, and professionalism to create effective and efficient working environments (PCAST, 2011,2014; Manyika et al., 2012; Shipp et al., 2012; Banchiu, et al., 2013; Giffi et al., 2015; Rosenbaum & Rosenbaum, 2015).

It is recommended for building principals to foster collaborative partnerships with advanced manufacturing organizations in their respective regions to collaborate and identify the 21st century skills that will maximize a student's career readiness upon graduating high school. Upon determining the 21st century skills that are most needed, curriculum and assessments need to be developed to enable the skills to be taught and assessed to measure a high school's progress towards ensuring students graduate college and career ready.

This substantive disconnect between the literature and data collected from respondents will need to be investigated further. A determination should be made to identify if students are showing improvement on their 21st century skills readiness when entering the workforce. The data reported in this study indicates students are more career ready than the literature suggests.

Recommendations for Policy and Practice

Federal and State Priorities

In 2011, PCAST, argued the importance of revamping the United States manufacturing processes from a focus on low-skill, inexpensive products, in which the U.S. is not capable of competing, to manufacturing that is derived from advanced manufacturing. PCAST (2011) believed placing an emphasis on manufacturing that requires advanced machinery and higher skill and knowledge level from the operator, is how the U.S. can once again become a global leader in manufacturing. Successfully transitioning to an advanced manufacturing environment will require employees to possess a higher skill set than traditional manufacturing (p. 9). In support of recommendations made to President Obama by PCAST (2011), he has pledged $500 million dollars each year since 2009 to help improve manufacturing processes to increase global competitive advantage (Martino, 2011).

Two bright spots for the U.S. in advanced manufacturing growth are New England and Michigan. New England is on the cusp of creating 7,500 to 8,500 jobs each year with an average salary of $80,000 if the advanced manufacturing sector in the region can attract better trained employees to meet the demands of advanced manufacturing organizations (PCAST, 2011). In Michigan, advanced manufacturing has been showing promise as an estimated 65 percent of the state's manufacturing jobs in 2007 and 72 percent in 2009 were in advanced manufacturing (PCAST, 2011).

Upstate New York, as defined by the state's comptroller, Thomas DiNapoli in 2010, includes everything north of the Hudson Valley. This region saw a 28 percent decline in manufacturing jobs between 2000 and 2008 (DiNapoli, 2010). However, one in every nine employees in upstate New York still has a job in manufacturing. Advanced manufacturing firms in computer and electronic industries experienced a growth of 7 percent during the same time period; adding over 7,000 jobs (p. 2). This growth is expected to continue with additional nanotechnology and chip fabrication plants in Albany, NY, Utica, NY, and Buffalo, NY.

With the positive climate surrounding advanced manufacturing in the state of New York and the U.S., ensuring students possess the hard and 21st century skills needed by the advanced manufacturing are essential for the industry to meet the most optimistic growth demands that will only be slowed by the lack of intellectual capital needed by the industry.

Create a Strategic Plan for an Advanced Manufacturing Pathway

The Pathways to Prosperity Network (Jackson, 2015) completed a case study in Massachusetts to provide educators and state leaders with examples on how schools districts can align with advanced manufacturing organizations to create a strategic plan to generate a continuous pipeline of employees to support economic growth (p. 1). School building leaders and system leaders must develop a strategic plan for a technology education pathway aligned to advanced manufacturing that is "employer driven, standardized and competency-based that spans the state's secondary and postsecondary education system" (p. 2). A comprehensive strategic plan can serve as a roadmap in which the Board of Education, school leaders, and faculty can all be held accountable. To create the plan, time, energy, and capital will be essential components to determine the needs of the industry, design curriculums that will enable articulation agreements to exist with colleges and universities for dual-credit opportunities, and develop a spending plan to purchase tools and equipment to develop students' hard skills.

Before the plan can be written, perceptions and social stigma associated with a career in advanced manufacturing must be expunged. Educating stakeholders on national and local college graduation rates and redefining the public's perception of "college for all" will be integral components of the plan (Symonds et al., 2011). The societal expectation of all students attending college must shift from one that expects all students to earn a bachelor's degree to one that encourages students to enroll in the appropriate form of higher education that will align with their interests and goals (Symonds et al, 2015; Ferguson & Lamback, 2013; Rosenbaum & Rosenbaum, 2015). The one aspect of college for all that will not change is the fact that all students will need to attend some form of higher education to develop the intellectual capital this country needs in advanced manufacturing as well as other fields (Symonds et al., 2011). To help build a pathway to advanced manufacturing, Ferguson and Lamback (2014) provide a blueprint to create a coherent and effective pathway.

Creating a pathway for students to obtain employment is not something that can be completed with just schools. It requires stakeholders in public education, higher education, industry, and policy makers to agree on common curricula, credentials, learning protocols, and teacher training that will positively impact local, state, and federal employers (Ferguson & Lamback, 2014).

The underpinning of creating a pathway for advanced manufacturing will be the creation of learning goals or benchmarks for students to meet for immediate employment or to continue studying at the collegiate level (Ferguson & Lamback, 2014). Curriculums must then be developed to provide the appropriate scope and sequence of learning experiences that will produce highly qualified and competent employees (p. 12). Policies and procedures for allocating funding for the development of the pathway must be made through collaboration of local, state, federal, and industry to ensure the initiative can be met (p. 12). Corporations and higher education must play a significant role in creating projects and supports aligned to industry to provide students with real-world learning opportunities. Feedback can then be generated to alter the curriculum, instruction, and assessments to ensure a fluid pathway in which students can enter the world of work or college for additional training and learning experiences as identified in the advanced manufacturing competency model (p. 12).

The importance of creating a collaborative group of stakeholders, industry leaders, and colleges and universities is essential to ensuring New York State, the U.S., and the advanced manufacturing industry will have a competent and capable workforce capable of supporting the most optimistic growth expectations. Producing the intellectual capital will help to attract advanced manufacturing organizations to the state or country while simultaneously improving the economy and society with good paying jobs and a stronger middle class.

Broaden the Definition of 21st Century Skills

The Partnership for 21st Century Learning (2008) has been an educational leader in promoting the importance of 21st century skills and civic responsibility as society continues to embrace a digital environment. The Partnership for 21st Century Learning (2008) framework has been an outstanding resource for schools to embrace as the “gold standard” to create curriculum and measurable objectives to ensure students graduate with the 21st century skills needed for college and the world of work. As technology education programs continue to embrace and implement the hard skills supported by advanced manufacturing organizations, it is important to also integrate the Advanced Manufacturing Competency Model.

The model, which was developed by the advanced manufacturing industry, contains essential competencies related to academics, workplace, personal, and industry wide competencies. The model is very similar to the design by The Partnership for 21st Century Learning (2008), but provides specific competencies aligned to advanced manufacturing organizations and is supported by the Manufacturing Institute and the Department of Labor. The competencies are not isolated to only technology education and can be implemented in more disciplines than just technology education. Each of the frameworks is equally compelling to display and review with students. However, it is not just a matter of reviewing the material with students, it must also be assessed. All of the 21st century and advanced manufacturing skills are capable of being assessed and must be, to ensure students demonstrate their mastery of the skill.

Provide Professional Development Opportunities

Dettelis (2011) states“…it is nearly impossible for the entire field of education to embrace new ideas and new products without the financial incentives and/or regulatory mandates” (p. 37). New York has not, nor is there a plan to create an economic strategic plan for advanced manufacturing with industry and secondary and higher education. When combined with the property tax cap limit and GEA formula, districts will need to create their own strategic plan aligned to advanced manufacturing. The lynchpin of the plan will be technology education teachers, as they will be the most integral part for creating an advanced manufacturing pathway (P. Dettelis, personal communication, July 23, 2015).

Recommendations for Future Research

The focus for this research was limited in scope, but it did provide insight into principal leadership and the development of technology education programs that are aligned to the advanced manufacturing industry through the incorporation of hard and 21st century skills. Conducting this research has led to additional questions for future research:

- Does a principal's efficacy positively impact curricular changes that are not mandated or financially incentivized? Or is principal efficacy positively related to all curricular changes in a building?
- To what extent has the state's adoption of the Common Core State Standards (CCSS) coupled with the property tax cap limit, GEA, and Annual Program and Performance Review (APPR) negatively impacted the ability to fully fund elective based programs and courses in schools?
- Why has there been such a significant decline in newly certified technology education teachers?
- Despite principals identifying the importance of preparing students for careers in advanced manufacturing, why have principals been unable to provide students with the necessary tools and equipment to support the development of hard skills?
- Given Massachusetts economic development plan supporting advanced manufacturing, how would the results of this study align? Is the inception of a state wide economic development plan essential in ensuring a tighter coupling of secondary education, higher education, and industry?

- What is the long-term applicability of curriculum programs such as PLTW? Do students who have taken PLTW courses possess the necessary levels of 21st century and hard skills related to advanced manufacturing?

There are a number of unanswered questions that are outside of the scope of this research. The focus of this research project was to ascertain principals' perceptions on advanced manufacturing and what, if anything, they were doing to help provide students with the hard and 21st century skills that are integral to this field according to the literature. The inherent truth is that there were 600,000 jobs in advanced manufacturing in 2011 that were unfilled due to a skills gap. Additionally, this number is expected to grow to 2 million jobs by 2020 (Giffi et al., 2015).

This research has determined that principals believe advanced manufacturing is a viable career opportunity, but the reasons identifying why New York State has not created an economic plan to connect government, industry, and education to help produce more trained employees will need to be analyzed further.

Principal Efficacy and Leadership of Curriculum

Data relative to research question 1 revealed fewer significant relationships than research question 2. There appears to be a significant disconnect between the two, despite principals identifying the importance of advanced manufacturing and the potential it has for the creation of student careers as a viable career path. Worthy of future studies is the level at which the property tax cap limit and GEA formula negatively impacted technology education programs, especially in regards to the development of hard skills by students.

Principals were not asked about how the rollout of the CCSS affected other disciplines including elective based curriculums. The state's adoption of the CCSS and subsequent Regents reform agenda has led to curriculum reform in English and math coupled with new summative assessments in English, algebra, geometry, and algebra 2. Much of the focus during the time of PCAST's (2011) recommendation to create an emphasis on advanced manufacturing has occurred during a large curriculum, instruction, and assessment changes in core subject areas that have graduation implications.

The importance of leadership in times of change is well documented (Dufour & Marzano, 2011; Fullan, 2008; Kotter & Cohen, 2002; and Waters et al., 2003) . This study measured principals' beliefs and leadership of courses and skills incorporating advanced manufacturing, but did not address the primary focus of their leadership efforts. Had the Regents reform agenda not been implemented, would a larger focus and appropriation of funds been allocated to technology education? Or were the most highly effective principals able to achieve success with the Regents reform agenda along with other curriculums that were not mandated or financially incentivized? To address these issues further research will need to be conducted to ascertain the level of significance the CCSS, property tax cap limit, and GEA factored into principals' perceptions on how well developed a technology education pathway aligned to advanced manufacturing needed to be.

Decline of Newly Certified Technology Education Teachers

The significant decline in the number of newly certified technology education teachers is alarming. There are only two educational programs in the state that have a technology education program – SUNY Buffalo State and SUNY Oswego. The drastic reduction in certified teachers is difficult to comprehend at a time when technology education teachers are needed. Five respondents (10%) who completed the survey desired to increase their technology education course offerings, but were unable to find a highly qualified individual to teach the classes. A review of all certifications since the 2007-2008 school year should be conducted to determine if technology education certifications are an outlier of all newly certified teachers, or an accurate reflection of a much larger problem in New York State.

Creating an Economic Development Plan in New York

The Pathways to Prosperity Project showcased the state of Massachusetts as a case study in which the state's legislature required the last elected governor to develop an economic development plan to ensure the growth of jobs in the state (Jackson, 2015). The governor's plan identified the importance of linking the advanced manufacturing industry to secondary and higher education programs to help create a viable pathway for students in advanced manufacturing (p. 2). It may be of value to distribute the survey used in this study, under the same parameters, to schools in Massachusetts to determine if the relationships that existed between leadership and the incorporation of hard and 21st century skills in technology education classes related to advanced manufacturing would be different. Determining the strength of the relationships could help guide the legislature in New York to develop a similar plan in order to fully support the ongoing initiative to attract and retain semiconductor manufacturing plants to the Albany and Utica area in addition to several other advanced manufacturing industries.

Conclusion

Manufacturing systems are considered essential by most nations for the creation and propagation of wealth. The U.S. currently has a manufacturing base that comprises 20% of its total gross domestic product, which also provides for 30% of all traded goods (Mital et al., 1999). Much of the world's low skill manufacturing once existed in the U.S. but now occurs in Asia and India because it is not cost productive to produce the products in the U.S. (Tassey, 2014). The United States is undergoing a paradigm shift in manufacturing as it progresses from the post-World War II era of low skill in which employees controlled machines that drilled, cut, stamped, or milled products as they passed through the effective and efficient assembly line, to one that is derived from scientific inquiry and technological innovation (PCAST, 2011). This shift in manufacturing processes improves production efficiency, quality, and diversity of products, and helps prevent a potential loss of competitive advantage in the global marketplace through new technologies, high precision tools, and advanced materials (Thomas et al., 2007; Mital, et al., 1999; PCAST, 2011; NSTC, 2012; Shipp et al., 2012; Manyika et al., 2011). For the benefits of advanced manufacturing to be fully realized, a more skilled workforce will be needed to operate the technological systems and computers that will power and control the manufacturing processes (Shani et al., 1992; Shipp et al., 2012).

The advanced manufacturing sector is currently creating jobs and is expected to sustain job growth. Within the K-12 framework, building and system level leaders will need to ensure students have access to an advanced manufacturing educational pathway necessary to earn a credential, associate's degree, or bachelor's degree after completing high school (PCAST, 2011; Banchiu et al., 2013).

High school principals serving students with 600 or fewer students in New York State, excluding New York City appear to have a firm understanding of the advanced manufacturing industry and its potential positive implications for the state of New York and the U.S.'s economy and society. Regardless of the financial stressors placed on districts through the property tax cap limit and GEA, principals were able to maintain or increase technology education classes related to advanced manufacturing (n = 72, 95%). However, principals have not been able to fully support their beliefs regarding advanced manufacturing through the incorporation of hard skills related to the advanced manufacturing industry. The reason why this reality has not been fully realized will require additional research.

On a positive note, respondents reported a high degree of comfort and capability to lead their technology education teachers on 21st century and advanced manufacturing 21st century skills. The degree of confidence and the number of statistically significant relationships regarding the incorporation and measurement of 21st century skills stands in stark contrast to reports indicating students lack essential 21st century skills needed for employment (Shipp et al., 2012; PCAST 2011, 2014; NSTC, 2012; Symonds et al., 2011; Manyika et al., 2011; and Rosenbaum & Rosenbaum, 2015).

Respondents reported that despite changes to the curriculum in technology education, the adoption of the CCSS, new Regents assessments in English and math, and reductions in financial aid due to the property tax cap limit and GEA, they still found advanced manufacturing as a appropriate pathway. High school principals took the necessary steps to educate themselves about advanced manufacturing, encouraged their technology education teachers to attend professional development opportunities on the topic, requested funding and additional classes from their respective superintendent and BOE, and incorporated hard and 21st century skills related to advanced manufacturing. This level of leadership speaks highly to principals' dedication to ensuring students have additional pathways after high school besides a bachelor's degree while supporting the advanced manufacturing initiative at the state and federal level.

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Appendix A: Principal Survey Instrument

Survey Introduction

My name is Matthew Lee. I am a doctoral student in the Educational Leadership program at The Sage Colleges, and a public high school principal. I am writing to invite you, a principal who has a responsibility for 600 or fewer students as well as students enrolled in grades 9-12, to participate in a research study. This study will investigate how well students in technology education classes are being prepared for careers in advanced manufacturing while developing 21st century skills.

The information gathered in this study will help to inform leaders in public schools and advanced manufacturing organizations on how well public high schools in New York State are preparing students for careers in this field. Specifically, it will help bridge the gap between the knowledge and skills the industry desires in its employees and the resources schools need to adequately prepare students for careers in advanced manufacturing.

I do not anticipate any risks to you by participating in this study other than those you encounter in your daily life. If you have any questions or concerns regarding the survey, please feel free to contact my doctoral chairperson, Dr. Deb Shea at shead@sage.edu. You may also contact Dean Lori Quigley at l.quigley@sage.edu with any questions or ethical concerns you may have regarding the survey. Participation in this study is entirely voluntary. You may, at any time during the survey, choose not to answer a question or withdraw from the survey.

I thank you for your consideration and I hope to work with you in this study. Your participation will help to create a picture on how well public schools in New York State are preparing students for careers in advanced manufacturing.

If you choose to participate in this survey, selecting “Yes” to the question below will constitute informed consent.

Principal Questionnaire

*1. Would you like to participate in this survey?

○ Yes
○ No

Section I: Demographic Information and Technology Education Offerings

2. What is your gender?

- ○ Male
- ○ Female

3. What is your age?

- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55 or Older

4. How many combined years, including this year, have you worked in the field of education as a teacher and administrator?

- ○ 0-4 years
- ○ 5-9 years
- ○ 10-14 years
- ○ 15-19 years
- ○ 20-24 years
- ○ 25-29 years
- ○ 30 or more years

5. What is the total student enrollment in your building?

- ○ 0-200 students
- ○ 201-400 students
- ○ 401-600 students
- ○ 601 or more students

6. What is the approximate percent of students eligible for free or reduced lunch in your building?

- ○ 0%-9%
- ○ 10%-19%
- ○ 20%-29%
- ○ 30%-39%
- ○ 40%-49%
- ○ 50% or greater

7. What is the grade configuration in your building?
- K-12
- 6-12
- 7-12
- 7-9
- 9-12
- 10-12
- Other – Please identify the grade configuration of your building.

8. Since the 2009 - 2010 school year, has the number of technology education courses incorporating 3-dimensional design software, 3-dimensional printing, CNC machining, or robotics offered to your students in grades 9 - 12 in your building or through off campus programs increased, decreased, or remained the same?

- Increased
- Decreased
- Remained the same
- My building has not offered technology education classes to students in grades 9-12 since the 2009-2010 school year.

Section II: Technology Education Offerings

Based upon the response given in question 8, respondents would be directed to question 9 or 10.

9. Please identify the reason(s) why you believe technology education classes incorporating 3-dimensional design software, 3-dimensional printing, CNC machining, or robotics offered to students in grades 9 -12 in your building or through off campus programs has increased.

- Increase in advanced manufacturing jobs in the United States.
- Increase in advanced manufacturing jobs within a 50-mile radius of my building.
- Student enrollment has increased since the 2009-2010 school year.
- Increase in student demand to enroll in classes that are more computer based.
- My technology education teacher(s) believed our technology education classes needed to be more computer based.
- I believed our technology education classes needed to provide our students with a kore computer based program.
- Other – Please identify any additional reason(s) why you believe technology education classes incorporating 3-dimensional design software, 3-dimensional printing, CNC machining, or robotics offered to students in grades 9 -12 in your building or through off campus programs has increased.

10. Please identify the reason(s) why you believe technology education classes incorporating 3-dimensional design software, 3-dimensional printing, CNC machining, or robotics offered to students in grades 9 -12 in your building or through off campus programs has decreased or remained the same.

- There has not been an increase in advanced manufacturing jobs in the United States.
- There has not been an increase in advanced manufacturing jobs within a 50-mile radius of my building.
- Student enrollment has decreased since the 2009-2010 school year.
- We have reduced course offerings in technology education classes due to the tax cap.
- We have reduced course offerings in technology education classes due to the Gap Elimination Adjustment (GEA) formula.
- Students have not requested technology education classes that are more computer based.
- My technology education teacher(s) feels the skills students should have before graduating high school are traditional wood and metal working skills.
- I believe the skills students should have before graduating high school are traditional wood and metal working skills.
- Other - Please identify any additional reason(s) why you believe technology education classes incorporating 3-dimensional design software, 3-dimensional printing, CNC machining, or robotics offered to students in grades 9 -12 in your building or through off campus programs has decreased or remained the same.

Section III: Principals' Perceptions on Advanced Manufacturing

In your current role as a building principal, please respond to each statement below:	**Yes**	**No**	**Unsure**
11. I have requested funds from my superintendent or Board of Education to purchase tools and equipment related to advanced manufacturing since the 2009-2010 school year for students to use in technology education classes in grades 9-12.			
12. I have requested my superintendent and Board of Education to offer classes regarding advanced manufacturing to students in grades 9-12.			
13. I have read literature regarding the necessity to prepare students for careers in advanced manufacturing.			
14. I have met with area businesses using advanced manufacturing technologies to help determine the skills my students need to be career ready upon graduating high school.			
15. I have encouraged my technology education teachers in grades 9-12 to attend professional development opportunities aligned to advanced manufacturing.			
16. I believe it is just as important for students to learn a trade as it is for students to go to college.			
17. I believe the only pathway for student success is through a 4-year college degree.			
18. I do not believe a career in advanced manufacturing is a viable opportunity for my students in New York State.			
19. I believe it is important to introduce students to careers in nanotechnology in high school.			
20. I have, or plan to work, with area advanced manufacturing organizations to create internship opportunities for my students.			

Section IV: Inventory of Advanced Manufacturing Tools and Equipment and Skill Development

Statement	**Yes**	**No**	**Unsure**
In technology education classes in grades 9-12:			
21. Students use 3-dimensional modeling software, such as Autodesk Inventor, Pro-Engineer, Solidworks, Google SketchUp, or another 3-dimensional modeling program.			
22. Students use a Computer Numeric Control (CNC) machine.			
23. Students use a 3-dimensional printer.			
24. Students design, build, and program robots for a specific purpose or competition.			
25. Students create presentations to share information with their peers.			
26. Students write papers to effectively communicate with their teacher(s).			
27. Students can read mechanical blueprints.			
28. Students have the opportunity to participate in internship programs.			
29. Students have the opportunity to enroll in at least one Project Lead The Way class.			
30. Students have the opportunity to enroll in at least one Engineering by Design class.			
31. Purchases of new equipment or software related to CNC machines, 3-dimensional printers, 3-dimensional modeling software, or robotics have been purchased since the 2009-2010 school year.			
32. Partnerships have been created with trade schools and/or community colleges to help provide graduates with opportunities to obtain employment in advanced manufacturing facilities.			
33. Students receive instruction on 21st century skills (i.e. work ethic, attitude, communication, time management, teamwork, etc.).			
34. Students are assessed on their 21st century skills (i.e. work ethic, attitude, communication, time management, teamwork etc.).			

Section V: 21st Century Skills

35. Please rank the following 21st century and advanced manufacturing skills from the most important (1) to the least important (10), that you think are necessary for students to be successful for a career in advanced manufacturing.

☐ Utilize time effectively to complete a task.
☐ Communicate effectively with others.
☐ Work in a cooperative team to complete a task on time.
☐ Accept praise, setbacks, and criticism with positivity and an open mind.
☐ Conduct oneself in a respectable and professional manner.
☐ Use a personal computer and related applications to convey and retrieve information.
☐ Use mathematics to solve problems.
☐ Ability to adapt to a change in routine or schedule.
☐ Think critically and problem solve.
☐ Maintain a safe and healthy work environment.

Section VI: Inventory of 21st Century Skills Used in Technology Education Classes

For each statement regarding 21st century skills in technology education classes in grades 9-12, please select your response by choosing one of the five options ranging from strongly disagree to unsure.

Statement	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**	**Unsure**
36. I am comfortable discussing 21st century skills with my technology education teacher(s).					
37. My superintendent has supported my professional growth in leading 21st century skills for my teachers.					
38. My technology education teacher(s) value my discussions with them regarding evaluating student mastery of 21st century skills.					
39. I encourage my technology education teacher(s) to participate in professional development opportunities related to developing 21st century skills in students in their class(es).					
40. I receive positive feedback from my superintendent regarding my leadership of incorporating 21st century skills into technology education classes.					
41. I work with local organizations to ensure students in technology education classes are meeting their expectations of 21st century skills upon graduating from high school.					
42. In technology education department meetings, I regularly discuss how to infuse 21st century skills into our daily lesson and unit plans.					
43. In technology education department meetings, I review how to assess student mastery and application of 21st century skills.					
44. My technology education teacher(s) view 21st century skills as a vital asset in which students are expected to have mastered before graduating from high school.					
45. My technology education teacher(s) have planning time to incorporate 21st century skills into their curriculums and lesson plans.					
46. My technology education teachers incorporate 21st century skills in every lesson.					
47. My technology education teachers incorporate 21st century skills in every unit.					
48. Every activity's rubric assesses student mastery of specific 21st century skills.					
49. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered them by the end of the class.					
50. Technology education teachers have created 21st century skills benchmarks to ensure all students have successfully mastered all of them by the end of the technology education sequence our high school offers.					