A PROGRAM EVALUATION STUDY FOR A PRECISION MANUFACTURING APPRENTICESHIP EMBEDDED IN A TRADITIONAL HIGH SCHOOL CURRICULUM

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A notable segment of high school students interested in STEM careers is underserved by the traditional college preparatory-vocational education duality structure employed by public school systems over the past decades. The mismatch between student interest in STEM vocational pathways and the "college-for-all" precept indicates that our secondary school model fails to prepare students for a large segment of high-growth occupations immediately available after high school graduation. Within the American high school, academically-minded students rarely elect CTE pathways because of the life-changing commitment they require. Often, the CTE choice removes a student from like-minded peers who share a strong affinity toward school, conflicts with extracurricular programs, and hinders the scope of electives due to limitations within the master schedule. For many, the cost to attend off-site CTE programs is too high. This tension inherent in the CTE model strains loyalties and erodes in-school opportunities beyond perceived value, yet many will opt into fields of study that provide a low return-on-investment while lucrative high-tech STEM trade careers are ignored.

This research evaluates the effectiveness of an advanced manufacturing apprenticeship program embedded in a traditional high school curriculum. In 2014, Highlands School District partnered with Oberg Industries, a world-leading manufacturer of high-precision metal products for the aerospace, medical, and tool and die sector to form the Junior Apprenticeship Advantage (JAA) program. A specific curriculum consisting of Computer-Aided Design (CAD), Geometric Dimensioning and Tolerancing (GD&T), Metrology (Measurement Science), and Advanced Geometry/Trigonometry is taught by Highlands faculty in conjunction with traditional senior year classes. Additionally, students in this program travel to Oberg's facilities twice per month during the school year for job-shadowing experiences working with Oberg's skilled craftspeople.

This study finds the JAA program *is* effective at preparing students for advanced manufacturing apprenticeship certification training. Quantitative and qualitative data from survey instruments, training records, and institutional financial documents provide evidence to compare JAA graduates directly with their otherwise similar CTE counterparts. Although JAA graduates begin at a slight deficit in manufacturing skills, results show their academic focus and intellectual range allow them to rapidly acquire industry certifications which earn them the most prestigious and coveted positions within the organization.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

[It is recommended that acknowledgments, nomenclature used, and similar items should be included in the Preface.]

[The Preface is optional.]

1.0 INTRODUCTION

The economic success of the United States in the 21st Century will depend on the knowledge and skills of its population. Although relatively small in number, the science, technology, engineering, and math (STEM) workforce has a disproportionate effect on the nation's economic competitiveness, growth, and standard of living. For example, the U. S. Department of Commerce Economics and Statistics Administration (ESA) reports the STEM wage premium averages twenty-six percent above all other occupations across all levels of education (ESA, 2012, p. 1). As the world economy becomes increasingly technological, the Bureau of Labor Statistics (BLS) predicts STEM-sector employment will grow 13 percent annually over the next decade adding more than one million jobs through 2022 (BLS, 2014, p. 6). The quality of STEM education will determine if America can sustain its economic advantage over rapidly developing countries such as India and China. Despite piecemeal efforts at education reform within the K-12 school system, the United States ranks 29th out of 109 nations in developing a STEM-educated workforce (NSF, 2016). Not only do our students perform poorly in math and science standardized tests, they are rarely challenged to demonstrate the critical thinking and communication skills required in today's global economy (Wagner, 2008, p. 104). Moreover, student apathy toward STEM-related subjects, particularly within underrepresented populations, deprives the nation of a vast pool of human capital. Until now, the United States has been able to rely on foreign students studying and working domestically to offset the STEM workforce shortage. As economies in China and India outpace United States' GDP growth, the talent pool of highly educated foreign-born scientists and engineers is likely to find more lucrative opportunities off-shore (Clifton, 2011). This trend places greater pressures on the American educational system to cultivate STEM talent from within.

Within the past five years, reports from the Organization for Economic Cooperation and Development (OECD), the U.S. Departments of Commerce and Labor, the International Labor Office (ILO), the World Bank, and other salient workforce and economic literature describe a rapidly changing world economy where "advanced technologies have replaced many human tasks, resulting in an increased demand for 'knowledge workers' and higher-level skills" (Wang, 2012, p. 1). Additionally, G-20 leaders stress, "Good quality primary and secondary education, complemented by relevant vocational training and skills development opportunities, prepare future generations for their productive lives, endowing them with the core skills that enable them to continue learning" (ILO, 2010, p. 1). It is incumbent upon domestic educational leaders to consider existing practices and structures in context of global competition. Do our schools prepare American students for the "hard" technical competencies and "soft" survival skills Thomas Friedman and Tony Wagner describe? "To succeed after high school, students must think creatively, solve problems, work in groups, speak in public, and apply what they have learned in real-world situations" (Wagner, 2008, p. 281). The viability of our nation depends upon addressing these issues in earnest before our standard of living is eclipsed by those countries that have effectively aligned educational policy with market demands.

1.1 BACKGROUND OF THE PROBLEM

The greatest advancements in our society have come from the minds of those interested in the study of Science, Technology, Engineering, and Math (STEM). The STEM workforce has an acute "impact on a nation's competitiveness, economic growth, and overall standard of living" (ESA, 2017,). National data shows that STEM occupations have grown six times faster than non-STEM careers over the past decade. The U.S. Department of Labor estimates that one million additional STEM graduates will be needed over the next 10 to 15 years with 150,000 more STEM employees in the Western Pennsylvania region alone. Secretary of Education Arne Duncan stated, "A STEM education is a pathway to prosperity–not just for an individual but for America as a whole" (U.S. Department of Education, 2011). To address the impending skills gap, the President's Council of Advisors on Science and Technology (PCAST) developed specific recommendations to ensure the United States is a leader in STEM education throughout the coming decade.

Federal education policy initiatives follow two predominant themes delineated by the demarcation of K-12 and post-secondary institutions. At the university level, Congressional legislation expands National Science Foundation (NSF) doctoral fellowships in STEM, increases underrepresented minority populations through NASA scholarships and Pell grants through the NSF, and offers economic enticements for universities to establish Professional Science Masters programs (Atkinson, Hugo, Lundgren, Shapiro, & Thomas, 2006, p. 14). Additionally, many universities improve freshmen STEM retention offering study group and remediation support in addition to mentorship programs with faculty and upper class students (Honken and Ralston, 2013, p. 7). Within the K-12 educational system, PCAST (2010) advocates for improvements such as: Stipends for "highly qualified" STEM teachers, improved science teacher professional development opportunities to include guidance counselor STEM career training, more rigorous undergraduate science and math courses for all education majors, and streamlined teacher certification programs for experienced scientists and engineers (p. 57).

The burgeoning growth of STEM occupations necessitates a closer review of current K-12 educational policy beginning with school district curriculum, classroom pedagogy, graduation requirements, internship opportunities, dual-enrollment programs, and teacher training. In addition, school district policymakers should consider post-secondary education practices to align STEM transitioning beyond high school. A preponderance of literature describes shortcomings in the nation's K-E (*Employment*) education system which impedes matriculation of students from high school into lucrative and stable STEM sector career opportunities *regardless* of post-secondary degree attainment; however, few prescriptions offer tangible evidence indicating sustainable results. An "all of the above" approach to previously described remedies incrementally decreases the STEM workforce deficit and improves the economic competitiveness of the United States, yet "virtually all the reports on [this] issue and legislation addressing it largely ignore one of the most potentially successful policy interventions in this area: specialized math and science technology high schools" (Atkinson et al., 2006, p. 16). Programs of this nature, therefore, merit more detailed investigation. According to Merriam (2009), theoretical framework is a disciplinary orientation or lens through which one views the world (p. 71). This construct is the foundation for qualitative study which "defines the system of concepts, assumptions, expectations, beliefs, and theories that informs [one's] research" (Maxwell, 2005, p. 33). Current educational initiatives fail to address student self-identity with STEM careers at the critical period of transition planning during the final two years of high school. Within this time frame, key decisions begin to shape an individual's education, employment, and career trajectories.

In 2013, the Highlands School District implemented a Science, Technology, Engineering, Art, Math, and Medicine (STEAMM) Academy and Junior Apprenticeship Advantage (JAA) Program utilizing the "school-within-a-school" concept. Although these programs are not "stand-alone" magnet or charter STEM schools, they do represent a sub-set of the specialty math and science school programs advocated in HR 2272, the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Act signed into law in 2007. This research examines one of these high school initiatives designed to increase student self-identity with Science, Technology, Engineering, and Math "culture" through a cohort learning experience structured to increase the affinity and interest of students to pursue STEM careers.

1.2 STATEMENT OF THE PROBLEM

A notable segment of high school students interested in STEM careers is underserved by the traditional college preparatory-vocational education duality structure employed by public school systems over the past decade. An example is "Kara" (pseudonym), a seventeen year old Highlands High School junior involved in stage band, the foreign language club, varsity soccer, and the high school musical production. In addition to her intra-curricular activities, Kara holds a 3.2 G.P.A. and shows a strong interest in the applied sciences. Although her class schedule is comprised of "college-prep" courses, Kara is not considering post-secondary education since her 900 combined SAT score preclude her from entering a collegiate science or engineering program directly upon graduation. Conversely, Kara never entertained enrolling in the school's off-site vocational education program. Such a commitment would force her to choose between many of the curricular electives she enjoys and a vocational pathway in health sciences, technology, or precision manufacturing. Like Kara, a significant portion of these students possess above average academic ability yet do not intend to enroll in college programs. Furthermore, these students exhibit strong engagement and affinity toward high school activities so they discount off-site vocational programs which displace Career Technical Education (CTE) participants a minimum of four periods each day. Conversely, many college-bound students opt into fields of study that provide a low return-on-investment while lucrative high-tech STEM trade careers are ignored.

To gain a broader perspective, it is prudent to reflect upon the academic and social context when CTE pathways are selected. According to the Pennsylvania Department of Education, early career exploration for secondary students begins during ninth grade when students investigate various occupational clusters and complete a standardized interest assessment. Based in part to results of the Career Interest Survey, guidance from school counselors and vocational education recruitment presentations, the adolescent mind begins to formulate strategies to achieve near-term goals. Research shows that a student's intrinsic motivation begins to decline in middle school and continues to erode through high school (Gottfried, Marcoulides, Gottfried, Oliver, & Guerin, 2007). An individual's intrinsic motivation is positively related to his/her perception of his/her competence (Wigfield & Eccles, 2002). It follows students who experience repeated disappointments in school often do not perceive themselves as competent in a traditional classroom setting. In the tumult encompassing the ninth grade transition to high school, our current educational structure exacts from young adolescents a heavy cost. For many, the burden is not financial, rather lost happiness–a toll measured by economists and psychologists who study individual motivation. For students disillusioned with the high school experience, the opportunity for half-day vocational education programs presents a salient alternative to a traditional academic pathway.

Historically, vocational education is stigmatized in the United States. Many schools unfairly placed students who lacked academic potential and exhibited disciplinary transgressions into CTE programs. Although there are examples of excellence, "vocational programs became a dumping ground" opines Robert Schwartz, head of the Pathways to Prosperity Project at Harvard's Graduate School of Education (Summers, 2014). The programs offered school administrators a place to send high-risk students to keep them in school. Furthermore, some research has shown that vocational programs increase students' alienation and disaffection from the high school experience when students are physically moved off-site to attend a work-based learning program (Allan, 2014). Data from the National Monitoring the Future Survey of 15,000 students at five-year intervals shows vocational students are less likely than their high school peers to say that doing well in school is more important than getting a job. Additionally, vocational students are more likely to state that schooling prevents them from getting the job they desire, that their classmates would admire them if they cheated, that friends encourage disruptive classroom behaviors, and that they willfully damage school property (Boesel, 2001). These recalcitrant attitudes parallel the marginalization and "stigmatation" of vocational programs from previous decades, some of which had become dated or became dumping grounds for poorly performing students while changes in the labor market increased the value of a college degree (Besharov & Cohen, 2005).

In addition to attitudinal evidence toward school, the National Center for Education Statistics (NCES) finds that students with lower GPAs generally complete more vocational credits (2009). Levesque and Hudson (2003) report career and technical education attempts to attract a wide range of students, yet those in a high academic achievement group are far less likely to enroll in a vocational concentration. Additionally, the NCES study reports students who find success in academic pursuits expect to enroll in post-secondary programs regardless of race, ethnicity, or English as a Second Language (ESL) status. Coincidentally, white, black, and Hispanic students differ little from the overall pool in terms of the numbers of vocational and occupation–specific credits they earn in career sector concentration. Asian students represent the only outlier with appreciably smaller numbers enrolled in vocational programs. However, disadvantaged students from lower socioeconomic quartiles, students with disabilities, and individuals with above-average remedial credits are more likely to specialize in vocational career pathways (NCES, 2009). The focus of these studies underscores a perpetual undercurrent which stigmatizes efforts to attract high-performing academic students to CTE programs.

Understanding the general profile of the "common" CTE student is relevant when considering the dynamic between academic-focused students and their aversion toward CTE participation. Despite ongoing efforts to raise the bar with challenging high-tech career opportunities, industry-recognized technical certifications, and job placement, the image of career and technical education is tarnished.

Vocational education programs are often purported to benefit at-risk students through access to choice, experiential learning, authentic career exploration, and other attributes that engage the individual's interests, build a sense of achievement, and bolster self-worth. Although a number of studies have shown the advantages of CTE programs in this regard, others have noted deleterious effects such as low academic expectations and reduced educational achievement. In a 2009 study, Kelly and Price provide a comprehensive examination of vocational education juxtaposed with traditional academic programs. Using the National Education Longitudinal Survey (NELS:88) database, their report Vocational Education: A Clean Slate for Disengaged Students? finds vocational course-taking does not lead to ". . . substantial improvement in [students'] social psychological adjustment to school as compared to other students during high school" (Kelly and Price, 2009, p. 819).

Contemporary research often focuses on extreme ends of the educational spectrum: at-risk, underserved, disadvantaged, and gifted student outcomes. For example, recent studies using the NELS:88 database suggest that CTE course-taking has a modest effect on high school completion after controlling for prior background characteristics, grade, and achievement. The drop-out risk is lowest when students complete three Carnegie units of CTE for every four Carnegie units of academic subjects (Besharov & Cohen, 2005). Paradoxically, Kelly and Price (2009) conclude enrollment in CTE leads to minimal recovery of engagement for at-risk populations.

> Our conceptualization of vocational education as offering a *clean slate* to disengaged students may more accurately describe what is possible than what is typical. In addition to using data which can more robustly identify students' social psychological adjustment to school, future research should investigate the effects of the specific elements of the vocational curriculum: choice, a career focus, experiential learning, multidimensional performance data, and teacher-student mentoring relationships in strong well-elaborated vocational education programs. (Kelly and Price, 2009)

What if these "clean slate" precepts were also applied within the context of a general academic/college-prep student population? Can *dropping out* for at-risk students equate to *complacent resolution* for strong academic students who show interest in high-tech vocational careers but opt-out to attend college by default? In this context, they too are at risk of underachieving their potential both to themselves and society.

According to the *Monitoring the Future Study*, high school seniors today feel an increased disaffection with school and believe their education is inadequate (Boesel, 2001, p.5). Although conveniently easy to focus on the high school drop-out statistic as a baseline, it is more compelling to frame disengagement among the general student population as a failure of current educational paradigms. Alternative models, such as CTE Program of Study (POS), initiatives have yielded qualitative measures of improved engagement and achievement across all student levels (Castellano, Sundell, Overman, & Aliaga, 2012). In longitudinal studies, treatment schools refined school design and culture by integrating academic learning encompassing career contexts and developing a sense of identity around CTE Programs of Study. It is, however, important to note that these schools embedded CTE curriculum within the high school rather than bridge off-site training locations.

A broader issue often overlooked in this research is the “missed opportunity cost” incurred by students who share an interest in CTE course selection but settle on traditional academic trajectories due to perceived detractors in the current CTE model. In *Beyond College for All: Career Paths for the Forgotten Half*, James Rosenbaum warns of these costs to students, families, and society when a college-for-all norm is perpetuated in secondary education. In his research, Rosenbaum notes that 40 percent of high school seniors view high school as irrelevant believing they are predestined for college regardless of effort or achievement (2001, p. 80). Furthermore, these poorly prepared and over-optimistic students bypass opportunities to prepare for a meaningful vocation which could optimize their potential “encouraging poorly achieving students to delay their work preparation until they see the results of their college ‘experiment’ makes it likely that they will make poor use of vocational [opportunities] in high school" (Rosenbaum, 2001, p. 80). Other researchers have shown a modest degree of CTE credit completion relates to improve earnings (Campbell et al. 1986; Kang and Bishop 1986; Rosenbaum 1996). A third and perhaps obscure cost is directly related to the CTE course selection by current vocational education concentrators. Many of these students lack the academic temperament to engage in highly technical vocational careers. Less than 30 percent of CTE credits are earned in the engineering technologies, manufacturing, health sciences or computer science fields (U.S. Department of Education, 2013). Not only a lost opportunity for students, this dynamic places an increased educational premium upon the tax base. According to a recent study by the National Association of State Directors of Vocational-Technical Education Consortium, vocational instruction adds a 20 percent premium over the cost of traditional academic courses (Klein, 2001). Although state funding in Pennsylvania reimburses school districts up to one-third of eligible expenses, the tax base ultimately bears the responsibility for overall funding. Therefore, schools should encourage CTE programs for more academically-minded students to take advantage of high-tech vocational certifications to optimize the rate of return for this educational investment. A major paradigm shift is necessary to counter the college-for-all mindset.

In *Career and Technical Education in the United States*, the authors claim 83 percent of high schools offer vocational programs on-site (Levesque et al., 2008). This statistic, however, does not appear plausible within Western Pennsylvania where off-site vocational schools are overwhelmingly the norm. When faced with the specter of leaving school four hours a day, a thirty-plus minute bus ride each way to the CTE campus, and enduring the effects of a disproportionately large at-risk population, many potentially high-achieving CTE candidates opt for a traditional education. This detail is critical to understand a hidden dynamic undermining vocational course selection by an important subset of students whose scholastic engagement, intellectual capacity, and self-motivation would otherwise guide them to successful careers in high-tech STEM trades. This research will evaluate the effectiveness of a school district and private industry partnership aimed at promoting precision manufacturing apprenticeships for academically-minded, CTE non-participants.

1.3 PURPOSE OF THE STUDY

The purpose of this research was to evaluate the effectiveness of a precision manufacturing apprenticeship program embedded in a traditional high school curriculum. In a 2004 research study, Vespia successfully applied a five-point evaluation model based on the conceptual framework of Tyler (1949), Kirkpatric (1998), and Guskey (2000) to analyze the outcomes of a youth special education program. Similarly, the Highlands–Oberg Junior Apprenticeship Advantage Program (JAA) with respect to five sequential criteria for evaluating professional development programs was reviewed: S***tudent reactions*** (Level 1), ***student learning*** (Level 2), ***organizational support*** (Level 3), ***student behavior*** (Level 4), and ***extended student results*** (Level 5). Although traditionally applied to professional development training, Vespia (2004) successfully advanced the application of Guskey's systematic framework to study student learning program evaluation. The entry point for this research was the Oberg Industries Apprenticeship Training Facility where recent JAA graduates train side-by-side with their vocational education counterparts.

The Oberg Apprentice Training Center presents the researcher an opportunity to compare a common learning experience of otherwise similar students as they matriculate through their apprenticeship education. Students fall into three general categories: JAA graduates, machine tool vocational education graduates, and "off-the-street" hires with a broad range of experience, age, and diverse manufacturing training backgrounds. From its conception, Oberg and Highlands' leadership questioned the viability of a training model where three years' vocational education is supplanted by an accelerated precision manufacturing education embedded in a single-year traditional high school curriculum. Now, with three years' program history to investigate, empirical research may reveal whether the JAA endeavor develops apprentices with comparable skill sets and intellectual capacity to succeed in the Oberg Apprenticeship Program and the precision manufacturing industry.

1.4 RESEARCH QUESTIONS

Applying the five sequential criteria for evaluating professional development programs, this research investigates if the Junior Apprenticeship Advantage program is an effective pathway for students entering precision manufacturing apprentice certification training:

1. Is there evidence of student, employer, and school district satisfaction with the JAA program?
2. Do apprenticeship competency tests and advancement rates of JAA graduates compare favorably with vocational education counterparts?
3. What aspects of the JAA program do students and Oberg instructors identify as paramount to the successful matriculation and development of apprentice trainees?

4. Is there evidence of elevated career decision self-efficacy and adoption of Oberg corporate values for JAA alumni?
5. Do post-graduate activities provide evidence of the effectiveness of the JAA program?

Additionally, results from this study may uncover institutional and societal barriers that inadvertently undermine STEM vocation career options for students who do not participate in a high school CTE program. These issues are addressed in Chapter Five.

1.5 SIGNIFICANCE OF THE STUDY

Research from this study integrates into a broader issue encountered by families of high school students across the nation. The public's perception that four-year college *credentialing* is paramount to *field of study* obscures viable alternative educational pathways. Elements of this case study provide evidence that wage premium and standard of living are closely aligned with one's employment sector rather than credential. Research findings from this investigation may advance the argument for increasing STEM pathways along the entire educational continuum.

Labaree's (2010) theory of a consumer-driven education marketplace is evident when analyzing the recruitment strategies of postsecondary institutions. What contributes to society's misguided and often irrational fixation on four-year "credentialing" above other forms of intellect and educational attainment? The Lumina Foundation for Education cites major public policy shifts in recent decades which illustrate the transformation of higher education from a public to a private good. Governmental policies such as the GI Bill, the Truman Commission's expansion of the community college system, the Civil Rights and Higher Educational Acts, and the Supreme Court's decision in Brown v. Board of Education greatly expanded access for all students through the 1970's (Kinzie et al., 2004).

While postsecondary participation rates grew at an exponential rate, many universities refined and expanded their marketing strategies to compete with the burgeoning regional and community college industry. The researchers outline a ". . . growing use of business techniques, marketing research and more sophisticated forecasting models . . . [where] colleges combined admissions, financial aid, orientation, retention and institutional research under one department in the hope of making the enrollment process more effective" (Kinzie et al., 2004, p. 26). Unfortunately, a study by Robert Martin (2006) found these formalized recruiting efforts and "academic branding" campaigns do little to change educational quality yet substantially increase university costs (p. 258). Adding to the fiercely competitive nature of college recruitment and marketing efforts during this transformational era, U.S. News and World Report compiled the first edition of college rankings in 1983. According to Kinzie et al., this sentinel publication ". . . ignited public interest in media-generated ratings and rankings as a proxy for the relative quality of colleges" (2004, p. 26).

The economic expansion across all socio-economic sectors during the 1980's fueled a wave of consumerism that further defined postsecondary education as a private good conveying status, prestige and exclusivity. Educational researcher Howard Bowen (1980) predicted this phenomenon in his text, *The Costs of Higher Education: How Much Do Colleges and Universities Spend per Student and How Much Should They Spend?* Over the past three decades, many colleges employ what Bowen identified as the Revenue *Theory of Cost*. Under this economic model, institutions raise all the money they can and spend all the money they raise (Blaug, 1982, p. 91). Marginal cost per student, therefore, is driven mostly by revenue rather than a long-term financial strategy. Bowen's findings, not surprisingly, show American colleges and universities differ widely in their total expenditure per student specifically in how they allocated costs among various institutional functions. The more affluent universities invest a disproportionate amount of funds to expand administrative staff and capital facilities rather than increasing the number of full-time faculty. Blaug (1982) notes, "The dominant goal of American colleges and universities are excellence, prestige, and influence and the higher education system as a whole provides no guidance of any kind that weighs the costs and benefits in terms of public interest" (p. 92). In contrast, one may ask if these economic strategies satisfy the financial objectives of Labaree's consumer-dominated marketplace delivering the tangible economic benefits of wage differential as advertised by the postsecondary education industry.

Claudia Goldin and Lawrence Katz, a research team from Harvard's Department of Economics, conducted a long-term study in 2007 to investigate educational wage differentials over the century. They utilized a supply and demand framework to understand the factors modulating wage premium variances between high school and college graduates. Their findings, not surprisingly, coincide with the Bowen, Chingos, and McPherson (2009) data that indicates a slowdown in the growth rate of college-educated workers starting at the end of the 1980's. This persistent trend coupled with demand for a more technologically-biased workforce demonstrates an elastic wage premium correlation for college-educated workers overall yet a tightly coupled relationship when education is aligned to the expanding science, technology, engineering, math and medicine (STEMM) sector of the economy. For those graduates, both the private and societal aims articulated by Labaree are fulfilled. The individual enjoys a suitable return from college investment while the nation benefits from advances in technological capacity.

Technological change is the engine that drives economic growth. "A nation's economy will grow more as technology advances, but the earning of some may advance considerably more than the earnings of others" (Goldin & Katz, 2007, p. 26). Although increasing the college graduation rate is an admirable objective, Bowen, Chingos and McPherson (2009) miss a key issue buried in their data. Much of the college wage premium over the past three decades is driven by demand in the STEMM fields. The authors lament, ". . . the United States has relied on 'imports' of well-educated students from other countries to compensate for its own difficulties in graduating enough native-born candidates for advanced degrees and, in particular, for jobs in science and engineering . . . the percentage of science and engineering Ph.D. graduates who were foreign born increased from 23 percent in 1966 to 39 percent in 2000" (Bowen, Chingos, & McPherson, 2009, p. 7). Furthermore, Goldin and Katz (2007) conclude, ". . . supply changes are critical, and education changes are by far most important on the supply side" (p. 29). It is not adequate for our country to blindly invest in educational funding without first considering the long-term benefits to national economic growth. In fact, Goldin and Katz's (2007) supply and demand analysis found compelling data that proved an abundance of college-educated workers had a ". . . substantial and significant negative impact on the college wage premium across the entire period" (p. 9). Field of study, not the four year credential, is the crucial factor for both the individual and society when contemplating investments in postsecondary education.

Analyzing the cost-benefit relationship of education through the lens of Labaree, the two-year associate degree or technical certification is also a relevant consideration. This analysis is curiously omitted from the Goldin and Katz study and the Bowen, Chingos, and McPherson text. A 2013 on-line article in CNN Money by Jon Marcus of the Hechinger Institute lauds STEMM-centered Associate degrees out-earn certain Bachelor degree holders. “Nearly 30 percent of Americans with Associate’s degrees now make more than those with Bachelor’s degrees according to Georgetown University’s Center on Education and the Workforce. In fact, other recent research in several states shows that, on average, community college graduates right out of school make more than graduates of four-year universities” (Marcus, 2013). The notable caveat is the phrase, *right out of school*. However, when tuition for a two year degree averages $6,200 and a private four-year university costs $108,000, the time-value of money and compounding interest of college loan debt drives the break-even point far into the future for most graduates and families. Increased wage baselines for community college STEMM graduates is charged by a high demand for *middle skill* careers such as lab technicians, computer technicians, draftsmen, radiation therapists, paralegals, machinists, and nurses. The Georgetown Center on Education estimates 29 million jobs require only an Associate’s degree while demand for these specialized skills is outpacing qualified applicants (Marcus, 2013).

Contemporary and longitudinal evidence strongly support field of study rather than generalized credentialing as most relevant to income differentiation and wage premium. Mark Shneider, Vice President of the American Institute for Economic Research counters Bowen, Chingos, and McPherson’s premise stating, “There is a perception that the Bachelor’s degree is the default, and, quite frankly, before we started this work showing the value of a technical Associate’s degree, I would have said that too” (Marcus, 2013). Yet, there is a misguided perception in America that equates all four-year degrees with a positive wage differential. This illusion does little to satisfy either the public or private good. When college aid is allocated to credential students in fields oversaturated with unemployed graduates, public funds are diluted and squandered. When public perception is distorted by well-funded marketing and recruitment campaigns, the individual shoulders the burden of increased college tuition in return for marginally marketable professional attributes such as prestige and exclusivity. Additionally, if the consumer attends a high-ranking institution without the credentials to enter a program that offers a positive rate of return on investment, their lifetime earning potential is impoverished. As a nation, we could benefit by incentivizing those educational paths that serve societal needs while compensating graduates with competitive incomes. The objective, however, is not static. At this point in our history, the technological age driven by careers in STEMM occupations is our future. Bowen, Chingos, and McPherson (2009) add, "Serious thought needs to be given to the incentives that influence choice of major among U.S. undergraduates and to the incentives used to encourage students to undertake-and complete-advanced degrees" (p.7). Two and four year postsecondary recruitment strategies are instrumental in shaping public perception and influencing consumer choice. Unfortunately, the competitive nature of revenue-driven college enrollment obfuscates the public's understanding of underlying economic reality. Value is a personal construct. If college choice is an economic decision, a STEMM degree at any level of academic attainment should satisfy both the collective and private good. High school programs which demonstrate reasonable progress toward advancing STEM self-identification and student interest in STEM careers should be promoted as a conduit of economic opportunity for the individual, their family, community and nation. Evidence from this qualitative study, although unique to the context of one school at a discriminate period of time, may resonate with educational leaders and other interested readers to evoke value and appreciation for increasing student self-identification with STEM pathways during the formative years of high school.

1.6 CONCLUSION

Descriptive research methodology was applied for this research. Since this approach spans both qualitative and quantitative realms, it gives the researcher a wide array of tools to address each aspect of Guskey and Kirkpatick's professional training model. Quantitative data is drawn from three sources of information: the Oberg Apprenticeship Survey, school district and company financial data, and Apprentice Competency Acquisition reports. Qualitative evidence is obtained through scripted interviews with Oberg training personnel. Multiple sources of evidence help build a more robust investigation. This descriptive, mixed-methods research forces each strategy to share the research questions, to collect complimentary data, and to conduct counterpart analyses (Yin, 2006). Patton (2002) suggests a number of practical research principles are appropriate for research designs. Three of these apply to this context:

> 1. The focus of the research is on the process, implementation, or development of a program.
> 2. The program emphasizes individual outcomes.
> 3. The intent is to understand program theory – that is, the staff members' (and participants') beliefs as to the nature of the problem they are addressing and how their actions will lead to the desired outcomes. (Mertens, 2010, p. 228)

Mixed-methods research is designed to examine the intricate details of a specific, bounded system - a "phenomenon of some sort occurring in a bounded context" (Miles and Huberman, 1994, p. 25). Merriam (2009) provides additional insight outlining three characteristics of the case study component:

> [Case studies are] ***particularistic*** since the research focuses on one particular phenomenon, program, situation, or event; ***descriptive*** since this form of research is a

thick, detailed account containing a vast array of variables and their interaction over time; ***heuristic*** in that case studies enlighten the reader's understanding of a phenomenon or bring about new interpretations and meaning-making. (p. 43)

In this investigation, the object of study is a STEM apprenticeship initiative within an urban, low-income school district. The Highlands-Oberg JAA Program prepares seniors for a high-tech manufacturing apprenticeship immediately after graduation. Unlike a traditional three-year CTE program at an off-site technical center, this initiative works within the bounds of a traditional high school curriculum. An unconventional education-industry partnership of this scope is well-suited for case study research. It is specific to a unique context, contains a rich source of detail, and promises a window of understanding to refine and illuminate the reader's assessment of STEM education within a high school setting. Additionally, the embedded single case design described by Yin (2009) "adds significant opportunities for extensive analysis, enhancing the insights into the single case" (p. 52). This study seeks to describe and understand the effectiveness of the JAA initiative and interpret the barriers which impact a STEM vocation decision for CTE non-participants.

2.0 REVIEW OF THE LITERATURE

In 2012, the Math and Science Collaborative cited a Bureau of Labor Statistics study stating that there are 2.4 open STEM jobs for every qualified applicant in Pennsylvania and 1.9 open STEM jobs nationally (Math & Science Collaborative, 2012). This shortage of STEM applicants for the jobs available has created an impetus in research which will be discussed in depth in the Review of Research section of this chapter.

2.1 SEARCH DESCRIPTION

I conducted a formal search of the literature to screen information from a systemic perspective to provide background and context to the issue. This approach helped to enrich observations at the 'tip of the spear" within a high school setting adding depth to issues of practicality and implementation. Sources were exacted that were reviewed within the context of their respective research communities: The National Academy of Engineering, President's Council of the Advancement of Science and Technology, Pittsburgh Technology Council (PTC), and Business-Higher Education Forum (BHEF) to validate the consensus of each report. For balance, independent literature was added from single authors that provided alternative perspectives on the STEM education models proposed by these collective organizations. From this cursory exercise, three broad strategies emerged: Standards-based STEM reform, integrated and mutually supporting K-16 programs, and business- community-schools partnerships called "K thru Employment". (Table 1)

Table 1. Standards-based STEM reform strategies

Source	Purpose	Questions	Populations	Limits
NAE	This source advocates for the National Research Council's Next Generation Science Standards that integrate STEM	How can CCSS integrate STEM in math and ELA to effect teaching pedagogy for Project-Based Learning	National K – 12	Top-down approach Policy does not translate to practice
PCAST	2010 Policy recommendations to President to address STEM shortage	What national policies can standardize STEM education and centralize efforts of key agencies	National K – 12	Top-down approach Politically motivated Policy does not translate to practice
Crow, T	Counterpoint to CCSS movement	How does a top-down approach impact district autonomy	State School District	Singular argument Lacks peer-review
Broaler & Brodie	Nature and impact of teacher questions to develop mental processes	Can teacher questioning techniques impact student higher-order thinking skills	National K – 12	Math only study
Stein & Matsumura	Research paper describing how instructional practice influences student learning	Does teaching behavior increase student capacity to think beyond the CCSS	National K – 12	Policy paper with no empirical data

There is a preponderance of information that prescribes a new set of standards embedded into the Common Core that coalesce the STEM subject areas of math, science, technology, engineering and ELA into K-12 education and standardized testing. The National Academy of Engineering (NAE) and PCAST have "evaluated the Nation's needs with respect to engineering education . . . highlighting the key concepts and abilities students should acquire . . . including the emphasis of engineering design, developmentally appropriate mathematics, science and technology knowledge and the promotion of 'engineering habits of mind'" (NAE, 2009, p. 47). To achieve this aim, a host of organizations including the NAE, PCAST, the National Research Council (NRC), Achieve, Inc., the National Governors Association, and Council of Chief State School Officers have proposed amendments to the Common Core to embed engineering principles into math, ELA and science standards.

As with most "top-down" education initiatives, many in the education community may not appreciate the immediate linkage between traditional curriculum and pedagogy and infusion of these engineering-centered precepts within the Common Core. If adopted by Pennsylvania, these changes to the Common Core State Standards (CCSS) present universal implications for the school's program of studies, methods of instruction, course content and teacher evaluation rubric. Implementing these addendums within the Common Core is an opportunity to dismantle existing educational paradigms and restructure teaching to focus on doing fewer things well within an integrated framework that supports STEM education. The convergence of math topics and heavy emphasis on informational text across all subject areas shifts the focus from "preparing students to graduate high school to preparing our students to be successful in college and careers" ("Instructional Leadership and the CCSS", n.d.). This new era prompts educators to create a climate that stimulates high-order, intellectually challenging work that capitalizes on critical thinking skills demanded by the 21st century workplace. Current research indicates, "School learning should be authentic and connected to the world outside of school . . . not only to make learning more interesting and motivating to students but also to develop the ability to use knowledge in real-world settings" (Crow, 2008, p. 7). Integrating engineering themes enhances these authentic learning opportunities building critical thinking skills through open-ended problem scenarios.

A central theme of the proposed CCSS champions this philosophy of engaging, rigorous content linked to real-world applications. Whether it is ELA instruction that requires high academic demands through challenging texts, connections of printed medium to real-world experiences and metacognitive strategies that foster thoughtful textual conversation, or math lessons advancing multiple representations, cognitively challenging tasks and authentic questions without one specific answer, the object is for teachers to engage students in their zone of proximal development to "influence student engagement, critical thinking and achievement" (Broaler and Brodie, 2004). Evidence of quality instruction materializes through collaborative unit planning and lesson content; cross-curricular projects linking common vocabulary, themes and procedures; inquiry-based activities; project-based learning and student work that demonstrates synthesis among multiple concepts. Stein and Matsumura (2008) add, "students' work provides a window on the quality of students' opportunities to think, reason, and support their assertions; teachers' interpretation of standards . . . and what a teacher values in students' work" (p. 190). PCAST implores the education, government and industry communities to "actively support the state-led shared standards movement . . . to look beyond their individual objectives and focus on the greater common goal [for] the Nation to complete the standards and ensure their widespread use" (PCAST, 2010, p. 53). Quality professional development will necessarily follow to build staff pedagogical competencies necessary to implement this approach.

In addition to integrating STEM–aligned standards, research supports aggressive professional development for education professionals at all levels to understand STEM sector career opportunities, to experience the dynamic nature of the STEM fields through industry tours, and to engage with STEM professionals to form collaborative partnerships that enhance classroom practice. (Table 2) Great STEM teachers have at least two attributes: deep content knowledge in STEM and strong pedagogical skills for teaching their students STEM. These attributes enable teachers to excite students about STEM fields motivating them for lifelong study. However, according to the National Research Council (2011), “few teacher preparation programs put an emphasis on these two attributes of great STEM teachers.” Additionally, the Pittsburgh Technology Council’s (PTC) 2011 STEM Summit calls upon institutions for higher education to “adopt more stringent STEM curriculum in teacher preparation programs and pre-service and in-service internship programs with industry to understand applications of STEM content” (PTC, 2011, p. 7). These initiatives also include guidance counselors and administrators since their support is integral to a successful school-wide learning culture.

Table 2. Mutually supporting K–16 programs

Source	Purpose	Questions	Populations	Limits
NAE	Research paper advocating changes to teacher education programs at the college level	How should teacher preparation programs change to improve STEM education	College programs	Study does not address college faculty
PTC	Compilation of findings from the 2011STEM Summit	What systemic changes are required in K-12 education	K-16 Educators and policymakers	Limited empirical evidence
BHEF	Applied a system dynamics model to examine the U.S. education system	What are the highest leverage points to effect change Ascertain the effect of scaling nationally	National ACT database	Model is only 3 years old and has not been validated

However, the professional development initiative is not relegated to K-12 educators alone. In fact, the NAE (2013) states, secondary institutions should align education programs to acknowledge the "federal and state policy context and address current and emerging efforts affecting STEM education, such as the Common Core State Standards, Next Generation Science Standards, 100Kin10 movement to train 100,000 STEM teachers in the next 10 years, and [the]Association of Public and Land-Grant Universities' (APLU's) Science and Mathematics Initiative" (Wilson, p. 1). In addition, the Business-Higher Education Forum (BHEF), in cooperation with Raytheon Company, developed a *systems dynamics model* of STEM education to provide a depoliticized, comprehensive approach to understand the "behavior" of the K-16 educational system over time. With more than 200 unique variables to simulate the effects of various education inputs, one key finding validates "neither P-12 strategies nor post-secondary strategies alone . . . can achieve the goal of doubling the number of STEM graduates" (BHEF, 2010, p. 10).

Although much of the available research promotes STEM education initiatives within the context of the K-12 learning environment, a broader, more comprehensive approach is necessary to effectively address the imminent shortage of qualified STEM applicants in the Nation's labor pool. (Table 3) Jim Clifton, author of *The Coming Job's War: What every leader must know about the future of job creation,* suggests the next breakthrough will come "from the combination of the forces within big cities, great universities, and powerful local leaders. Those three compose the most reliable, controllable solution" (2011, p. 63). He astutely observes the natural synergy that exists within spheres of local control:

> Strong leadership teams are already in place within cities. A natural order is already present, in governments and local business and philanthropic entities. Every city has strong, caring leaders working on numerous committees and initiatives to fuel their local

economic growth – let's call it the city GDP–and to create good jobs (Clifton, 2011, p. 64).

Such is the case of Long Beach, California. In 1994, local civic leaders recognized the need to improve their educational system through cross-sector collaboration by businesses, higher education, the K-12 school system, and community partners. Initially, the Long Beach Seamless Education Partnership's (LBEP) central mission was to "… ensure that all students progress smoothly through the educational systems and into the workforce" (BHEF, 2009, p. 3). However, with the need to capitalize on the growing demand for STEM sector jobs, the LBEP has refined its charter to provide "world-class education from preschool to graduate school and prepare Long Beach students for successful engagement in the global knowledge economy" (BHEF, 2009, p. 5). The success of this model is based on four tenants: Broad-based community demand for improvement in the educational system as a driver for economic development and societal well-being; strong long-term leadership across school district, community college, and state college institutions; three-way support structures between

Table 3. Business–community–school partnerships (K thru E)

Source	Purpose	Questions	Populations	Limits
Clifton	Adds a divergent perspective from outside the education community	How can America stay competitive in the global economy How must education change	National	Often lacks data to support the interdependency of concepts
BHEF	Case study of an effective K - E partnership	Can businesses, government and educational systems improve collaborate to improve the pool of qualified job applicants	City of Long Beach, CA	Not STEM specific No cost analysis
Wagner	Clarifies 21st Century thinking skills	What are the 21st Century skills students must acquire What partnerships are necessary	National	Idealistic point of view does not recognize the limitations of CCSS and student motivation

administration, faculty, and school board (parents); elevated public awareness through proactive media engagement. The net result of this initiative has been a dramatic increase in high school graduation rates, college admission, and employment in the local economy. For example, this year the program recorded some of the largest gains in Latino and black student college entrance exam scores for English and math. As a result, the Long Beach Community College and school district received the 2013 Pacific Region Equity Award. The success of Long Beach vindicates Clifton's assertion that "talented and effective local tribal leaders are essential to cities. Their mentorship is essential to the people who create jobs" (2011, p. 73). In *The Global Achievement Gap*, Wagner concurs, "The concept of leading by influence is another example of a skill that's important . . . how citizens make change today in their local communities–by trying to influence diverse groups and then creating alliances of groups who work together toward a common goal" (2008, p. 28).

Although beneficial within a narrow context, the fragmented approach employed by the Math & Science Collaborative, Project Lead the Way, Math + Science = Success, and Change the Equation do not address the systemic alignments necessary to accommodate the STEM employment needs at all skill levels. Current programs lack a unified framework that provides clear pathways across institutions of education, business, and industry supported by governmental policies that unleash the entrepreneurial, spirit of highly influential leaders in the region's economy. In Tony Wagner's *The Global Achievement Gap*, the author laments, "Teachers and administrators do not feel a real sense of urgency . . . teachers work in isolation when the rest of the world works in teams" (Wagner, 2008, p. xiv). Although these observations acutely address the nature of public education, they equally apply to the region's tribal leadership. Key institutions, working independently without a mandate to change the status quo will not produce the volume of highly-skilled STEM applicants necessary to maintain the Nation's leadership in the world economy.

Within the city of Pittsburgh and Western Pennsylvania, the strong demand for STEM-educated employees required action from the "tribal leaders" in government, education, business, and philanthropic entities to promote the health and prosperity of the region's economy. Patrick Gallagher, Chancellor of the University of Pittsburgh, stated, "My top priority will be to continue to build upon Pitt's collaborations with UPMC, Carnegie Mellon University, and the city of Pittsburgh" (Coyne, 2014). Secretary of Commerce, Penny Pritzker, said the new University President "embodies the best in public service with his passion, commitment, innovation, and ability to get results" (Coyne, 2014). Could the University of Pittsburgh Chancellor and Carnegie Mellon University President Farnam Jahanian serve as catalysts to galvanize the resources of key regional leaders to develop a coherent vision for STEMM career assimilation? In the past, these leaders collaborated to bring together the National Robotics Initiative, the Big Data Initiative, and the Advance Manufacturing Initiative while working together in Washington, D.C. What impetus is required to leverage their political cache to align the efforts of so many independent actors on the STEMM education stage?

According to Merriam (2009), theoretical framework is a disciplinary orientation or lens through which one views the world (p. 71). This construct is the foundation for qualitative study which "defines the system of concepts, assumptions, expectations, beliefs, and theories that informs [one's] research" (Maxwell, 2005, p. 33). The theoretical framework for this research topic, therefore, asserts current educational initiatives fail to address student self-identity with STEM careers at the critical period of transition planning during the final three years of high school. Within this time frame, key decisions begin to shape an individual's education, employment, and career trajectories.

Using the Long Beach Seamless Education Partnership as a template of city empowerment, a *continuum of support* is necessary to orient prospective students toward the vast array of STEMM opportunities affording individuals multiple entry points along the educational spectrum. To illustrate a theoretical alignment of key institutions, Figure 1 was developed which linked key stakeholders with initiatives that promoted matriculation into STEM career opportunities.

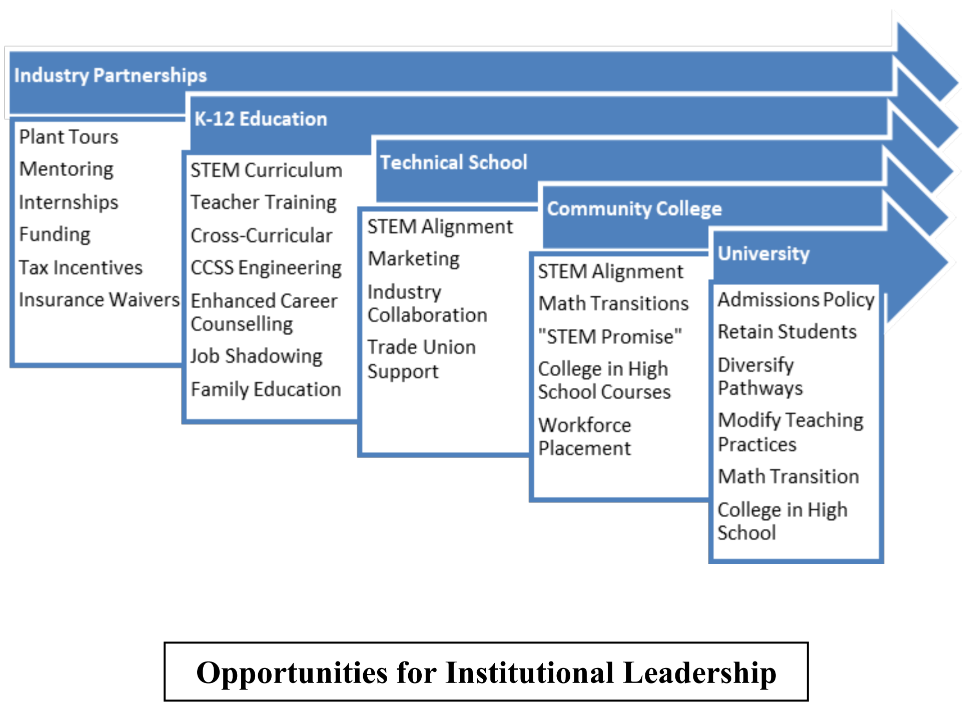


Figure 1. Model for STEM collaboration

2.2 REVIEW OF RESEARCH

2.2.1 STEM instructors and counselors

To improve the matriculation of students into a high-tech workforce, research supports aggressive professional development for education professionals at all levels to understand STEM sector career opportunities, to experience the dynamic nature of the STEM fields through industry tours, and to engage with STEM professionals to form collaborative partnerships that enhance classroom practice. Great STEM teachers have at least two attributes: Deep content knowledge in STEM and strong pedagogical skills for teaching their students STEM. These attributes enable teachers to excite students about STEM fields motivating them for lifelong study. However, according to the National Academy of Education (NAE), few teacher preparation programs put an emphasis on these two attributes of great STEM teachers (NAE, 2013). Additionally, the Pittsburgh Technology Council's (PTC) 2011 STEM Summit calls upon institutions of higher education to "adopt more stringent STEM curriculum in teacher preparation programs and pre-service and in-service internship programs with industry to understand applications of STEM content" (PTC, 2011, p. 7). These initiatives also include guidance counselors and administrators since their support is integral to a successful school-wide learning culture. These initiatives require a willingness to adopt new ways of thinking about cross-department interactions, the relationship of the school with industry partners, and *acting* on new curriculum to improve student transition to the world of meaningful employment.

2.2.2 Challenging the paradigm

Within organizations, there is resistance to change. In high schools, there exists a pre-determined bias among educators to resist initiatives which promote vocational pathways for "college-bound" students. Taking guidance from Frank Rhodes' work, *The Creation of the Future: The Role of the American University*, professional educators should strive to build a "sense of community' where the conviction of scholars, living and working, not in isolation, but in the yeasty and challenging atmosphere of community is the foundation on which universities thrive (Rhodes, 2001, p. 47). This citation, while stylistically humorous, clearly articulates a fundamental prerequisite for incubating the closely-coupled relationships that advance not only the structures of higher education but also in the workings of our public school system and its relation to stakeholders. Opportunity for greater learning is diminished when societal institutions form enclaves that "shelter their members from lively interaction with the wider community reducing the value of [life] experience for all" (Rhodes, 2001, p. 47). Rhodes's observation, while directed at the compartmentalized structure which exists in many universities, parallels a common deficiency within the K-12 educational system.

A group of individuals interacting in the "common space" of community is also a theme advanced by Tony Wagner in *The Global Achievement Gap*. Wagner warns that the accelerated pace of change in the 21st Century is outpacing the type of learning in our K-12 classrooms. "Students and teachers continue to learn and work in isolation–whereas the rest of the work world [is] organized into teams for decades" (Wagner, 2008, p. xiv). Like Wagner, Rhodes understands how collaborative discourse builds synergy of purpose and common identity. To be relevant and viable, an organization must leverage the value of communal interaction and dispense with the territorial entrapments that limit growth. Most educators in the K-12 system work in relative isolation from peers, supervisors, and the external institutions they serve. This reality is borne of increased class load, limited and separate planning time, and predilection to maintain the status quo. Rhodes highlights the tendency of many faculty members to regard their own discipline or profession as self-contained and freestanding, “in need of neither the assumptions, nor the conclusions, nor the support of other studies [is] thus exempt from scrutiny or critique” (Rhodes, 2001, p. 53). Is arrogance or insecurity the root cause of such behavior? When faced with change that threatens the existing educational “group-think,” withdrawal is the safest default. However, Rhodes warns, “Only in community, in dialogue, across the boundaries that now divide them, can [schools] regain their full effectiveness” (2001, p. 54). I find it illogical that “educated” people elect to act differently ignoring the barriers we educators have erected that limit opportunity for success in vocational enterprise. In spite of overwhelming data to the contrary, secondary educators default to the college degree as a prescription for success.

2.2.3 Finding meaning in vocational pursuits

The educational community, therefore, should promote excellence in all endeavors, not just the "intellectual" demonstrations of learning conferred by a Bachelor's degree. We should strive for equality of opportunity, not the "credentialing" outcomes suggested in *Crossing the Finish Line* by Bowen, et al. (2009). “Forcing all students into a common curriculum “may put our democracy at risk" (Noddings, 2013, p. 34). These authors also refer to the 1980-1982 *High School and Beyond (HSB)* longitudinal study conducted by Ellwood and Kane which indicates a strong correlation between education and income level. A key omission to this study is the correlation of vocational pursuits and income level. How would the HSB report differ if it adjusted income level by the opportunity cost of four years’ deferred income and student debt?

John Gardner (1984) recognized this misconception in his work, *Excellence*. He opines, "The society that scorns excellence in plumbing because plumbing is a humble activity and tolerates shoddiness in philosophy because it as an exalted activity will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water" (Gardner, 1984, p. 102).

2.2.4 Education's role in developing human capital

The fixation of Bowen, Chingos, and McPherson on educational attainment defined by a Bachelor's degree misses the mark. The authors suggest there is "too much discussion focused on initial access to educational opportunities rather than attainment" (Bowen et al., 2009, p. 1). A more compelling assertion is to explore other educational opportunities outside of the traditional Bachelor's degree. Educational policymakers should rethink the myopic focus the Common Core curriculum dictates. It is unreasonable for the educational community to expect all students enter college and graduate with a four-year degree. Noddings (2013) keenly notes, "If we identify the intellectual with the exercise of intelligence, the algebra taught in schools is not inherently more intellectual than cooking or motorcycle repair" (p. 35). The goal for education, therefore, is to develop all kinds of human capital in pursuit of both individual aspirations and societal objectives. We need not waste human and economic resources credentialing a population of college graduates. To paraphrase Labaree, this approach leads to a "zero-sum game."

Labaree's (2010) theory of a consumer-driven education marketplace is evident when analyzing the recruitment strategies of postsecondary institutions. What contributes to society's misguided and often irrational fixation on four-year "credentialing" above other forms of intellectual and educational attainment? In a 2004 publication by the Lumina Foundation for

Education entitled *Fifty Years of College Choice: Social, Political, and Institutional Influences on the Decision-Making Process*, Kinzie, Palmer, Hayek, Hossler, Jacob, & Cummings, (2004) cite major public policy shifts in recent decades which illustrate the transformation of higher education from a public to a private good. Governmental policies such as the GI Bill, the Truman Commission's expansion of the community college system, the Civil Rights and Higher Educational Acts, and the Supreme Court's decision in Brown v. Board of Education greatly expanded access for all students through the 1970's.

2.2.5 Marketing a college diploma

While postsecondary participation rates grew at an exponential rate, many universities refined and expanded their marketing strategies to compete with the burgeoning regional and community college industry. The researchers outline a "growing use of business techniques, marketing research, and more sophisticated forecasting models . . . [where] colleges combined admissions, financial aid, orientation, retention, and institutional research under one department in the hope of making the enrollment process more effective" (Kinzie et al., 2004, p. 26). Unfortunately, a 2006 study by Robert Martin entitled *Cost Control, College Access, and Competition in Higher Education* finds these formalized recruiting efforts and "academic branding" campaigns do little to change educational quality yet substantially increase university costs. Adding to the fiercely competitive nature of college recruitment and marketing efforts during this transformational era, U.S. News and World Report compiled the first edition of college rankings in 1983. According to Kinzie, et al., this sentinel publication ". . . ignited public interest in media-generated ratings and rankings as a proxy for the relative quality of colleges" (Kinzie, et al., 2004, p. 26).

The economic expansion across all socio-economic sectors during the 1980's fueled a wave of consumerism that further defined postsecondary education as a private good conveying status, prestige, and exclusivity. Educational researcher Howard Bowen predicted this phenomenon in his 1980 text *The Costs of Higher Education: How Much Do Colleges and Universities Spend Per Student and How Much Should They Spend?* Over the past three decades, many colleges employ what Bowen (1980) identified as the "Revenue Theory of Cost." Under this economic model, institutions raise all the money they can and spend all the money they raise. Marginal cost per student, therefore, is driven mostly by revenue rather than a long-term financial strategy. Bowen's findings, not surprisingly, show American colleges and universities differ widely in their total expenditure per student, specifically in how they allocated costs among various institutional functions. The more affluent universities invest a disproportionate amount of funds to expand administrative staff and capital facilities rather than increasing the number of full-time faculty. Blaug (1982) notes, "The dominant goals of American colleges and universities are excellence, prestige, and influence, and the higher education system as a whole provides no guidance of any kind that weighs the costs and benefits in terms of public interest" (p. 684). In contrast, one may ask if these economic strategies satisfy the financial objectives of Labaree's consumer-dominated marketplace delivering the tangible economic benefits of wage differential as advertised by the postsecondary education industry.

2.2.6 The v*alue* of the "right" degree

Claudia Goldin and Lawrence Katz, a research team from Harvard's Department of Economics, conducted a long-term study in 2007 to investigate educational wage differentials over the century. They utilized a supply and demand framework to understand the factors modulating wage premium variances between high school and college graduates. Their findings, not surprisingly, coincide with the Bowen, Chingos, and McPherson (2009) data that indicates a slowdown in the growth rate of college-educated workers starting at the end of the 1980's. This persistent trend, coupled with demand for a more technologically-biased workforce, demonstrates an elastic wage premium correlation for college-educated workers overall yet a tightly coupled relationship when education is aligned to the expanding science, technology, engineering, math, and medicine (STEMM) sector of the economy. For those graduates, both the private and societal aims articulated by Labaree are fulfilled. The individual enjoys a suitable return from college investment while the Nation benefits from advances in technological capacity.

Technological change is the engine that drives economic growth. "A nation's economy will grow more as technology advances, but the earnings of some may advance considerably more than the earnings of others" (Goldin & Katz, 2007, p. 26). Although increasing the college graduation rate is an admirable objective, Bowen, Chingos, and McPherson (2009) miss a key issue buried in their data. Much of the college wage premium over the past three decades is driven by demand in the STEMM fields. The authors lament, "The United States has relied on 'imports' of well-educated students from other countries to compensate for its own difficulties in graduating enough native-born candidates for advanced degrees and, in particular, for jobs in science and engineering . . . the percentage of science and engineering Ph.D. graduates who were foreign born increased from 23 percent in 1966 to 39 percent in 2000" (Bowen, Chingos, and McPherson, 2009, p. 7). Furthermore, Goldin and Katz (2007) conclude "supply changes are critical, and education changes are by far most important on the supply side" (p. 29). It is not adequate for our country to blindly invest in educational funding without first considering the long-term benefits to national economic growth. In fact, Goldin and Katz's (2007) supply and demand analysis found compelling data that proved an abundance of college-educated workers had a "substantial and significant negative impact on the college wage premium across the entire period" (p. 9). Field of study, not the four-year credential, is the crucial factor for both the individual and society when contemplating investments in postsecondary education.

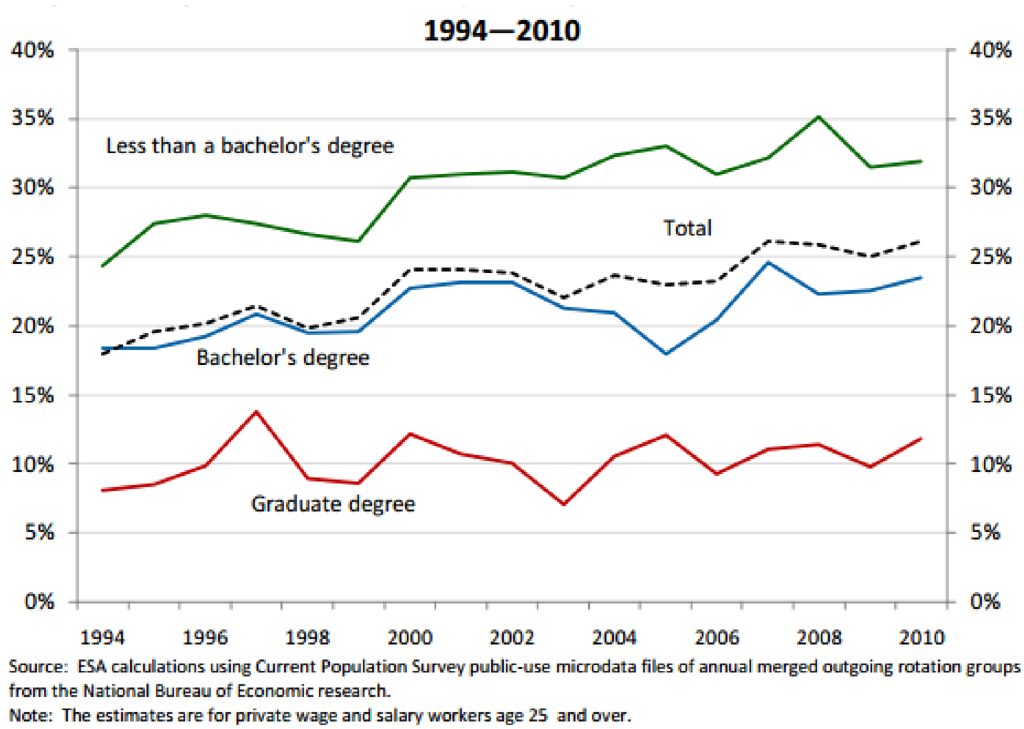
2.2.7 A cost-effective investment

Analyzing the cost-benefit relationship of education through the lens of Labaree, the two-year Associate's degree or technical certification is also a relevant consideration. This analysis is curiously omitted from the Goldin and Katz (2007) study and the Bowen, Chingos, and McPherson (2009) text. A 2013 on-line article in *CNN Money* by Jon Marcus of the Hechinger Institute lauds STEMM-centered Associate's degrees out-earn certain Bachelor's degree holders. "Nearly 30 percent of Americans with Associate's degrees now make more than those with Bachelor's degrees according to Georgetown University's Center on Education and the Workforce. In fact, other recent research in several states shows that, on average, community college graduates right out of school make more than graduates of four-year universities" (Marcus, 2013). The notable caveat is the phrase "right out of school." However, when tuition for a two-year degree averages $6,200 and a private four-year university costs $108,000, the time-value of money and compounding interest of college loan debt drives the break-even point far into the future for most graduates and families.

For example, the U.S. Department of Commerce Economics and Statistics Administration (ESA) conducted a population survey using micro-data spanning 1994 through 2010 to evaluate the STEM wage premium. (Figure 2) After controlling for standard regression characteristics such as age, race, geographic region, and industry, the results indicate a 26 percent overall wage premium across all educational levels. For secondary school policy-makers, a noteworthy statistic is the 32 percent premium for graduates below the Bachelor's degree level. Additionally, historic unemployment rates for the STEM field trend four percent below the national average.

Yidan Wang (2012) posits, "Education prepares people for both the society of today and the future." (p. 5). There are ample opportunities for educational leaders to capitalize on contemporary environmental factors to prepare graduates with the requisite competencies to "develop their full capacities and seize employment and social opportunities" (ILO, 2010, p. 4). Amidst the last decade of economic stagnation, individuals with education and experience in the high demand sectors easily found employment enjoying a "high skills-high wage equilibrium and could envisage a prosperous life ahead of them" (OECD, 2013, p. 15). Opportunities abound for secondary schools to embrace the evidence substantiating a strong STEM-centered education underpinned by project-based learning. Curriculum, course structure, and pedagogy that hone the 21st Century critical thinking and communication skills demanded by industry leaders and

advanced by Wagner in The Global Achievement Gap will position our high school graduates with viable options to bridge their learning to achieve stable and vibrant careers. Increased wage baselines for community college STEMM graduates is charged by a high demand for "middle skill" careers such as lab technicians, computer technicians, draftsmen, radiation therapists, paralegals, machinists, and nurses. The Georgetown Center on Education estimates 29 million jobs require only an Associate's degree while demand for these specialized skills is outpacing qualified applicants.



(ESA Issue Brief #03-11)

Figure 2. Regression-based hourly earnings premiums for STEM workers

Contemporary and longitudinal evidence strongly support field of study rather than generalized credentialing as most relevant to income differentiation and wage premium. Mark Shneider, Vice President of the American Institute for Economic Research, counters Bowen, Chingos, and McPherson's premise stating, "There is a perception that the Bachelor's degree is the default, and quite frankly, before we started this work showing the value of a technical Associate's degree, I would have said that too" (Marcus, 2013). Yet, there is a misguided perception in America that equates all four-year degrees with a positive wage differential. This illusion does little to satisfy either the public or private good. When college aid is allocated to credential students in fields that are oversaturated with unemployed graduates, public funds are diluted and squandered. When public perception is distorted by well-funded college marketing and recruitment campaigns, then individuals shoulder the burden of increased college tuition in return for marginally marketable professional attributes such as prestige and exclusivity. Additionally, if the consumer attends a "high-ranking" institution without the credentials to enter a program that offers a positive rate of return on investment, his/her lifetime earning potential is impoverished. As a Nation, we could benefit by incentivizing those educational paths that serve societal needs while compensating graduates with competitive incomes. The objective, however, is not static. At this point in our history, the technological age driven by careers in STEMM occupations is our future. Bowen, Chingos, and McPherson (2009) add, "Serious thought needs to be given to the incentives that influence choice of major among U.S. undergraduates and to the incentives used to encourage students to undertake and complete advanced degrees" (p.7). Two- and four-year postsecondary recruitment strategies are instrumental in shaping public perception and influencing consumer choice. Unfortunately, the competitive nature of revenue-driven college enrollment obfuscates the public's understanding of underlying economic reality. Value is a personal construct. If college choice is an economic decision, a STEMM degree at any level of academic attainment should satisfy both the collective and private good.

2.2.8 Failing to prepare adolescents for consequential choices

When the educational community offers conflicted messages to students and parents about access to high-tech STEM careers, then what is expected of adolescent "consumers" to rationally choose the optimum educational investment? Under existing vocational education models, students begin to explore career pathways during eighth and ninth grade when standardized interest surveys are administered. The current model forces individuals to make important decisions concerning their future education and occupational direction during the middle school to high school transition. According to Turner and Lapan (2013), career awareness is fundamental to career exploration, preparation, and choice. During early adolescence, children enter a tentative age and become aware of themselves in relation to the world of work. These young learners begin to form the attitudes, interpersonal skills, habits of the mind, and ethical behaviors which underpin their exploration and synthesis of career pathways. Deci and Ryan (1985) report how choices initiate and regulate self-determined behaviors and the correlation between a person's behavior in anticipation of self-related goals. With students at this critical juncture, it is imperative for secondary educators to cultivate a broad understanding of career pathways and offer on-site workplace experiences over a variety of career clusters.

Recognizing the importance of a student's educational-work transitional period, Finland's National Board of Education set out to investigate the societal and personal dimensions which impact students' developmental processes. Finnish researcher, Kelervo Friberg, applied a *fitting belief-based path model* to measure the interaction of initiative, independence, and self-guidance in apprenticeship-VET (Vocational Education Training) conation. When designing effective intervention models that facilitate choices for future career and education, Friberg (2014) concluded self-guidance significantly converged to apprenticeship (VET) willingness. The importance of facilitating students' self and occupational awareness and promoting their behavioral control of self-determination and self-efficacy during the transitional period before the entry into vocational secondary education has important implications for educational-vocational interventions that strive to individualize VET pathways and encourage behavioral change (Friberg, 2014). Finland's macroscopic objectives differ little from our domestic aims. School-based work-life orientation has the dual purpose of bringing schools and society closer, and facilitating students' matriculation into gainful employment pursuits. The eighth through tenth grade transition is critical for engaging latent antecedent beliefs regarding STEM career access. In order to influence and guide attitudes toward vocational pathways, student, parent, and educator's perception of the closely coupled connection between workforce and academic preparation must be addressed, yet the lack of preparedness for the demands of contemporary work remains a constant theme in educational scholarship.

2.2.9 The disjointed career education model

Self-determination is coveted in American education. However, the mismatch between student interest and growing occupational areas such as STEM indicate that our secondary school model has failed to prepare students for a large segment of high-growth occupations. Other developed nations, by comparison, have deliberately opted to strengthen, broaden, and expand their vocational education systems while the United States has focused on post-secondary education as a proxy for employability or work readiness (Kunchinke, 2013). Within the American high school, academically-minded students rarely explore CTE pathways because of the life-changing commitment they require. The CTE choice removes the student from peers who also share a strong affinity toward school, conflicts with art electives such as drama, chorus, and concert band, and hinders the scope of electives due to class section limitations within the master schedule. For many, the cost to attend off-site CTE programs is too high. The "dual-citizenship" created by the CTE model strains loyalties and erodes in-school opportunities beyond perceived value. The default is to follow a traditional course of studies relegating potential STEM CTE concentrators to the college-for-all mill regardless of the student's likelihood to achieve a STEM-related degree. Yet, the Center on Education Policy and American Youth Policy Forum report CTE students enter postsecondary education at approximately the same rate as all high school graduates and were more likely than their peers to obtain a degree or certification within two years (2000). Other Organization for Economic Cooperation and Development (OECD) countries offer strong vocational education that introduces desirable and demanding options for a majority of CTE concentrators. An integration of learning and working provides viable alternatives to higher education and offers the smartest and quickest route to a wide range of occupations in other developed countries (Hoffman, 2011).

Self-governing principles also yield unintended consequences. If self-relevant goals promote engagement in a process, it follows that students use vocational education to disengage with the traditional high school experience (Dweck, 2000). Academic disidentification is a pattern of behavior that seeks to insulate one's self-concept from potential failure when struggling to achieve mastery in academic endeavors. Crocker and Major (1989) reported many adolescents "selectively disidentify with the academic domain allowing other pursuits and interests to assume larger roles in shaping their personal identities and evaluations of self" (p. 58). Steel, Ferguson, and Gordon (1997) refer to several cultural manifestations by which academic disidentification is expressed, including the development of "opposition culture" (p. 59). In the contemporary climate of school and popular culture, this prejudice is pervasive. Many minorities deride their academically-focused classmates often taunting them not to act "too white"–a pejorative term which refers to a person's perceived betrayal of their culture by assuming the social expectations of white society (Fryer, 2006). Conservative black leaders are besmirched for being an "Oreo" or an "Uncle Tom." Ogbu and Fordham (1986) hypothesized that academic disidentification is an adaptation based on a perception that minority and disadvantaged students do not have the same kind of opportunity to access the high-status careers that education is supposed to make available as white people do (p. 59). Do sub-par freshmen grades and the challenge of social adjustment to high school fuel the "opposition culture" defense mechanism in these students? According to the NCES statistics on CTE, disadvantaged students from lower socioeconomic quartiles and individuals with above-average remedial credits are more likely to concentrate in vocational pathways (2009).

The seditious and perhaps overt role of CTE programs--a "dumping ground" for troubled youth, a "clean slate" for disengaged students and a "safe haven" to protect a child's psyche, has diluted the participation rate of many engaged, academic students like Kara who share a strong affinity to traditional school culture. Unfortunately, there is a paucity of evidence to illustrate the *perceptions* of academically-minded students toward vocational education programs and the stereotype imbued upon CTE participants. However, indirect evidence such as discipline, attendance, and remedial learning indicate a clear disparity between these two groups. Most "college-track" students don't envision CTE as a viable alternative which can lead to post-secondary opportunities and high-paid technical careers. Students and families are targets of college marketing campaigns and open enrollment strategies which obfuscate the low odds of success of many freshmen. The U.S. Department of Education finds, "More research is needed to better understand public opinion on career and technical education, determine what the main misconceptions are, and assess different strategies for changing opinion" (Cohen and Besharov, 2002).

2.2.10 Public school-private industry partnerships

A preponderance of literature describes shortcomings in the Nation's K-20 education system which impedes matriculation of students from high school into lucrative and stable STEM sector careers regardless of post-secondary degree attainment. From this research, three models prescribe the changes necessary to fill the personnel pipeline with one million new STEM-educated job candidates over the next decade. The first educational initiative prescribes a new set of standards embedded into the Common Core that coalesce the STEM subject areas of science, technology, engineering, math, and English/language arts (ELA) into K-12 education and standardized testing. The National Academy of Engineering (NAE) and the President's Council of Advisors on Science and Technology (PCAST) have "evaluated the Nation's needs with respect to engineering education . . . highlighting the key concepts and abilities students should acquire . . . including the emphasis of engineering design, developmentally appropriate mathematics, science, and technology knowledge, and the promotion of 'engineering habits of mind'" (NAE, 2009, p. 47). To achieve this aim, a host of organizations including the NAE, PCAST, the National Research Council (NRC), Achieve, Inc., the National Governors Association, and the Council of Chief State School Officers have proposed amendments to the Common Core to embed engineering principles into math, ELA, and science standards.

2.2.11 Critical thinking in real-world contexts (21st century skills)

As with most "top-down" education initiatives, many in the education community may not appreciate the immediate linkage between traditional curriculum and pedagogy and infusion of these engineering-centered precepts within the Common Core. If adopted by Pennsylvania, these changes to the Common Core State Standards (CCSS) present universal implications for the school's program of studies, methods of instruction, course content, and teacher evaluation rubric. Implementing these addendums within the Common Core is an opportunity to dismantle existing educational paradigms and restructure teaching to focus on doing fewer things well within an integrated framework that supports STEM education. The convergence of math topics and heavy emphasis on informational text across all subject areas shifts the focus from "preparing students to graduate high school to preparing our students to be successful in college and careers" ("Instructional Leadership and the CCSS", n.d.). This new era prompts educators to create a climate that stimulates high-order, intellectually challenging work that capitalizes on critical thinking skills demanded by the 21st Century workplace. Current research indicates, "School learning should be authentic and connected to the world outside of school . . . not only to make learning more interesting and motivating to students but also to develop the ability to use knowledge in real-world settings" (Crow, 2008, p. 7). Integrating engineering themes enhances these authentic learning opportunities building critical thinking skills through open-ended problem scenarios.

A central theme of the proposed CCSS champions this philosophy of engaging, rigorous content linked to real-world applications. Whether it is ELA instruction that requires high academic demands through challenging texts, connections of printed medium to real-world experiences and metacognitive strategies that foster thoughtful textual conversation, or math lessons advancing multiple representations, cognitively challenging tasks and authentic questions without one specific answer, the object is for teachers to engage students in their zone of proximal development to "influence student engagement, critical thinking, and achievement" (Broaler and Brodie, 2004). Evidence of quality instruction materializes through collaborative unit planning and lesson content; cross-curricular projects linking common vocabulary, themes, and procedures; inquiry-based activities; project-based learning and student work that demonstrates synthesis among multiple concepts. Stein and Matsumura (2008) add, "Students' work provides a window on the quality of students' opportunities to think, reason, and support their assertions; teachers' interpretation of standards . . . and what a teacher values in students' work" (p. 190). PCAST implores the education, government, and industry communities to "actively support the state-led shared standards movement . . . to look beyond their individual objectives and focus on the greater common goal [for] the Nation to complete the standards and ensure their widespread use" (PCAST, 2010, p. 53). Quality professional development will necessarily follow to build staff pedagogical competencies necessary to implement this approach.

2.2.12 Educator enlightenment

In addition to integrating STEM-aligned standards, research supports aggressive professional development for education professionals at all levels to understand STEM sector career opportunities, to experience the dynamic nature of the STEM fields through industry tours, and to engage with STEM professionals to form collaborative partnerships that enhance classroom practice. Great STEM teachers have at least two attributes: deep content knowledge in STEM and strong pedagogical skills for teaching their students STEM. These attributes enable teachers to excite students about STEM fields motivating them for lifelong study. However, according to the National Academy of Education (2009), few teacher preparation programs put an emphasis on these two attributes of great STEM teachers. Additionally, the Pittsburgh Technology Council's (PTC) 2011 STEM Summit calls upon institutions of higher education to adopt more stringent STEM curriculum in teacher preparation programs and pre-service and in-service internship programs with industry to understand applications of STEM content (PTC, 2011, p. 7). These initiatives also include guidance counselors and administrators since their support is integral to a successful school-wide learning culture.

2.2.13 Locus of control

Although much of the available research promotes STEMM education initiatives within the context of the K-12 learning environment, a broader, more comprehensive approach is necessary to effectively address the imminent shortage of qualified STEMM applicants in the Nation's labor pool. Jim Clifton, author of *The Coming Job's War: What Every Leader Must Know About the Future of Job Creation*, suggests the next breakthrough will come "from the combination of the forces within big cities, great universities, and powerful local leaders. Those three compose the most reliable, controllable solution" (2011, p. 63). He astutely observes the natural synergy that exists within spheres of local control:

> Strong leadership teams are already in place within cities. A natural order is already present in governments and local business and philanthropic entities. Every city has strong, caring leaders working on numerous committees and initiatives to fuel their local economic growth–let's call it the city GDP–and to create good jobs. (Clifton, 2011, p. 64)

In The Global Achievement Gap, Wagner concurs, "the concept of leading by influence is another example of a skill that's important . . . how citizens make change today in their local communities–by trying to influence diverse groups and then creating alliances of groups who work together toward a common goal" (2008, p. 28).

Albert Einstein once quipped, "If I had an hour to solve a problem, I'd spend 55 minutes thinking about the problem and 5 minutes thinking about solutions." The preponderance of information regarding STEM learning across all levels of the education spectrum corresponds to the "55 minutes of thought" Einstein identifies. Current literature abounds with documented research that spans a multitude of K-16 educational initiatives to address the Nation's lagging development of a STEMM workforce. Although many high-level policy recommendations are in play at the federal level, a coherent strategy to address the STEMM shortage may best be initiated at the state, regional, or city level as suggested by Jim Clifton. The essential questions for the influential leaders who may ultimately shape STEMM education policy are: What constitutes effective STEMM education and what can be done to inspire students to pursue STEMM fields? A tangible solution is within reach if key leaders from business, colleges, government, and school districts agree to work collaboratively to create a scalable framework for STEMM education that transcends K through "E" (employment).

2.2.14 Highlands School District programs

Highlands High School, the site of the present research study, offers two unique educational experiences for senior year students. The Highlands STEAMM Academy (Science, Technology, Engineering, the Arts, Mathematics, and Medical) is designed to engage academically motivated seniors through a "full immersion experience" in the fields of science, technology, engineering, and the applied sciences within a framework of integrated college-level courses augmented by authentic enrichment opportunities. By enrolling in the STEAMM Program, students enjoy the benefits of a cohort structure where all members participate in the same classes and work on cross-curricular projects that span multiple disciplines and promote real-world experiential learning. Furthermore, STEAMM students are afforded job shadowing opportunities with local companies, governmental organizations, and health care facilities. The Academy's capstone course, Introduction to Engineering, is a three-credit college-level engineering class taught by a Highlands' faculty member. A model for other school districts, this curriculum has been presented to educators and business leaders during the New Century Career Symposium at Butler

Community College, Bots IQ Teacher Orientation Seminar at California University of Pennsylvania, STEM Outreach Initiative at Penn State University, and the University Of Pittsburgh School Of Education. In its inaugural year, 32 students enrolled in the STEAMM Program of which 18 entered college in pursuit of a STEM-related degree, roughly 10 percent of the graduating class. The brochure illustrated in Figure 3 and Figure 4 outlines the STEAMM Academy structure. For clarity, Figure 3 highlights the course requirements and academic pathways offered to prospective students. Note the option of receiving 23 college credits for courses in the program of studies and the internship periods built into the weekly class schedule.

About STEAMM

Science - Technology - Engineering
Art - Mathematics - Medicine

The Highlands High School STEAMM Academy is a forward-thinking concept in education. By creating a "school within a school", a cohort of approximately twenty 12th grade honors students are immersed in the applied science and engineering curricula with rigorous classes focused on career pathways in engineering, medicine, technical design, art and the applied sciences. STEAMM students are also afforded opportunities to observe manufacturing, healthcare, design and production operations with partner organizations in the local area to further their understanding "beyond the traditional classroom."

"A school *within* a school"

The importance of integrating Science, Technology, Engineering, Art, Mathematics and Medicine continues to be a high priority in K-12 education and at colleges and universities in both undergraduate and graduate programs. STEAMM education creates critical thinkers, increases literacy, and empowers the next generation of innovators. Innovation leads to new products and processes that sustain our economy. Most jobs of the future will require a basic understanding of math and science. Ten-year employment projections by the United States Department of Labor show that of the twenty fastest-growing occupations projected for 2014, fifteen of them require significant mathematics or science preparation (Eberle, 2010).

Highlands began to advance STEAMM education a few years ago by offering a three credit college-level engineering course to students through Robert Morris University. Aside from building on mathematics and science fundamentals, students in this course complete a capstone robotics project used for competition in the Western PA Bots IQ. Students must research, conceptualize, and build a full scale mock up of their proposed machine and present their plan to local manufacturing companies who partner with the student teams to machine and fabricate the robot components. This course was the foundation of the STEAMM Academy vision.

Eberle, Francis. National Science Teachers Association. Why STEM Education is Important. 2010

"*21st* Century teaching and learning"

The Highlands STEAMM Academy embodies the fundamental constructs of 21st Century teaching and learning, including rigor, relevance, and habits of mind that drive life-long learning. Our students are facing significant challenges in a global marketplace. To address these new 21st Century skills, schools must rethink the blueprints used to prepare students to be college and career ready.

Through required core courses and a designated engineering, medical or technological pathway, Highlands High School STEAMM Academy students may earn 23 credits toward a college degree.

How to Enroll

Juniors who meet the pre-requisite courses for Core Courses are eligible to enroll during the scheduling session for their senior year.

There is no cost to be enrolled in the STEAMM Academy. However, if college credit for any course is preferred, instructors will assist parents and students with the credit process at the beginning of the school year. The average college credit cost through STEAMM is about $70 per credit. By starting their college courses in high school, students are not only shortening the length of their college enrollment, but they are saving thousands of dollars. Most credits are generally transferrable to any college or university, but the transfer could depend on the student's major, grades, and the institution's policies. We advise students to choose a college that will honor the dual enrollment credits.

STEAMM Course Structure

12th Grade Cohort

CORE COURSES	PERIODS	COLLEGE CREDIT
Introduction to Engineering (RMU)	5	3
AP Calculus (Pitt)	5	4
American Government (Seton Hill)	5	3
College Literature (Seton Hill)	5	3
Art History (Seton Hill)	5	6
Physical Education	2	
Multimedia Design / Approved Elective	5	
PATHWAY (Choose one)		
Engineering		
AP Physics (Pitt)	7	4
Lab Assistant / Internship*	1	
Medical		
Anatomy & Physiology (Differentiated)	5 + 2	
Lab Assistant / Internship*	1	
Technology		
Honors 2-D Art	5 + 2	
Lab Assistant / Internship*	1	
**See back of brochure for participating companies.*	40	23

Figure 3. Highlands STEAMM Academy Brochure

Page 1 of the Highlands STEAMM Academy Brochure outlining the rationale for creating the educational program and details on course structure and enrollment. *Copied with permission from the Highlands School District, 2013.*

STEAMM Instructors

John J. Malobicky *(Intro to Engineering)*
A graduate of the US Military Academy at West Point (BS: Mechanical Engineering), the University of Pittsburgh (Executive MBA), and Chatham College Graduate School (MAT), Mr. Malobicky is a PA certified level II instructor for both mathematics and physics. He has been teaching Highlands HS physics and engineering since 2001. Prior to teaching, Mr. Malobicky was an operations manager for the US Army Ordinance Corps; an engineer, capital projects manager and fabrication division manager for Elliott Turbomachinery Co., Inc.; and a quality assurance manager and operations manager for Leading Technologies, Inc. A Highlands alum, he is also involved in the Engineers' Society of Western PA.

Vicki A. Uhrinek *(AP Calculus & Physics)*
A graduate of Clarion University (BS: Secondary Education / Math & Physics), Ms. Uhrinek has 22 years of experience in teaching College in High School calculus and physics at Highlands HS. She is a PA certified level II instructor for both mathematics and physics, and serves as the Science Department Chairperson. Ms. Uhrinek has received numerous educational awards, including the National Society of High School Scholars Educator of Distinction Award.

Ryan V. Wilpula *(Literature & Multimedia Design)*
A graduate of Gannon University (BA: Liberal Arts) with a Master's degree from the University of Pittsburgh (MA: Teaching), Mr. Wilpula has been an English teacher at Highlands for 13 years. He teaches four levels: World Lit, American Lit, British Lit, and AP English Lit & Comp. He was also the HHS yearbook advisor, and is currently the online school newspaper advisor. Mr. Wilpula was chosen in 2007 & 2008 to assess the open-ended essay questions on the AP English Literature & Composition Test. In addition, he is an Adjunct Professor of the Secondary Curriculum and Methods Course at Carlow University.

Michael V. Krzeminski *(American Government)*
A Highlands alum and graduate of Indiana University of PA (BS: Secondary Social Studies Education), Mr. Krzeminski has taught social studies at Highlands for 15 years. Currently the Social Studies Department Chairperson, he has taught Civics & PA History, AP US Govt. and Politics, World Cultures, and Economics. Also certified in firefighter instruction and hazmat awareness and operations, Mr. Krzeminski developed the Fire Service Training course at HHS - the first of its kind in Pennsylvania. He continually looks for opportunities to provide 'Beyond the Classroom' experiences for his students.

Teresa M. Emeloff *(Art History & 2D Art)*
A graduate of Indiana University of PA (BS: Art Education) with a Master's Equivalency with credits from Ohio Wesleyan University & Gannon University, Highlands alum Mrs. Emeloff has been a Visual Arts teacher at Highlands for 14 years. She is also the Art Department Chairperson and a graduate of the Arts Education Collaborative Leadership Academy. She has twice received accolades in School Arts Magazine, and has instituted the Artist in Residency Program at HHS by hosting one or two artists per year since 2006. She is a member of the Pittsburgh Craftsmans Guild, Arts Education Collaborative Advisory Council, and the International Society of Glass Beadmakers. She also coordinated the set design for musicals and the Prom construction at Highlands since 1999.

Matthew Taladay *(Anatomy & Physiology)*
A graduate of Clarion University (BS: Biology and Environmental Education), Mr. Taladay has been a science teacher at Highlands HS for 14 years. He has taught Biology I, Biology 2, Physical Science, Science 9, Energy and the Environment, Computer Applications, and Anatomy and Physiology (9 years).

STEAMM

Partnering Companies

STEAMM Academy students will have job shadowing and internship opportunities. Highlands is coordinating with these companies to provide valuable internships for STEAMM students.

Allegheny Technologies Inc.
Allegheny Valley Hospital / WPAHS
Brackenridge Water Plant
General Press Corporation
Greco Steel Products
JV Manufacturing
Pittsburgh Anodizing
Siemans Energy
UPMC
Valley News Dispatch / Trib Total Media
Bayer / Medrad

Contacts

John Malobicky - STEAMM Coordinator
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Highlands High School Guidance Counselors

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Susie Giovengo - 724-226-1000, ext. 4212
sgiovengo@goldenrams.com

Marilyn Skwortz - 724-226-1000, ext. 4106
mskwortz@goldenrams.com

www.goldenrams.com
Facebook & Twitter @HighlandsSD

The STEAMM Academy at Highlands High School

Highlands STEAMM Academy

Empowering the next generation of innovators in

Science Technology
Engineering Art
Mathematics Medicine

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Figure 4. Highlands STEAMM Academy Brochure

Page 2 of brochure citing the vitae of STEAMM faculty and points of contact for program enrollment. *Copied with permission from the Highlands School District, 2013.*

1. Core Courses

	Periods	College Credit
Introduction to Engineering (RMU) ENGR 1010	5	3
AP Calculus (Pitt) MATH 0220	5	4
American Government (Seton Hill) PS 121	5	3
College Literature (Seton Hill) EL 250	5	3
Art History (Seton Hill) / Approved Art Elective AR105 / AR110	5	6
Gym	2	
Multimedia Design / Approved STEM Elective	5	

2. Pathways

	Periods	College Credit
A. Engineering		
AP Physics (Pitt) PHYS 0174	7	4
Lab Assistant / Internship	1	
B. Medical		
Anatomy and Physiology (Differentiated)	5 + 2	
Lab Assistant / Internship	1	
C. Technology		
Honors 2 – D Art (Differentiated)	5 + 2	
Lab Assistant / Internship	1	
	40	23

3. Approved Electives

Art: Band, Advanced Foreign Language, Chorus

STEM: AP Chemistry, Probability and Statistics (Pitt + 4 credits)

Figure 5. Highlands STEAMM Academy Course Structure

Details of the course pathways and opportunity for college credit for STEAMM participants.

The second STEM educational initiative in the Highlands School District, illustrated in Figure 6 and 7 is the JAA (Junior Apprentice Advantage) Program. This program was developed in conjunction with Oberg Industries, a world-leading manufacturer of high-precision metal products for the aerospace, medical, and tool and die industries. Seniors who demonstrate select aptitudes work toward preferred placement in Oberg Industries' state-certified Registered Apprenticeship Program. A specific curriculum consisting of Computer-Aided Design (CAD), Geometric Dimensioning and Tolerancing (GD&T), Metrology (Measurement Science), and Advanced Geometry/Trigonometry is taught by Highlands' faculty in conjunction with traditional senior year classes. Additionally, students travel to Oberg's facilities once per month during the school year for lesson-specific enrichment and job shadowing experiences working with Oberg's skilled craftspeople. The Oberg-Highlands Junior Apprentice Advantage Program (JAA) is offered exclusively to participating Highlands High School seniors at no cost.

Students who complete the JAA Program courses in good academic standing and satisfy Oberg's apprenticeship entrance requirements are pre-qualified for hire as full-time apprentices at Oberg Industries upon graduation. "This is an exciting opportunity for our students to learn hands-on, develop a plan for their futures, and contribute to a global market right in their hometown community," boasted Dr. Michael Bjalobok, Superintendent of Highlands School District, in a 2015 interview. As with the STEAMM Academy, this unique learning experience offers senior-level students the opportunity to explore the field of high-tech precision manufacturing through a collection of career-specific classes designed to fulfill first-year apprenticeship "competencies" and qualifies graduates for full-time employment with a world-class manufacturing company upon graduation from high school. Although this program consists

and the Benefits You Can Receive

What's An Apprenticeship?

- Apprenticeship is a proven way to train people for careers that demand a wide range of skills, knowledge, and independent judgement.
- A combination of on-the-job skills training and related classroom instruction.
- There are apprenticeships for a wide variety of jobs ranging from advanced manufacturing to health care.

For over 60 years, the Oberg Industries' Apprenticeship Program has successfully developed and equipped nearly 1,000 employees with the skills and knowledge to succeed in the metal working job market of their day and the emerging industries of tomorrow. Our Apprentice Program has been an essential component for developing and maintaining a workforce with the right skills to meet and exceed the needs of our customer partners.

A Powerful Local Partnership Provides a New Opportunity For You

Oberg Industries, a local contract manufacturer of precision metal components for over 67 years, has partnered with Highlands High School to offer a unique learning experience created only for 12th grade students at Highlands High School known as "The Junior Apprentice Advantage" (JAA). This program will continue to give students a head start into learning the technological skills needed to work in the challenging and lucrative advanced manufacturing industry.

Consider a rewarding occupation that makes the most of your special talents. Spend your senior year at Highlands High School working towards preferred placement in the Oberg Industries' state-certified Registered Apprenticeship Program. The curriculum, with a manufacturing emphasis, will be taught by Highlands faculty at the high school in conjunction with traditional academic classes and activities. Additionally, you will travel to Oberg's facilities at select intervals during the school year for one day, lesson specific, learning enrichment and job shadowing experiences working with Oberg's skilled craftspeople.

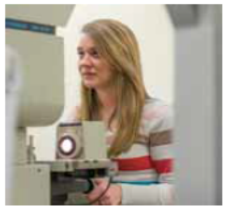
Start Shaping Your Future Today

Each interested student is required to take Oberg's apprentice aptitude test to be eligible for enrollment. Those top ranked students who successfully complete JAA in good academic standing and satisfy Oberg's apprenticeship entrance requirements will be offered preferred placement into Oberg's Apprenticeship Program, a full-time employment opportunity, upon graduation from high school.

JAA Junior Apprentice Advantage
A STEM Initiative Program

Figure 6. Highlands-Oberg Junior Apprenticeship Advantage Brochure

Page 1 of JAA brochure describing the opportunities afforded through an apprenticeship with Oberg Industries. *Reprinted with permission from Oberg Industries, 2015.*


Course Descriptions

- **Engineering CAD & Geometric Dimensioning & Tolerancing (GD&T)**
  This course focuses on 3-D computer-aided drafting and translating 3-D objects onto 2-dimensional prints with geometric dimensions and tolerances. Students will use 3-D drafting software to recreate and design virtual 3-D models of a wide range of objects. Each student will become the engineer as they design projects such as 3-dimensional dice, chess pieces, geared machines, automotive wheels, and small board games. They will also explore how drafting is applied in careers related to engineering and manufacturing.
- **Advanced Geometry & Trigonometry**
  This course is designed to apply principals of algebra, geometry, and trigonometry. Areas of study will include a variety of topics such as: algebraic expressions, systems of equations, problem solving techniques for word problems, geometric principles, and more. Completion of this course provides a solid base to continue in the fields of advanced manufacturing, engineering, and design.
- **Metrology**
  This is a required science course for students enrolled in the Oberg/Highlands Junior Apprentice Advantage (JAA) program. The course is designed to meet the precision measurement competencies outlined in the JAA program. Students will follow a scientific approach to understand the advanced measurement techniques and instrumentation to record geometric tolerances, critical dimensions, and quality control parameters. There will be hands-on labs and activities in this class requiring students to use precision instrumentation such as micrometers, calipers, and gage blocks to record data. Students will also learn and practice industry safety procedures to gain awareness of work-site protocol.
- **Academic English 12: British Literature and Professional Writing**
  Today's successful employees are able to effectively communicate in the workplace. This is a highly recommended course designed to educate and prepare students with the required communication skills used in today's manufacturing environment. A special JAA class project will also be assigned.

Gain Confidence In Your Post-High School Plans

Our forecasting indicates that when considering future business expansion, compounded with retirement and other attrition, we will need up to 30 apprentices annually for the next few years. This aggressive growth will depend, in part, on reliable programs such as JAA. Consider your JAA experience to be a path from Highlands to Oberg that will provide you with a head start into your learning, personal development, and growth as a skilled professional. Additionally, apprentices can earn nationally recognized credentials and gain countless career opportunities. Nationally, 3.4 million job openings are projected for highly skilled workers over the next decade.*

** Source: Deloitte analysis based on data from U.S. Bureau of Labor Statistics and Gallup Survey 2015.*

What Does JAA Consist of?

- Specialized courses designed to prepare you for a career in advanced manufacturing
- Scheduled learning enrichment trips to Oberg's facilities
- No costs or additional fees required

Apprenticeship and Industry Facts You Should Know...

- Precision machining provides a practical basis for an engineering or business degree
- Apprenticeships provide the ability to "earn while you learn", significantly reducing student debt
- Individuals completing apprentice programs earn approx. $50,000 per year – over $300,000 more than their peers in life-time earnings
- Shortage of highly skilled workers could worsen to about 875,000 by 2020
- 61% of employers face challenges filling skilled worker vacancies
- 48% of employers have candidates lacking technical competencies

What's Next?

- **Take Apprentice Aptitude test at Highlands on March 19**
- Register and attend **the JAA Student/Parent Information Night on April 16 *(details to follow)***
- Tour Oberg's facilities
- Get answers to your questions, learn more about this exciting program
- Meet with Highlands faculty anc Oberg's professionals and engag in a JAA panel discussion while enjoying light refreshments

Junior Apprentice Advantage
A STEM Initiative Program

 The Junior Apprentice Advantage is a STEM Initiative Program Created in Partnership with Oberg Industries / Highlands High School

Figure 7. Highlands-Oberg Junior Apprenticeship Advantage Brochure

Page 2 of JAA brochure outlining required courses and attributes of the precision manufacturing industry. *Reprinted with permission from Oberg Industries, 2015.*

consists of only three core classes, students engage in cross-curricular manufacturing projects and semi-weekly job shadowing experiences at the Oberg Manufacturing facility. Of the six students enrolled in the JAA Program during the 2014-2015 inaugural year, five have been offered full-time employment with a starting salary of $36,000 per year and full benefits including tuition reimbursement for college. (One student opted to apply to college rather than accept the employment offer, although she is pursuing a STEM-related degree.) For the 2015-2016 school year, seven out of ten students have received offers of employment. These programs are unique examples of successful collaboration between the private and public sector. Leaders from each institution recognize the advantages these alliances yield.

3.0 METHODOLOGY

3.1 SETTING AND RESEARCH DESIGN

The setting for this study is the Highlands School District. Located in Southwestern Pennsylvania, the district comprises three municipalities, an aggregate area of twenty-four square miles, and a population of roughly 20,500 people. The composition of the surrounding communities ranges from turn-of-the century steel mill row houses with high-density populations to rural farm tracks with limited development. The Pennsylvania Department of Education identifies this district as an Urban-Suburban school system. Median family income is $42,200 or 12 percent below the state average while median home prices fall 26 percent short of the state-wide mean. The entire district qualifies for the Free and Reduced Lunch Program. According to the Common Core database, there are 2,742 students enrolled in pre-kindergarten through the twelfth grade. The Highlands School District employs 210 full time educators and administrators with a district-wide student to faculty ratio of thirteen to one. Currently, there are approximately 185 students in each graduating class.

The design influence for this program at Highlands High School originated from the North Carolina Department of Education's STEM Attribute Implementation Rubric published in 2013 and the Texas Science Technology Engineering and Mathematics Academies Design Blueprint Project (T-STEM) Initiative of 2010. Fundamentally, both rubrics offered similar guidance for designing comprehensive programs that engaged students to pursue STEM careers. However, there are four key attributes that distinguish model programs: The number of cross-curricular projects centered on STEM topics; the number of advanced courses at the collegiate level of instruction and learning; partnerships with local manufacturing, technology and science-related businesses; and faculty engagement amongst peers (in STEM PLC's) and mentorship of students (Atkinson et al., 2006).

Within the context of the Highlands–Oberg JAA program, the conceptual framework advanced by Tyler (1949), Kirkpatric (1998), Guskey (2000), and Vespia (2004) was applied: A five-level model for evaluating professional development and training. The study was operationalized according to Table 4.

3.2 RESEARCH QUESTIONS

1. Is there evidence of student, employer, and school district satisfaction with the JAA program?
2. Do apprenticeship competency tests and advancement rates of JAA graduates compare favorably with vocational education counterparts?
3. What aspects of the JAA program do students and Oberg instructors identify as paramount to the successful matriculation and development of apprentice trainees?
4. Is there evidence of elevated career decision self-efficacy and adoption of Oberg corporate values for JAA alumni?
5. Do post-graduate activities provide evidence of the effectiveness of the JAA program?

Table 4. Evaluation data collection for Highlands-Oberg JAA Program

Evaluation Level	Questions to Address	Data Collection	How is Data Analyzed?
Student Reactions **Level 1**	**Research Question 1** **(Student - Focused)**	***Pre-Apprenticeship Survey*** • ***Affinity*** • ***Conflict*** • ***Readiness*** • ***Duration***	*Independent:* **JAA vs. CTE students** *Dependent:* **Likert rankings for each Pre-Apprenticeship question**
Student Learning **Level 2**	**Research Question 2**	***Competency Test*** (Certifications) for initial 6-month review	*Independent:* **JAA vs. CTE students** *Dependent:* **6-month Competency test score**
Organization Support **Level 3**	**Research Question 1** **(Employer and District – Focused)** **Research Question 3**	***Financial Analysis*** ***Instructor Interviews*** ***Pre-Apprenticeship Survey*** • ***Content*** • ***Quality***	*Independent:* **JAA vs. CTE students** *Dependent:* **Qualitative data from instructor interviews** **Likert rankings for Program Quality and Program Content questions**
Student Use of Knowledge and Skills **Level 4**	**Research Question 2**	***Competency Test*** (Certifications) for 12, 18, and 24 month reviews	*Independent:* **JAA vs. CTE students** *Dependent:* **12 thru 24 month Competency score**
Extended Student Outcomes **Level 5**	**Research Questions 4 and 5**	***My Vocational Situation (MVS) Survey*** ***Oberg Division Placement***	*Independent:* **JAA vs. CTE students** *Dependent:* **MVS score ranking** **Oberg division hierarchy**

Note: Adapted from the works of Guskey (2000) and Kirkpatrick (1998).

3.3 PARTICIPANTS AND DATA COLLECTION

The sample population for this study was comprised of apprenticeship students currently employed at Oberg Industries in Freeport, Pennsylvania. Within the training program, there are 27 students working through a series of 140 apprenticeship "competencies" prescribed by the National Tooling and Machining Association (NTMA). Apprenticeship training is highly individualized; therefore, student duration ranges between 30 to 48 months depending on the certification level and demonstration of aforementioned competencies. "Students advance through certification when they demonstrate they can train their instructor on the applicable skill" comments Linda Wood, Training and Learning Experience Coordinator for Oberg Industries. "Instructors 'sign-off' when students internalize the learning" (Wood, 2017). The Highlands-Oberg JAA initiative has produced nine apprentice trainees over the past three years with seven additional candidates preparing for the Oberg Entrance Exam in the 2018 high school graduating class. Partnering with the corporate Training Manager and Vice President of Human Relations, all JAA graduates and Vocational Education counterparts were sampled and quantifiable information was gathered regarding the viability of the Highlands-JAA training model.

Two survey instruments were used to gather quantitative information from the apprenticeship population: A *Pre-Apprenticeship (Pre-A) Survey* and the *My Vocational Situation Survey (MVS)*. (Appendices A and B) The Pre-A Survey was designed to address the first three evaluation levels outlined in Guskey (2000) and Kirkpatrick's (1998) model: Student Reactions, Student Learning, and Organizational Support. This 15 minute questionnaire, comprised of three sections: *Background Data, Program Content*, and *Program Quality* was administered to all apprentices who fell within a 36-month time window following high school graduation. Student B*ackground Data* distinguished respondent's high school technical education; respondent's self-reported academic, extra-curricular, disciplinary, attendance, and early employment information; and influential forces in career development. The Pre-A Survey allowed the sample to be stratified into two distinct comparison groups–JAA and CTE graduates with otherwise similar characteristics. Data from this survey additionally provided contextual information to address the secondary research question regarding societal barriers that may undermine the pursuit of STEM high-tech manufacturing careers.

The *Program Content* section of the Pre-A instrument was designed to ascertain how well pre-apprenticeship training prepared students for the rigors of Oberg's program. Analyzing program content served a dual purpose. This line of questions produced data that compared JAA versus CTE student preparedness while concurrently reviewing the content of the JAA curriculum.

Program Quality was a subjective measure that rated apprentices' perceived satisfaction with high school training program structure, resources, and commitment to student success. This line of questions offered insight into the degree of organizational support viewed from a trainee's perspective. The responses of JAA and CTE presented valuable distinctions that influenced changes in the JAA experience.

Both *Content* and *Quality* response data addressed the first three evaluation levels: Student Reaction, Student Learning, and Organizational Support, but to further augment this research, additional evidence was needed to clarify the findings. Student Learning, Level 2, was measured through a comparison of first-year competency rates among the apprentice sample. (Competencies were the demonstrated skills set forth by the NTMA.) Since these results were tabulated for all apprentices every six months, two progress reports were available within the first year of matriculation from high school. Lastly, a Return on Investment (ROI) analysis between the JAA and CTE groups allowed the researcher a financial measure of organizational support while assessing the economic viability of the high school JAA training model.

Levels 4 and 5 of Guskey and Kirkpatrick's Professional Training Evaluation, *Student Use of Knowledge and Skills* and *Extended Student Outcomes,* were closely related to years 2 and 3 of the Oberg Industry Apprenticeship training cycle. To evaluate student use of knowledge and skills, data was collected on competency acquisition rates between the comparison groups within a 12 and 36 month training window. Extended Student Outcomes, Evaluation Level 5, was measured by two metrics: Oberg job classification and the *My Vocational Situation* (MVS) survey. During the course of Oberg's apprenticeship training, students are exposed to each manufacturing discipline within the entire corporation: High Volume Machining, Striker Milling, Tool-Making, Precision Grinding, Stamping, Rounds, Inspection, and Assembly Departments. As individuals close in on the final six months demonstrating NTMA competencies, the Human Resource training team evaluates the knowledge and skill set of each apprentice, their personal area of interest, and the staffing demands of manufacturing. Each manufacturing division represents a hierarchy within the field of precision machining, and as such, reflects the technical expertise of its employees. These assignments are an additional indicator of student outcomes. Oberg training personnel are interviewed to collect qualitative information regarding the apprenticeship population. A fifteen-minute scripted interview ascertains the perception of instructors of student attendance, attentiveness, initiative, skill set, and learning rate. Oberg instructors also provide suggested improvements to the JAA program. Their insight is applicable across all evaluation levels of this study and substantiates improvements in pre-apprentice education.

The MVS instrument is a self-reported screening tool developed by Holland, Daiger, and Power (1980) to assess a student's vocational identity status, knowledge of career information, and barriers to career objectives. Since the 18-question true and false vocational identity scale has the most accepted psychometric properties and relevance to this study, the later sections will not be administered, hence an "abridged" moniker. Scoring was straightforward: Larger numbers of "false" responses indicated a stronger vocational identity while the converse revealed a lack of self-satisfaction and confusion about the respondent's vocational orientation. Extended student outcomes, a Level 5 evaluation measure, addressed the impact of training programs on student self-efficacy; therefore, MVS scores discerned a difference between JAA and CTE graduate's pre-apprenticeship experiences.

3.4 DATA ANALYSIS

This study was intended to address whether the Junior Apprenticeship Advantage program is an effective pathway for students entering precision manufacturing apprenticeship certification training. Quantitative data from the survey instruments, training records, and institutional financial documents provided evidence to compare JAA graduates directly with their otherwise similar CTE counterparts. For this investigation, two distinct groups within the Apprenticeship Training Program--JAA graduates and CTE graduates formed two independent "treatments" of otherwise similar students. No apprentices were members of both groups. For this study type, the 2-sample t- test was applied to calculate a confidence interval and test whether the means of two groups statistically differ. The confidence interval, or Type I error rate ($\alpha = 0.05$) for all relevant parameters is set to 95%.

Since this test was designed to compare the difference between JAA and CTE graduate population means ($u_1 - u_2$), the Null Hypothesis states there is no difference or effect between the two groups of apprentices:

$$\mathbf{H_o : u_1 - u_2 = 0}$$

Conversely, the Alternative Hypothesis suggests there is a difference or effect of pre-apprenticeship education:

$$\mathbf{H_1 : u_1 - u_2 \neq 0}$$

The 2-sample t-test determined whether there was a significant mean difference between JAA and CTE graduates across the parameters listed in the study outcomes.

4.0 DATA ANALYSIS AND RESEARCH FINDINGS

4.1 INTRODUCTION

This chapter describes the data analysis followed by a discussion of the research findings. The data was processed to identify and describe the relationship between students who graduate from a traditional Career Technical Education (CTE) machining program and those who graduate from the Highlands Junior Apprenticeship Advantage (JAA) program to determine if pre-apprenticeship training embedded in a traditional high school academic setting is effective preparation for a precision manufacturing apprenticeship. The professional development evaluation framework of Tyler (1949), Kirkpatric (1998), and Guskey (2000) serves as the structure to address five core research questions:

1. Is there evidence of student, employer, and school district satisfaction with the JAA program?
2. Do apprenticeship competency tests and advancement rates of JAA graduates compare favorably with vocational education counterparts?
3. What aspects of the JAA program do students and Oberg instructors identify as paramount to the successful matriculation and development of apprentice trainees?
4. Is there evidence of elevated career decision self-efficacy and adoption of Oberg corporate values for JAA alumni?
5. Do post-graduate activities provide evidence of the effectiveness of the JAA program?

Data was drawn from the entire apprenticeship training class on October 16, 2017 at Oberg Industries corporate training center in Sarver, Pennsylvania. Within the training program, there are 28 students working through a series of 140 apprenticeship "competencies" prescribed by the National Tooling and Machining Association (NTMA). Apprenticeship training is highly individualized; therefore, student duration ranges between 30 to 48 months depending on the certification level and demonstration of aforementioned competencies. Following a ten-minute explanation of the survey instruments and review of the *Consent to Participate* form, all twenty-eight (28) apprentice trainees completed the survey in its entirety. Of these, 22 surveys were usable (n=22) for the analysis since six respondents fell outside the study parameters: (a) they were not participants in either the JAA or a CTE training program prior to entering Oberg Industries, (b) they were fourth-year apprentices who had no JAA counterparts. Therefore, study subjects represent 78.6% of the apprentice population.

In addition to apprentice survey data, the primary Oberg training instructors were interviewed to ascertain the critical elements of pre-apprenticeship programs necessary for successful matriculation of students into precision manufacturing careers. Three lead instructors participated individually (n=3) in a face-to-face interview with the researcher. This represented 75% of the training cadre. Scripted, open-ended questions (Appendix D) afforded opportunities to aggregate perceptions and knowledge over multiple respondents (Stake, 1995, p. 65).

4.2 DESCRIPTIVE ANALYSIS

This section outlines the results of descriptive analysis to include: (a) frequency and percentage for pre-apprenticeship training program type (JAA versus CTE), (b) frequency and percentage for high school graduation year, (c) frequency and percentage for high school self-reported class academic rank, (d) years in Oberg apprenticeship. These results are presented in Table 5. The sample population for this study is comprised of apprenticeship students currently employed at Oberg Industries in Freeport, Pennsylvania. The age of study participants range from 18 to 23 years with more than 81% of students 20 and younger. Apprentice seniority is similarly skewed since 18 students (81%) have worked for Oberg Industries less than two years. Of the 22 subjects targeted for this investigation, 40.9% are graduates of the Junior Apprenticeship Advantage (JAA) program and 59.1% are Career and Technical Education (CTE) program graduates. Most (76.9%) CTE graduates participated in a computer-numerically controlled (CNC) training program for 2 years while in high school and 15.4% were 3 year CNC students. Only 7.7% of CTE graduates were in their CNC training for a single year. In contrast, the JAA program is a one year training opportunity offered during senior year. The disparity between CTE and JAA student metalworking experience is amplified by the fact that most CTE students are afforded internship opportunities in a machining facility during high school. These paid internships average 270 hours per student. No JAA graduates have metalworking or manufacturing experience prior to entering the Oberg program.

Oberg apprentice seniority indicates 36.4% (n=8) of students are in their first year. The JAA and CTE population is evenly split 4 to 4 respectively. Second year apprentices comprise 45.4% (n=10) of the ranks with only 20% (n=2) of the cohort from JAA and 80% (n=8) from a CTE background. (It is reported that a third JAA student resigned from the program less than two months prior to this study.) The third year apprentice class makes up 18.2% (n=4) of the Oberg program. However, 75% (n=3) are JAA alumni with a single 25% (n=1) CTE graduate.

The disproportionate shift in seniority is due to company hiring practices over the past three years. Oberg's dedicated apprentice training facility was commissioned in 2016, a year after the first wave of JAA graduates were hired. Prior to that, the company could only accommodate small (4 to 6 individuals) groups of apprentice candidates at one time with the training resources available. In 2106, Oberg dedicated four full-time lead instructors to apprentice training and commissioned a 20,000 square-foot facility to address the workforce employment shortfall projected in the company's strategic plan. Consequently, apprentice acquisition rates will hold steady at approximately 10 hires per year.

Study participants are graduates from one of five Western Pennsylvania school systems: Highlands School District, Natrona Heights; Lenape Technical School, Ford City; Northern Westmoreland Career and Technology Center, New Kensington; Forbes Road Career and Technology Center, Monroeville; Butler County Area Vocational-Technical School, Butler. Student-reported high school rank indicates 36.4% (n=8) Oberg apprentices graduated in the top quartile of high school class while 36.4% (n=8) reported graduating in the middle 50% academically. No students reported graduating in the bottom quartile (n=0), yet 27.3% of respondents did not know their high school class rank.

Table 5. Frequencies and percentages for program type, high school graduation year, self-reported high school academic rank, years in apprenticeship for all participants

Variable	n	%
Pre- Apprenticeship Program Type		
JAA	**9**	**40.9**
CTE (total)	**13**	**59.1**
1 year CTE	1	7.7
2 year CTE	10	76.9
3 year CTE	2	15.4
High School Graduation Year		
2014	1	4.5
2015	3	13.6
2016	10	45.4
2017	8	36.4
High School Class Rank (self – reported)		
Top 25%	8	36.4
Middle 50%	8	36.4
Bottom 25%	0	0.0
Don't Know	6	27.3
Years in Oberg Apprenticeship		
1st Year	**8**	**36.4**
JAA	4	50.0
CTE	4	50.0
2nd Year	**10**	**45.4**
JAA	2	20.0
CTE	8	80.0
3rd Year	**4**	**18.2**
JAA	3	75.0
CTE	1	25.0

4.3 RESEARCH QUESTION 1

Research question 1 asked, *Is there evidence of student, employer, and school district satisfaction with the JAA program?* Four dependent variables from the Pre-Apprenticeship Survey (Appendix A) provide quantitative evidence to analyze student's perceptions between JAA and CTE pre-apprenticeship programs: School Affinity, Influence Conflict, Perceived Readiness, and Program Duration (Tables 3 and 4). Employer and school district satisfaction is measured by JAA program cost analysis (Table 8) plus qualitative information gathered through personal interviews with supervisory personnel.

4.3.1 School affinity

An independent sample t-test was conducted to test whether there is a difference in mean School Affinity scores between JAA and CTE students. Affinity ratings were derived from six criteria and counted by year in high school: academic award, sports participation, extracurricular involvement, work hours, absentee rate, and discipline. The independent sample t-test shows there is a significant difference in School Affinity scores between JAA ($M = 34.67$, $SD = 29.29$) and CTE ($M = 2.92$, SD 30.99) students, $t(20) = 2.414$, $p = 0.025$, $d = 1.053$. Cohen's effect size measure indicates JAA students have a much higher affinity to a traditional high school academic and extracurricular setting than their CTE counterparts. The significance of this measure underscores the rationale employed to create the JAA structure as described in the Problem Statement section of Chapter One. These students, who demonstrate an affinity toward school academic and extracurricular programs, elected to participate in the pre-apprenticeship training program within a traditional high school setting because they found value in the opportunity afforded. The program gave participants a lucrative career option that heretofore did not exist. Their willingness to commit to the program indicates satisfaction with the construct.

Table 6. Research Question 1

Indicators for student perceptions of JAA and CTE programs

Indicator		JAA	CTE	DoM	SED	t-test
Affinity	M	34.67	2.92	31.74	13.15	t(20) = 2.414
	SD	29.29	30.99			p = 0.025, d = 1.053
Conflict	M	5.11	4.77	0.34	1.42	t(20) = 0.240
	SD	3.41	3.19			p = 0.813, d = 0.103
Readiness	M	3.56	4.38	-0.83	0.35	t(20) = -2.345
	SD	1.01	0.65			p = 0.029, d = 0.963
Duration	M	-0.33	-0.31	-0.03	0.21	t(20) = -1.305
	SD	0.50	0.48			p = 0.207, d = 0.052

Note: Difference of the mean (DoM), standard error of the difference (SED)

4.3.2 Influence conflict

An independent sample t-test was conducted to test whether there is a difference in mean Career Influence scores between JAA and CTE students. Influence Conflict was taken as the difference between inter-personal stimuli that guided participants during their career decision-making process. The independent sample t-test shows that there is not a significant difference in Career Influence scores between JAA (M = 5.11, SD = 3.21) and CTE (M = 4.77, SD 3.07) students, t(18) = 0.240, p = 0.813, d = 0.103. This result suggests there is no statistical difference between the JAA and CTE population with respect to tensions between positive and negative career influences. Both groups share equal dissonance factors when choosing a precision manufacturing apprenticeship.

When one compares the most pronounced sources of Influence Conflict, a pattern emerges from the data. Of the 22 respondents, 50% report Parental Influence and 41% added High School Teacher encouragement as the largest positive factors in career planning. No student reported Parent Influence as a negative factor. Conversely, Teachers, guidance counselors and friends account for the combined majority (36%) of negative influence. Seven cases represent students who reported significant degrees of tension between positive and negative career influences. These were: Teachers and Friends (43%), Parent and Teacher (29%), Teacher and Guidance Counsellor (14%), Parent and Friend (14%). Conflicted viewpoints amongst JAA participants reduced to only three respondents all of which experienced friction between a teacher's encouragement and friend's opposition. Although there is no statistical difference between JAA and CTE Influence Conflict, unanimous positive encouragement from parents is a solid indicator of JAA and CTE program satisfaction.

4.3.3 Perceived readiness

An independent sample t-test was conducted to test whether there is a difference in mean Perceived Readiness scores between JAA and CTE students. Students rated Readiness on a five-point Likert scale (Strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly Disagree = 1). The independent sample t-test shows there is a significant difference in Perceived Readiness scores between JAA ($M = 3.56$, $SD = 1.01$) and CTE ($M = 4.38$, $SD = 0.65$) students, $t(20) = -2.345$, $p = 0.029$, $d = 0.963$. Career and technical students believe their pre-apprenticeship training adequately prepares them for the technical rigors of the Oberg program. Cohen's ($d = 0.963$) indicates Junior Apprenticeship Advantage students are far less confident in their perceived manufacturing skill set. However, when first year JAA program students are eliminated from the data set, the independent sample t-test shows there is no difference between the two populations: JAA (M=4.00, SD = 0.00) and CTE (M = 4.38, SD = 0.65), $t(17) = -1.426$, $p = 0.172$. Finn et al. (2001) showed it is typical for school programs to go through a phase of chaos and turbulence during the start – up phase. Since the JAA program was a completely unique endeavor for school faculty, it follows that first year graduate's experienced discontent with the program during the inaugural year. Longitudinal evidence shows, however, these students have successfully matriculated into the Oberg apprenticeship and are among the top – rated students according to Linda Wood, Oberg Training Program Manager.

4.3.4 Program duration

An independent sample t-test was conducted to test whether there is a difference in mean Perceived Program Duration scores between JAA and CTE students. The independent sample t-test shows there is a not a significant difference in Perceived Duration scores between JAA (M = - 0.33, SD = 0.50) and CTE (M = - 0.31, SD 0.48) students, $t(20) = - 1.305$, $p =0.207$, $d = .0522$. Although there is a discernable gap between student groups' perceived readiness scores, both populations share a statistically similar attitude toward their pre-apprenticeship program duration, $\chi^2(2, n = 22) = 0.016$, $p = 0.899$. Table 7 outlines the descriptive statistics for all Program Duration responses. No students in the survey thought their training lasted too long.

Table 7. Frequencies and percentages for program duration for all participants

Question	Program	Response	n	%
Length of time in my pre-apprenticeship program	JAA	Too Short	3	33.3
		About Right	6	66.7
		Too Long	0	0.0
	CTE	Too Short	4	30.8
		About Right	9	69.2
		Too Long	0	0.0

4.3.5 Program costs

School district and employer satisfaction with the JAA initiative is measured by the annual financial commitment invested to sustain the program. Table 8 summarizes expenses assumed by both entities. Total program annual expenses are shared by both organizations with Highlands shouldering 67.6% of the outlay and Oberg Industries supporting 32.4%. These values represent a cost-per-pupil rate of $8,613 and $4,122 respectively *for each student hired* into the apprenticeship program. Conversely, CTE – sourced apprentices cost Oberg $3,240 per student. (This expense results from a 270 hour internship experience afforded prospective CTE recruits.) For Highlands School District, the JAA program represents 0.10 % of the total (26.1 million) instructional budget based on FY 2016 financial data. For Oberg Industries, the JAA program expense equates to 2.2% of the company's (883K) training budget. Financial commitments of this magnitude indicate strong support for the JAA program.

Table 8. Annual JAA Program costs

Line Item	Amount	%
Highlands School District[1]		
Personnel		
3 Teachers @ $67 per period (full burden rate) and 50% utilization	18,300	47.9
Program Expenses		
Machining Lab Capital Expense (depreciation)	1,740	4.6
Consumables	3,000	7.9
Job-Shadowing Transportation	2,800	7.3
Total	25,840	67.6
Oberg Industries[2]		
Personnel		
3 Apprentice Training Staff	6,000	15.7
Program Expenses		
Open House Recruitment Night	300	0.7
Educational Software	792	2.1
Machine Shop Hours	3,000	7.9
Consumables	1,676	4.4
Safety Equipment	600	1.4
Total	12,368	32.4
JAA Annual Cost	**38,208**	**100.0**

Notes: (1) Estimate of Highlands Business Manager, March, 2017.
(2) Oberg Industries Corporate Controller, December, 2017.

4.3.6 Training personnel interviews

To gather qualitative data regarding research question one, four Oberg training supervisors were interviewed separately at the company's corporate offices. Three individuals are apprentice instructors directly responsible for all CTE and JAA student training and evaluation. Additionally, the Training Programs Manager for Oberg Industries was also queried to gather information regarding the company's satisfaction with the school district – private company partnership and performance attributes of JAA employees. Three themes emerged from all interviews. The first observation common amongst respondents is the deficit of JAA graduate's machining and shop practices aptitude compared with CTE counterparts. JAA students struggle in the first six months of training because the "manufacturing environment is unfamiliar territory". On the other hand, two of the trainers offered, JAA students are more focused since much of what they experience in the initial year is "completely fresh". Secondly, each trainer suggested JAA students need more "hands-on" time with basic equipment such as micrometers, gage blocks, and hand tools. All but one respondent followed this observation with a comment that the JAA students, however, are quick to learn these fundamentals when immersed in their daily training routines. Finally, all individuals surveyed stated the JAA students are very good employees and are "mostly on – par" with CTE alumni by the end of the first twelve month evaluation cycle. In fact, a common phrase amongst Oberg training personnel is, "Once they're here, we'll make them successful!"

4.4 RESEARCH QUESTION 2

Research question 2 asked, *Do apprenticeship competency tests and advancement rates of JAA graduates compare favorably with vocational education counterparts?* Six month competency test and 12 through 24 month competency test results serve as the dependent variables to analyze quantitative relationships between JAA and CTE pre-apprenticeship programs (Table 9). The December 2017 Oberg training database is the source of information for these comparisons.

4.4.1 Six-month competency data

An independent sample t-test was conducted to test whether there is a difference in mean 6 Month Competency scores between JAA and CTE students. The first competency test serves as a baseline indicator for Oberg training staff. Competency Test 1 is administered after six months of apprenticeship training and reflects the number of NTMA competencies earned per employee within the training period. The independent sample t-test shows there is a significant difference in mean 6 Month Competency scores between JAA ($M = 23.81$, $SD = 8.25$) and CTE ($M = 39.81$, SD 16.80) students, $t(20) = -2.632$, $p = 0.016$, $d = 1.209$. Cohen's effect size indicates CTE students have a much higher 6 month competency attainment than their JAA counterparts. This follows from the descriptive data section (Table 5) that shows 76.9% or 15.4% of CTE graduates completed two or three years respectively of pre-apprenticeship vocational training where Career and Technical schools build curriculum around the National Institute for Metalworking Skills (NIMS) credentialing model. As certified NIMS sites, the CTE schools can certify graduates in foundational manufacturing skills such as Material Layout, Tool Selection, Machine Tool Operation, and Equipment Maintenance. NIMS credentials supplant a portion of foundational competencies evaluated in Oberg's initial 6 Month review affording CTE alumni a 37 point advantage in baseline NTMA competency scores.

Table 9. Research Question 2

Indicators for NTMA competency and advancement rates

Indicator		JAA	CTE	DoM	SED	t-test
6 - Month	M	23.81	39.81	-16.00	6.08	t(20) = -2.632
	SD	8.25	16.80			p = 0.016, d = 1.209
12 - Month	M	19.62	17.31	2.31	5.07	t(12) = 0.455
	SD	8.10	9.55			p = 0.657, d = 0.261
18 - Month	M	9.30	11.32	-2.02	6.15	t(12) = -0.329
	SD	10.86	11.10			p = 0.748, d = 0.184

Note. Difference of the mean (DoM), standard error of the difference (SED)

4.4.2 Twelve through twenty-four month competency data

An independent sample t-test was conducted to test whether there is a difference in mean 12 through 24 Month Competency scores between JAA and CTE students. Oberg staff identifies the 12, 18 and 24 month scores as Competency Test 2, 3, and 4 respectively. For research study purposes, the Percent Gain from Competency Test 1 is the baseline score to compare advancement rates between the apprentice populations. The independent sample t-test shows there is no significant difference in 12 Month Competency score gain between JAA (M = 19.62, SD = 8.10) and CTE (M = 17.31, SD 9.55) students, t(12) = 0.455, p = 0.657, d = 0.261. Additionally, the independent sample t-test shows there is no significant difference in 18 Month

Competency score gain between JAA (M = 9.30, SD = 10.86) and CTE (M = 11.32, SD 11.10) students, t(12) = -0.329, p = 0.748, d = 0.184. Advancement rates are similar between both groups of students reinforcing Oberg training personnel's claim that they will make each apprentice successful. Once acclimated to the rigors and terminology of a precision manufacturing environment, JAA students advance comparably to their more experienced CTE classmates.

Since the data set for the 24 Month Competency scores consist of only four individuals, no statistical tests were applied. However, a scatter plot of all apprenticeship data shows a general trend in test scores that supports prior results (Figure 8). Although the correlation coefficient for this data is weak, the graph suggests JAA students enter the Oberg training program at a deficit in NTMA competencies, yet advance at similar rates to CTE graduates.

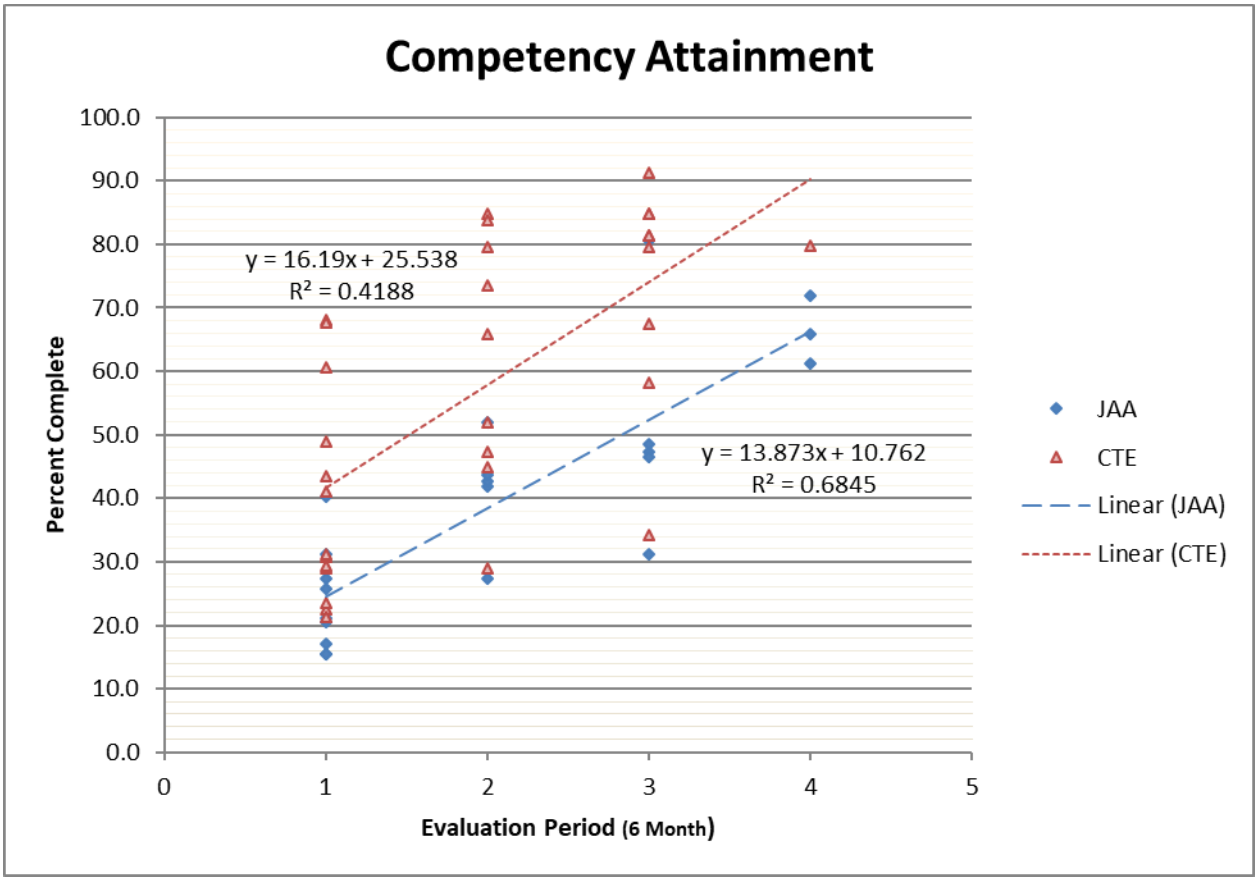


Figure 8. Apprentice competency attainment versus evaluation period

4.5 RESEARCH QUESTION 3

Research question 3 asked, *What aspects of the JAA program do students and Oberg instructors identify as paramount to the successful matriculation and development of apprentice trainees?* Two dependent variables provide quantitative evidence to analyze student's perceptions between JAA and CTE pre-apprenticeship programs: Program Content, and Program Quality (Table 10). Oberg instructor's observations were gathered through personal interviews and summarized in qualitative terms.

4.5.1 Program content

An independent sample t-test was conducted to test whether there is a difference in mean Program Content scores between JAA and CTE students. The independent sample t-test shows there is a significant difference in Program Content scores between JAA ($M = 19.33$, $SD = 4.18$) and CTE ($M = 30.38$, SD 2.73) students, $t(20) = -7.530$, $p < 0.001$, $d = 3.130$. When comparing the Program Content between a two or three year CTE program and a single year JAA experience, research data confirms longer duration improves exposure to manufacturing competencies. This follows the students' response to Perceived Readiness addressed in Research Question 1 (Table 6) and baseline competency scores analyzed in Research Question 2 (Table 9). Career and technical students believe their pre-apprenticeship training adequately prepares them for the technical rigors of the Oberg program. Cohen's ($d = 0.963$) indicates Junior Apprenticeship Advantage students are far less confident in their perceived manufacturing acumen.

Table 10. Research question 3

Indicators for Pre-Apprentice Program content and quality

Indicator		JAA	CTE	DoM	SED	t-test
Content	M	19.33	30.38	-11.05	1.47	$t(20) = -7.530$
	SD	4.18	2.73			$p < 0.001$, $d = 3.130$
Quality	M	27.11	35.00	-7.89	1.77	$t(20) = -4.446$
	SD	5.71	2.48			$p < 0.001$, $d = 1.792$

Note: Difference of the mean (DoM), standard error of the difference (SED)

4.5.2 Program quality

Apprentice students were also surveyed to determine if there is a difference in Pre-Apprenticeship Program Quality between JAA and CTE students. The independent sample t-test shows there is a significant difference in Program Quality scores between JAA ($M = 27.11$, $SD = 5.71$) and CTE ($M = 35.00$, SD 2.48) students, $t(20) = -4.446$, $p < 0.001$, $d = 1.792$. When comparing Program Quality between the resources afforded in a manufacturing CTE program versus the JAA curriculum embedded in a traditional high school environment, Perceived Quality of training strongly favors CTE. It is important to note the data for this study reflects alumni attitudes over three years JAA progression.

4.5.3 Oberg instructor interviews

To gather qualitative data regarding Research Question 3, four members of the Oberg training staff were interviewed separately at the company's corporate offices. Three of these individuals are apprentice instructors directly responsible for all CTE and JAA student training and evaluations. Additionally, the Training Programs Manager for Oberg Industries provided insight with respect to the matriculation of these students into their apprenticeship experience.

Three issues dominated the interviews. First, all Oberg instructors commented how JAA students initially approach the apprenticeship environment. They observe JAA alumni acting "like high school students" in an academic setting rather than the "workshop" mindset expected of Oberg employees. The "recalibration doesn't take too long", one instructor said, but it "definitely is a shock to them". A second issue shared by Oberg staff is the lack of technical vocabulary of JAA students. CTE graduates benefit from two or three years exposure to the technical jargon of a machine shop environment and share an immersive experience during their internship with a manufacturing company. A JAA graduate has no equivalent experience other than bi-monthly job-shadowing experiences at Oberg's facility during the school year. The third general observation relates to machine tool exposure. Oberg instructors expect a large mismatch between JAA and CTE graduates in hands-on experience, yet they believe Highlands JAA instructors could better prepare students for the transition. "It takes about six months for JAA apprentices to catch up to CTE" a lead instructor noted with respect to terminology and machine tool familiarity. During this phase of apprentice training, however, the instructors lament, "It's a lot more work to get them (JAA students) up to speed."

A unanimous theme amongst all training leads is the frustration encountered when addressing prospective candidates and parents about apprenticeship opportunities and career pathways in precision manufacturing. Of the 14 job offers made to students who completed JAA and passed the NTMA qualification test, only 9 remain in the Oberg apprenticeship program. Of the five who opted out, four planned to enroll in a four-year college program. The sentiment of the training staff parallels Career Conflict data addressed in Research Question 1 where results suggested no statistical difference between the JAA and CTE populations with respect to tensions between positive and negative career influences (Table 6). Both groups share equal dissonance factors when choosing a precision manufacturing apprenticeship. According to the three Oberg training instructors, however, JAA students have a greater predilection to resign. In fact, two training instructors commented about adjusting their teaching style recognizing that "JAA students' aren't as confident and need more positive reinforcement".

4.6 RESEARCH QUESTION 4

Research question 4 asked, *Is there evidence of elevated career decision self-efficacy and adoption of Oberg corporate values for JAA alumni?* The *My Vocational Situation Scale* (abridged) (MVS) survey results serve as the dependent variable to analyze quantitative relationships between JAA and CTE pre-apprenticeship programs. The MVS instrument (Appendix B) is a self-reported screening tool developed by Holland, Daiger, and Power (1980) to assess a student's vocational identity status, knowledge of career information, and barriers to career objectives. For this study, the 18-question true and false vocational identity scale has the most relevant psychometric properties. Larger numbers of "false" responses indicate a stronger vocational identity while the opposite reveal a lack of self-satisfaction and confusion about the respondent's vocational orientation.

4.6.1 My Vocational Situation Scale

An independent sample t-test was conducted to test whether there is difference in mean MVS scores between JAA and CTE students (Table 11). The independent sample t-test shows there is not a significant difference in MVS scores between JAA ($M = 11.44$, $SD = 3.91$) and CTE ($M = 11.54$, SD 5.09) students, $t(20) = -0.047$, $p = 0.963$, $d = 0.023$. There is no evidence to suggest vocational certainty is different between JAA and CTE graduates. Both populations appear to share the same level of uncertainty about their vocational choices although Oberg training staff perceives JAA students to hold less allegiance to the apprenticeship program.

Table 11. Research question 4

Indicators for My Vocational Situation (abridged)--(MVS) scores

Indicator		**JAA**	**CTE**	**DoM**	**SED**	**t-test**
MVS	M	11.44	11.54	-0.09	2.02	t(20) = -0.047
	SD	3.91	5.09			p = 0.963, d = 0.023

Note: Difference of the mean (DoM), standard error of the difference (SED)

To determine where JAA and CTE student's vocational identity differed most, a chi-square contingency test was applied to measure the divergence between groups for individual questions. Table 12 lists the statistical metrics for the top five items where JAA and CTE differed along with three questions where both groups most agree in descending order of significance. Since the independent samples t-test showed no difference in MVS scores, it follows that one question, "*No single occupation appeals to me*", is the only notable response within a 0.05 level of statistical significance, $\chi 2$ (1, n = 22) = 3.936, p = 0.0467. JAA graduates are evenly split--55.6% True to 54.6% False whereas CTE graduates are more certain (15.4% to 84.6%) that no other occupation is appealing. It appears the multiple years of machine shop and manufacturing training while in CTE help crystalize student's identity with a precision manufacturing career. However, results of the MVS survey also illuminated three issues that run counter to this line of reasoning. JAA alumni overwhelmingly disagreed with the following questions, "*If I had to make an occupational choice right now, I'm afraid I would make a bad choice*" and "*I am not sure of myself in many areas of my life*" (11.1% True to 88.9% False). These responses reflect months of deliberation JAA students experience prior to high school graduation. Many weigh the college-internship decision and move forward with self-assuredness

Table 12. MVS comparison between JAA and CTE alumni

Question Number		JAA		CTE		$\chi 2$
		Freq.	**%**	**Freq.**	**%**	
12. No Occupation Appeal	True	5	55.6	2	15.4	(1, n = 22) = 3.936
	False	4	54.6	11	84.6	**p = 0.0467**
6. Wrong Choice	True	1	11.1	6	46.2	(1, n = 22) = 3.010
	False	8	88.9	7	53.8	p = 0.0827
16. Unsure of Self	True	1	11.1	5	38.5	(1, n = 22) = 2.006
	False	8	88.9	8	61.5	p = 0.1567
14. Increased Options	True	6	66.7	5	38.5	(1, n = 22) = 1.692
	False	3	33.3	8	61.5	p = 0.1933
3. Uncertain of Skills	True	2	22.2	6	46.2	(1, n = 22) = 1.316
	False	7	77.8	7	53.8	p = 0.2513
2. Changing Interests*	True	5	55.6	7	53.8	(1, n = 22) = 0.006
	False	4	44.4	6	46.2	p = 0.9369
7. Exploring Options*	True	4	44.4	6	46.2	(1, n = 22) = 0.006
	False	5	55.6	7	53.8	p = 0.9369
18. Career Certainty*	True	2	22.2	3	23.1	(1, n = 22) = 0.002
	False	7	77.8	10	76.9	p = 0.9625

Note: *Most agreement between groups

into the Oberg program, albeit not having the same insight into the machining occupation as their CTE colleagues. The last question of note, "*I am uncertain about occupations I could perform well*" reflects the JAA students' self-awareness, (22.2% True, 77.8% False). Although these three responses are not significant statistically when compared to the CTE population, they indicate JAA students have entered their vocational situation with a high degree of self-satisfaction.

4.7 RESEARCH QUESTION 5

Research question 5 asked, *Do post-graduate activities provide evidence of the effectiveness of the JAA Program?* Oberg's job classifications and respective wage scale is aligned in a hierarchical order: CNC Milling Machinist, CNC Turning Machinist, Precision Wire Cutter, Precision Grinder, and most elite, Precision Toolmaker. As apprentices advance through the first three years of Oberg training, each student qualifies for a classification based on their NTMA test scores, competency acquisition rates, and employee evaluations. The technically advanced and more challenging positions of Wire Cutter, Grinder, and Toolmaker require apprentices with advanced intellectual and mechanical aptitude. These positions are most difficult to fill; therefore, they require strong candidates with not only the fore mentioned attributes but also a desire to shoulder a rigorous training curriculum. The stratification and hierarchical order of Oberg's job classifications serve as dependent variables to analyze the quantitative relationships between JAA and CTE pre-apprenticeship programs.

4.7.1 Job classification hierarchy

An independent samples t-test was conducted to test whether there is a difference in mean Oberg Job Classification (Hierarchy) scores between JAA and CTE students (Table 13). The independent sample t-test shows there is not a significant difference in Hierarchy scores between JAA ($M = 2.33$, $SD = 1.32$) and CTE ($M = 3.23$, $SD = 1.74$) students, $t(20) = -1.305$, $p = 0.207$, $d = 0.583$. There is no evidence to suggest JAA students differ from their CTE counterparts when qualifying for any of the job classifications within the organization. Both pre-apprentice training models place apprentices equally across all positions, yet when group statistics are segregated by high versus low –level classification, there is reason to suggest JAA alumni obtain higher-ranking placement even though a chi-square analysis confirms the t-test result (Table 14).

Table 13. Research question 5

Indicator for job classification hierarchy

Indicator		JAA	CTE	DoM	SED	t-test
Hierarchy	M	2.33	3.23	-0.90	0.69	$t(20) = -1.305$
	SD	1.32	1.74			$p = 0.207$, $d = 0.583$

Note: Difference of the mean (DoM), standard error of the difference (SED)

Table 14. Job classification comparison between JAA and CTE alumni

	JAA		CTE		
Job Classification	**n**	**%**	**n**	**%**	χ^2
Toolmaker	3	33.3	4	30.8	$(1, n = 22) = 1.692$
Grinder	3	33.3	1	7.7	$p = 0.1932$
Wire Cutter	0	0.0	0	0.0	
High – Level Class Total	**6**	**66.6**	**5**	**38.5**	
CNC Turning	3	33.3	4	30.8	
CNC Milling	0	0.0	4	30.8	
Low – Level Class Total	**3**	**33.3**	**8**	**61.6**	
Total*	9	99.9	13	100.1	

Note: *Not 100% due to rounding

4.8 CONCLUSIONS

Data from all five research questions indicates the current apprentice class shares similar job-related attributes regardless of their pre-employment high school training model. JAA and CTE student populations reflect homogeneity across virtually all measures included in this study. Although JAA graduates display a stronger affinity toward conventional high school programs and lack the practical industry experience of CTE alumni, their technical learning rate is comparable to peers who benefit from two additional years of precision manufacturing experience. The Oberg Apprentice Program is founded on the NIMS credentialing model; therefore, student achievement is thoroughly documented and transparent. This research confirms the JAA Program is an effective pathway for STEM-minded students to enter precision manufacturing careers. Although the learning curve is much steeper for JAA graduates, their intellectual persistence and academic focus reward them with prestigious job classifications within the Oberg organization.

4.9 COMPETING EXPLANATIONS OF FINDINGS

A number of competing explanations for research findings are possible. The most plausible counterargument stems from the highly selective screening process of Oberg Industries. All prospective apprentice candidates must pass the NTMA-U Mechanical Aptitude Test which assesses an applicant's understanding of basic mechanical principles and their application within a manufacturing environment. The 90-minute computer-based test consists of four general topics: Applied Mathematics, Mechanical Reasoning, Mechanical and Spatial Relations, and

Theoretical Reasoning. In addition to Butler Community College placement testing, drug screening, and face-to-face interviews with a three-member hiring panel, high school CTE and JAA instructors are asked to submit referrals for each student applicant's demonstrated mechanical aptitude in a machine shop environment. The Apprenticeship Program freshmen are well-vetted and relatively similar in mechanical aptitude, reasoning, and technical ability. This stringent threshold could marginalize the effect of pre-apprenticeship training across both survey groups. The screening process may afford success to any mechanically-inclined individual with a modicum of mathematical understanding and strong academic focus to advance through apprenticeship training regardless of educational background.

A secondary alternative may be found in Oberg's commitment to sustaining a high-quality and comprehensive training center where apprentices are indoctrinated into the "Oberg Way." Over the past three decades, the company has invested millions of dollars into its on-site training facility which employs four full-time machinist instructors, provides 45 National Institute for Metalworking Skills (NIMS) certified "mentors", and integrates 26 credits of on-site community college courses earning students a Certificate of Apprenticeship Technology and tuition reimbursement toward an advanced degree. The training program is also recognized by the U.S. Department of Labor as a "Best in Class Apprenticeship Program" and is a "Registered Apprenticeship Program" in the state of Pennsylvania. According to Greg Chambers, Oberg Industries' Director of Compliance, "By credentialing our workforce, we really know what they can do. We can easily move people between job functions … from production and R&D and other subdivisions … and create a more agile workforce." This robust and immersive experience offers apprentices of all backgrounds a comprehensive vocational education in high-tech precision manufacturing while earning a competitive salary and full employee benefits. For those hired, Oberg Industries is deeply invested in the individual apprentice's success.

4.10 LIMITS AND GENERALIZABILITY

The Highlands–Oberg JAA Program is not an exclusive example of a school district–business apprenticeship training partnership; however, the unique and idiosyncratic degree of screening mechanisms and intensified training regimen may limit applicability beyond the context of this case study. If findings show the JAA Program is an effective pathway for students entering advanced manufacturing, can the researcher deduce what effects elaborate screening measures and comprehensive training augment the matriculation of apprentices into this career field? These factors may be the genesis for alternative studies comparing training across organizations with similar apprenticeship structures.

In a pragmatic epistemology, the researcher is liberated to study "what is of value, to study in the different ways that [he] deems appropriate, and utilize the results in ways that can bring about positive consequences within [one's] value system" (Tashakkori & Teddlie, 1998, p. 30). This predilection may be viewed negatively by a nondescript audience in-masse; however, descriptive case study reporting is often geared toward a specific audience with specific expectations. Yin (2009) suggests identifying potential readers at the onset of writing so that the report form meets the preferences of a target group. He cautions, "No single report will serve all audiences simultaneously" (Yin, 2009, p. 167). Although the researcher should guard against writing from an egocentric perspective (Yin, 2009, p. 170), the germination for a study is often borne from one's loci of interest and therefore rarely escapes the inherent orientation of the author's theoretical framework.

I believe our nation's future rests in our ability to educate and inspire the next generation of engineers and scientists. From this theoretical perspective, I find it essential for educational leaders to study and replicate those programs which show reasonable progress toward advancing STEM self-identification and student interest in STEM careers. A STEM-centric framework limits the generalizability of my research to those outside my target audience, yet the focus of the report should engage those interested in STEM educational initiatives. The philosophical guidance offered by Stake gives me reassurance that limitation is not a liability but an attribute to be valued. In Stake's (1995) Reflections chapter he writes, "Because it is an exercise in such depth, the study is an opportunity to see what others have not yet seen, to reflect the uniqueness of our own lives, to engage the best of our interpretive powers, and to make, even by its integrity alone, an advocacy for those things we cherish" (p. 136). The intent is to create meaning for both the reader and researcher.

Merriam (2009) also writes, "Interpretive research, which is where qualitative research is most often located, assumes that reality is socially constructed; that is, there is no single, observable reality. Rather, there are multiple realities, or interpretations of a single event. Researchers do not 'find' knowledge, they construct it" (p. 9). Triangulation is a widely-accepted protocol which encourages the researcher to employ multiple methods and sources of data to support the analysis and conclusions of a study. However, Merriam also advances the postmodern perspective of Richardson (2000) who states, "We do not triangulate; we crystallize. We recognize that there are far more than three sides from which to approach the world" (found in Merriam, 2009, p. 216). Crystallization allows for multi-faceted viewpoints dependent on the angle of approach. Regardless of one's semantic description, researchers "have ethical obligations to minimize misrepresentation and misunderstanding . . . [employing] deliberative effort to find the validity of data observed" (Stake, 1995, p. 109). Triangulation requires a large time commitment, so it is imperative to focus on "the important data and claims . . . if it is central to making 'the case', then we will want to be extra sure that 'we have it right'" (Stake, 1995, p. 112). Triangulating multiple sources of evidence and alternative perspectives provides an understanding of how the Highlands- Oberg JAA program influences students' self-identification with STEM careers and what organizational constructs are required to sustain and enhance the program.

5.0 CONCLUSIONS, DISCUSSION, AND SUGGESTIONS FOR FUTURE RESEARCH

5.1 INTRODUCTION

The purpose of this research was to determine if the Highlands School District-Oberg Industries Junior Apprentice Advantage Program is an effective pathway for students to enter precision manufacturing careers. Two independent groups, JAA and CTE alumni currently employed as apprentices in the Oberg training center, served as the subjects of this investigation. Descriptive research methodology was applied for this research. Quantitative data was drawn from three sources of information: The Oberg Apprenticeship Survey, Highlands' School District and company financial data, and Apprentice Competency Acquisition Reports. Qualitative information was obtained through scripted interviews with Oberg training personnel. These sources of evidence show the JAA program is an effective model for pre-apprenticeship education and matriculation into a precision manufacturing career at Oberg Industries.

5.2 SUMMARY OF FINDINGS

Research Question 1 asked, *Is there evidence of student, employer, and school district satisfaction with the JAA program?* There is strong evidence of student, employer, and school district satisfaction with the JAA program. Apprentice surveys show that JAA graduates are more tightly coupled to traditional high school archetypes of academics, sports, and extracurricular activities. The JAA option affords these students an opportunity to explore the precision manufacturing career field while maintaining their involvement in day-to-day school routines. Graduation from high school causes equal dissonance among both populations. Although there is no discernable difference in career decision conflict between JAA and CTE graduates, approximately one-third of all respondents indicated experiencing a struggle between positive and negative personal influences on career choice. One may suspect pre-apprenticeship participants to have a clearer career outlook, yet this result is minimal compared to Wimberly and Noeth's (2005) large-scale study that showed 78% of high school students had planned, but not crystalized their career goals preceding high school graduation. A statistically significant difference exists between CTE and JAA graduates' perceived readiness for the Oberg apprenticeship. It follows that two years' machine tool training at CTE affords students more experience than one year at Highlands' JAA, but both groups share similar opinions about the length of their pre-apprentice training programs. However, when first-year JAA data is removed from the readiness comparison, no statistical difference exists - an indication that the Highlands' program is evolving while improving participants' educational experience and technical confidence. Employer and school district investment in time, personnel, equipment, and money indicate continued support for the JAA program. Oberg's training staff interviews add additional evidence that JAA graduates are valuable additions to the apprenticeship class. In summary, these measures indicate overall satisfaction with the JAA program across student, employer, and school district parameters.

Research Question 2 asked, *Do apprenticeship competency tests and advancement rates of JAA graduates compare favorably with vocational education counterparts?* JAA and CTE graduates advance at the same rate through the Oberg Apprenticeship Program albeit an initial deficit exists in fundamental manufacturing skills. Career and Technical schools maintain the personnel and capital resources to secure NIMS accreditation. Their multi-year technical curriculum coupled with machine tool internship exposure adds to CTE students' education culminating in opportunities to earn multiple NIMS credentials which translate directly to Oberg's apprentice competency requirements. Although a 37 point difference in mean baseline test scores exist between JAA and CTE students, the 12 through 24 month data indicates JAA graduates rapidly acquire manufacturing-based skills they initially lacked. Oberg's training program is based on a traditional school model where classroom learning is coupled with practical machining skills applied in structured project-based assignments. Students must also maintain a 3.0 grade-point average while enrolled in on-site math, English, and other career-related classes through Butler Community College during apprenticeship training. Since JAA graduates show a stronger affinity toward traditional learning experiences, the Oberg training model provides a familiar template during the school-to-work transition.

Research Question 3 asked, *What aspects of the JAA program do students and Oberg instructors identify as paramount to the successful matriculation and development of apprentice trainees?* Successful matriculation of JAA graduates into the Oberg apprenticeship is a delicate balance between the high expectations of Oberg training staff and an understanding that JAA and CTE experiences are distinctly different. Both Program Quality and Program Content comparisons bore this out. Time is an impediment that is difficult to overcome and disadvantages the JAA student significantly during the transition into the rigors of apprenticeship training. However, after an initial half-year adjustment period, Advancement Rates indicate the JAA graduate to advance at equal rates to CTE alumni. Linda Wood, Oberg's Training Programs Manager concurs, "The learning curve is much steeper for JAA students, yet once acclimated, they seem to handle it well."

Research Question 4 asked, *Is there evidence of elevated career decision self-efficacy and adoption of Oberg corporate values for JAA alumni?* The apprentice population shares very similar career decision self-efficacy attitudes indicated in MVS results. The independent samples t-test shows no difference between the two pre-apprentice experiences. However, when individual MVS questions are analyzed, "No single occupation appeals to me" is the only response out of eighteen questions that triggers a significantly different viewpoint. CTE students appear to identify more closely with a precision machining career path than those from the Highlands High School JAA Program. Other questions, however, show the JAA student to be more deliberate and thus more satisfied in their choice to enter the apprenticeship program at Oberg Industries.

Research Question 5 asked, *Do post-graduate activities provide evidence of the effectiveness of the JAA Program?* Both student populations share statistically similar outcomes with respect to job placement. Group statistics, however, seem to suggest JAA alumni obtain higher-ranking placement even though a chi-square analysis confirms the t-test result that no significant difference exists. Having a large number of JAA graduates matriculate into high-skilled positions is encouraging since toolmaker and grinder positions are critically needed to offset a rapidly aging precision machinist workforce within Oberg Industries.

5.3 DISCUSSION

Results from this study indicate JAA graduates and CTE graduates are statistically similar in vital career-related attributes such as Job Classification Hierarchy and NTMA Competency Advancement Rates. Although JAA graduates enter their apprenticeship training at a notable skill-set deficit due to the inherent limitations of a traditional high school scheduling model, these students are more deliberate and thus more satisfied in their career pathway as indicated in MVS scores and institutional affinity. This research also illustrates Oberg Industries' commitment to the successful matriculation of each student throughout their forty-two month program. In addition, school district and corporate training budget analyses reveal Oberg Industries expends a 27% premium ($882 net) for JAA-sourced students. Corporate investment is not altruistic, however, the company requires high-quality candidates to supplant an aging workforce of skilled machinists and, most importantly, precision grinders and toolmakers. JAA graduates show a much higher School Affinity score than their CTE co-workers. The JAA graduate enters Oberg with a higher degree of academic achievement, affinity toward school culture, and participation in extracurricular pursuits. These attributes pair closely with the commitment to excellence promoted in Oberg corporate culture.

The JAA pre-apprenticeship training embedded in a traditional high school academic setting is effective preparation for Oberg's precision manufacturing apprenticeship. This program affords students an opportunity to pursue a high-paying career in an industry that was traditionally reserved for only CTE graduates or off-the-street hires with relevant industry skill sets. Metrics show, regardless of secondary school experience, the strength of the Oberg Apprentice Training Program assures positive results for a new generation of machinists and toolmakers in the precision manufacturing industry.

To assess and improve the JAA experience, the conceptual framework of Tyler (1949), Kirkpatric (1998), and Guskey (2000) was applied across five criteria for professional training: S***tudent Reactions*** (Level 1), S***tudent Learning*** (Level 2), O***rganizational Support*** (Level 3), S***tudent Behavior*** (Level 4), and E***xtended Student Results*** (Level 5). Research authorities such as Yin, Stake, Merriam, and Mertens suggest multiple sources of evidence to build a more robust investigation leveraging each strategy"…to share the research questions, to collect complimentary data, and to conduct counterpart analyses" (Yin, 2006). The Professional Development Evaluation Model augments this study by providing insight as to where JAA training can improve while addressing the primary research question. Within this context, Level 2 (Student Learning) and Level 3 (Organizational Support) are the weakest elements of the Highlands-Oberg Pre-Apprentice Program. Data shows a 37 point deficit in baseline NTMA scores for JAA graduates and a low perception of readiness as they enter Oberg's apprenticeship training. Although it is extremely difficult to overcome the time and exposure CTE graduates enjoy learning their trade in a manufacturing setting, the JAA school district could do more to mitigate the disparity. Financial support is not a major issue; rather, scheduling the JAA Program to maximize both faculty and facility resources could dramatically enhance the experience at Highlands. This would require modification to the master schedule so that the three prescribed JAA classes (Metrology, Advanced Geometry, and Engineering CAD) are offered as a block to optimize cross-curricular projects, allow for long-term practical labs, and immerse students in a "machine shop" environment. Furthermore, instructors would be able to co-teach units and share common plan time to develop more authentic learning opportunities. In addition, the district could support faculty training by offering curriculum rate to JAA teachers for summer internships at Oberg Industries. Staff members must also improve their knowledge of precision machining, manufacturing careers, and the expectations of private sector employers.

The Junior Apprenticeship Program could benefit by a longitudinal curriculum strategy which expands learning from freshman through senior year by integrating manufacturing, engineering, CAD, and College-in-High School courses through Butler Community College (BC^3) that replicate the course of studies in the Oberg training facility. NTMA on-line courses involving safety, blueprint reading, shop math, precision machining technology and diemaking, and metrology could be offered to bridge the learning gap over the summer break. Highlands' instructors could also attend training to obtain NIMS instructor credentials thereby offering JAA students an opportunity to achieve fundamental certifications that make them marketable to a wider range of manufacturing companies. These initiatives would mitigate the discrepancy in experience between JAA and CTE students.

5.4 SUGGESTIONS FOR FUTURE RESEARCH

The results of this study show that a pre-apprenticeship program embedded in a traditional high school curriculum is an effective pathway for students to enter precision manufacturing careers. The Highlands JAA Program gives access to a population of students who otherwise would not consider this lucrative and rewarding employment opportunity. However, the tension between choosing an apprenticeship career path versus attending college directly upon graduation from high school is a persistent obstacle for those involved with the JAA initiative. Future research may investigate the possibility of a "Delayed Entry Program" where qualified JAA graduates are offered the option to re-apply for an apprenticeship position within one year of high school graduation. Those who wish to exercise this option would re-take the Oberg Entrance Exam and carry forward all instructor evaluations from the JAA pre-apprenticeship at Highlands. There may be an "untapped" pool of qualified graduates whose experiment with the rigors of college left them unfulfilled.

A second avenue of research involves expanding the program along two fronts: Additional private partnerships and integrating the JAA model into neighboring school districts. One could investigate if there are additional companies interested in supporting the JAA Program by partnering with Oberg Industries and Highlands to create broader opportunities for students within the precision manufacturing sector. A more diverse field of corporate sponsors would enhance employment opportunities for graduates while broadening learning by job-shadowing in multiple manufacturing environments. Offering a pre-apprenticeship program within the confines of a traditional high school may be challenging to replicate in other districts, but further inquiry should test the feasibility of expansion. Centralizing JAA in one school district runs counter to the research presented in this study; rather, each school would "own" its own program. Alternately, each district may elect to collaborate with a private company exclusively and adopt a curriculum that is structured to support the employment requirements of the partnership.

5.5 A VISION FOR SCHOOL-BASED APPRENTICESHIP TRAINING PROGRAMS

Results of the Oberg-Highlands Junior Apprenticeship Program are encouraging, yet a broader effort amongst local leaders must be cultivated to make school to high-tech careers scalable in *all* business sectors. Clifton suggests the "jobs war" is won by knowledge workers. Cities and regions need a team to develop the alignment, focus, and strategies that put businesses and local institutions on the same page (Clifton, 2011). The JAA collaboration demonstrates what is possible when key leaders work in partnership toward building the human capital necessary for 21st Century economic competition. Tailoring curriculum between high schools and regional employers forms symbiotic relationships with immediate returns. There exists a nucleus of academically-minded young adults whose talents and interests correlate with the staffing needs of precision manufacturing, healthcare, energy, and other growing sectors of the economy. The education and subsequent career trajectory of this talent pool may be influenced through concerted educational campaigns for students *and* parents beginning early in high school. To this end, the Oberg Industries – Highlands JAA program plans to expand through a grant from the Pennsylvania Department of Community and Economic Development (DCED) to grow the program beyond its current footprint.

The Pre-Apprentice and Apprenticeship Grant Program (Apprenticeship Program) is a statewide program which offers assistance to registered apprenticeship programs. The program's goal is to increase apprenticeship availability to Pennsylvania employers to assist them with their talent recruitment and development (DCED, 2018). Using existing JAA architecture as a foundation, this grant will fund additional learning through bi-monthly e-learning classes via *Microsoft Teams* software. The objective is to introduce students to advanced manufacturing careers with interactive lessons embedded in their 9th and 10th grade math class. Introduction to Mechatronics, an on-line course designed by Oberg and Highlands staff will be offered to juniors interested in advanced manufacturing careers. Senior-level JAA classes and job-shadowing will continue with an additional emphasis on N.I.M.S. certification. These enhancements not only satisfy the Pennsylvania Department of Education's Career Awareness and Preparation, section

13.1 of the PA Core Standards, but also allow pre-apprenticeship content to reach more users including neighboring school districts and career training institutions.

In November of 2017, Pennsylvania released $2.3 million in funding to state employers to develop specialized training for workers to close skills gaps in the workplace and provide career pathways for students and adults. This is employer-driven model enables companies to provide classroom training necessary for particular talent needs. According to the Department of Labor & Industry (L&I) Deputy Secretary, the goal is to assist employers by providing funding to assist with their talent recruitment and development of employee training. These apprenticeship grants foster the development of new apprenticeship training programs and redirect state dollars to meet the most urgent regional employment needs (Cipriani, 2018). With this funding readily available, school district, community, and business leaders have the inimitable opportunity to develop and implement apprenticeship initiatives that will translate to immediate results for students, families, and communities. In addition to the government entities noted, industry and trade associations such as the NTMA, NIMS, Advanced Robotics for Manufacturing (ARM), New Century Careers, and the Catalyst Connection represent a small cross-section of the resources available within the region to assist with this endeavor.

The vision for education borne of this research is to expand opportunities and enlighten students of lucrative manufacturing careers pathways while regenerating the school – corporate alliance often overlooked by district and business leadership. Collaboration yields dramatic results. This singular example demonstrates how a tightly coupled program design can positively impact the lives of each JAA pre-apprentice graduate. State funding and organizational support is replete with resources to advance this narrative.

5.6 CONCLUSION

Self-determination is coveted in American education. However, the mismatch between student interest and growing occupational areas in precision manufacturing indicate that our secondary school model has failed to prepare students for a large segment of high-growth STEM occupations. Other developed nations, by comparison, have deliberately opted to strengthen, broaden, and expand their vocational education systems while the United States has focused on post-secondary education as a proxy for employability or work readiness (Kunchinke, 2013). Within the American high school, academically-minded students rarely explore CTE pathways because of the life-changing commitment they require. The CTE choice removes the student from peers who also share a strong affinity toward school, conflicts with art electives such as drama, chorus, and concert band, and hinders the scope of electives due to class section limitations within the master schedule. For many, the cost to attend off-site CTE programs is too high. The current CTE model strains loyalties and erodes in-school opportunities beyond perceived value. The normal default is to follow a traditional course of studies relegating potential STEM CTE concentrators to the "college-for-all" mindset regardless of the student's likelihood to achieve a STEM-related degree.

The Junior Apprenticeship Advantage Program was designed to address the segment of high school students interested in STEM careers yet underserved by the college preparatory - vocational education model perpetuated by school systems over the past two decades. This study offers evidence that the Highlands-Oberg JAA partnership adequately prepares graduates to accept the rigors of apprenticeship training. Although these graduates begin at a slight deficit in manufacturing skills, quantitative evidence shows their academic focus and intellectual range allow them to rapidly acquire industry certifications which earn them the most prestigious and coveted positions within the organization. In *Beyond College for All*, James Rosenbaum asserts fewer than 9 percent of high school graduates find jobs with the help of their school, yet most "college-bound" students are actually work-bound (2001, p. 267). Public-private partnerships such as the Junior Apprenticeship Advantage Program offer viable alternatives to STEM-minded students whose post-secondary aspirations align with career opportunities in the precision manufacturing industry.

APPENDIX A

PRE-APPRENTICESHIP SURVEY

This survey is designed to collect information about your ***technical training*** *in high school and/or vocational school prior to entering the Oberg Apprenticeship Program. The purpose of the survey is to learn how students perceive their pre-apprenticeship educational experiences and reflect on how well that early technical learning prepared them to advance through Oberg Industries' apprenticeship training today.*

If you choose to participate in this survey, all information will be held in the strictest confidence. ***No individual will be identified, and all responses will be confidential****. All responses will be reported in a generic, summarized format to maintain your anonymity. Your decision to participate in this survey will in no way affect your relationship or employment status with Oberg Industries.*

Pre-Apprenticeship Survey

Background Information

(Please circle the best response.)

1. High school graduating class: **2013 2014 2015 2016 2017**

2. I attended a vocational-education school (Forbes, Lenape, Westmoreland, etc.) for:

   4 years 3 years 2 years 1 year Did not attend vo-tech

3. I was enrolled in the Highlands Junior Apprenticeship (JAA) Program: **Yes No**

4. My academic standing (class rank) in high school was:

   Top 25% Middle 50% Bottom 25% Don't Know

5. Who were the persons or groups that ***encouraged*** and guided your decision about working through an apprenticeship in high-tech manufacturing? (Circle the ***most*** influential.)

Parent / Close Relative	**Close Friend**	**High School Teacher**
Guidance Counselor	**Co-worker / Employer**	**Article / Advertisement**
Trade Show	**Internet Search**	**No Advice Given**

6. Who were the persons or groups that hindered or ***discouraged*** you from pursuing an apprenticeship in high-tech manufacturing? (Circle the ***most*** critical.)

Parent / Close Relative	**Close Friend**	**High School Teacher**
Guidance Counselor	**Co-worker / Employer**	**Article / Advertisement**
Trade Show	**Internet Search**	**No Advice Given**

(The next series of questions asks you to place an "X" in the appropriate column that corresponds to the grade level in high school that makes the statement true.)

7. While in high school, I:

	9th	**10th**	**11th**	**12th**
Received an academic honors award				
Played a high school sport for an entire season				
Participated in a major extracurricular (band, musical, chorus, etc.)				
Worked more than 10 hours per week at a part-time job				
Was absent from school a total of 10 or more days in a school year				
Received a major disciplinary action (suspension or three or more detentions in a single school year)				

<u>Program Content</u>

(The next series of questions asks you to rate the technical content of your pre-apprenticeship training. Place an "X" in the box that reflects the degree to which you were prepared for each skill encountered in the Oberg Apprenticeship Program.)

8. My high school / vocational school experience prepared me to:

	Significantly	Generally	Somewhat	Seldom	Never
Read and interpret CAD drawings and technical prints					
Apply mathematic concepts to solve for missing dimensions on technical drawings					
Use precision measurement tools such as Vernier calipers, micrometers, surface gauges, and comparator					
Understand tolerances and apply them to dimensions on a machined part					
Describe metal cutting, how it is accomplished, and whether a cutting tool is performing properly					
Apply "G-Code" to operate a numerically-controlled machine tool					
Produce a machined part matching a process plan and technical specifications utilizing appropriate techniques					

Program Quality

(The next series of questions asks you to rate the perceived quality of your pre-apprenticeship experience. Place an "X" in the box that reflects your assessment of each quality indicator.)

9. My high school / vocational school pre-apprenticeship education:

	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Focused on the individual training needs of each student					
Presented topics in a logical and organized format					
Offered lessons that are relevant and important to my career development					
Covered material in sufficient detail and allowed adequate time to practice and/or re-learn skills					
Allowed sufficient hands-on experiences and practical applied training in a shop environment					
Employs highly-skilled and knowledgeable staff					
Utilized modern machine tools and well-maintained shop equipment					
Offered up-to-date textbooks, worksheets, simulation software, and computer labs					

10. The length of time in my pre-apprenticeship training program was:

Too Long	About Right	Too Short

11. Overall, my high school / vocational school technical training adequately prepared me for the Oberg Industries Apprenticeship Program:

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

APPENDIX B

MY VOCATIONAL SITUATION (ABRIDGED)

This survey is designed to collect information about your perceived ***vocational identity****. It asks questions about your career goals, interests, and abilities to determine the level of satisfaction with your career choices and how well you identify with your current occupation.*

If you choose to participate in this survey, all information will be held in the strictest confidence. ***No individual will be identified and all responses will be confidential. All responses will be reported in a generic, summarized format to maintain your anonymity.*** *Your decision to participate in this survey will in no way affect your relationship or employment status with Oberg Industries.*

Thank you for taking time to complete this survey. Your responses will be used to make the pre-apprenticeship training experience more meaningful to future employees of Oberg Industries.

My Vocational Situation Scale (Abridged)

(Try to answer each of the following statements as mostly TRUE or mostly FALSE. Circle the answer that best represents your present opinion.)

Thinking about your present job or in planning for an occupation or career:

1. I need reassurance that I have made the right choice of occupation.	**T**	**F**
2. I am concerned that my present interests may change over the years.	**T**	**F**
3. I am uncertain about occupations I could perform well.	**T**	**F**
4. I don't know what my major strengths and weaknesses are.	**T**	**F**
5. The jobs I *can do* may not pay enough to live the kind of life I want.	**T**	**F**
6. If I had to make an occupational choice right now, I'm afraid I would make a bad choice.	**T**	**F**
7. I need to find out what kind of career I should follow.	**T**	**F**
8. Making up my mind about a career has been a long and difficult problem for me.	**T**	**F**
9. I am confused about the whole problem of deciding on a career.	**T**	**F**
10. I am not sure that my present occupational choice or job is right for me.	**T**	**F**
11. I don't know enough about what workers do in various occupations.	**T**	**F**
12. No single occupation appeals strongly to me.	**T**	**F**
13. I am uncertain about which occupation I would enjoy.	**T**	**F**
14. I would like to increase the number of occupations to consider.	**T**	**F**
15. My estimates of my abilities and talents vary a lot from year to year.	**T**	**F**
16. I am not sure of myself in many areas of my life.	**T**	**F**
17. I have known what occupation I want to follow for less than one year.	**T**	**F**
18. I can't understand how some people can be so set about what they want to do.	**T**	**F**

APPENDIX C

CONSENT TO ACT AS A PARTICIPANT IN A RESEARCH STUDY

Study Title: A Program Evaluation Study for a Precision Manufacturing Apprenticeship Embedded in a Traditional High School Curriculum

Researcher: John Malobicky
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Site of Study: Oberg Industries Apprentice Training Center
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Freeport, PA 16229

Introduction: The purpose of this research is to evaluate the effectiveness of a precision manufacturing apprenticeship program embedded in a traditional high school curriculum. The conceptual framework of Tyler (1949), Kirkpatrick (1998), Guskey (2000), and Vespia (2004) will be applied to analyze the Junior Apprenticeship Advantage Program (JAA) with respect to five sequential criteria: student reactions (Level 1), student learning (Level 2), organizational support (Level 3), student behavior (Level 4), and extended student results (Level 5). Although traditionally applied to professional development training, Vespia (2004) advanced the application of Guskey's framework to study student learning program evaluation. The entry point for this research is the Oberg Industries Apprenticeship Training facility where recent JAA graduates train side-by-side with their vocational education counterparts.

All apprentice trainees currently enrolled in Oberg's Apprenticeship training are eligible to participate in this voluntary study. The research will compare the pre-apprentice training experiences and vocational satisfaction of JAA and CTE graduates using two ten-minute survey instruments: The *Pre-Apprenticeship Survey* and the *My Vocational Situation (Abridged) Survey*. The timeline for data collection will be July 2017 through September 2017.

Your responses will be confidential to ensure that they cannot be casually linked to you. Only the Principal Researcher has access to survey information. When the research is complete, a summary report will be written identifying participants by JAA or CTE groups only.

Study Risks: There are no foreseeable risks to those choosing to participate in the study although all investigations may encounter unforeseen risks. The benefit of this study may include: (a) discovery of new information concerning high school apprenticeship programs (b) insights into the experiences of stakeholders involved in apprenticeship training and (c) possible improvements to current pre-apprenticeship education models.

Consent to Participate: The above information has been explained to me and all of my current questions have been answered. I understand that I am encouraged to ask questions, voice concerns or complaints about any aspect of this research study during the course of this study, and that such future questions, concerns, or complaints will be answered by a qualified individual or by the investigators listed on the first page of this consent document at the telephone numbers given.

I understand that I may always request that my questions, concerns or complaints be addressed by a listed investigator. I understand that I may contact the Human Subjects Protection Advocate of the IRB Office, University of Pittsburgh (1-866-212-2668) to discuss problems, concerns, and questions; obtain information; offer input; or discuss situations that occurred during my participation.

By signing this form I agree to participate in this research study. A copy of this consent form will be given to me.

I certify that I am 18 years of age or older.

________________________________ ____________________
Participant's Signature Date

Investigator Certification: I certify that I have explained the nature and purpose of this research study to the above-named individual(s), and I have discussed the potential benefits and possible risks of study participation. Any questions the individual(s) have about this study have been answered, and we will always be available to address future questions, concerns or complaints as they arise. I further certify that no research component of this protocol was begun until after this consent form was signed.

____________________________________ __________________________
Printed Name of Person Obtaining Consent Role in Research Study

____________________________________ ____________
Signature of Person Obtaining Consent Date

APPENDIX D

APPRENTICE INSTRUCTOR INTERVIEW SCRIPT

1. **What is your role in the Oberg / JAA training program?**

2. **How long have you served in this capacity?**

3. **What differentiates JAA versus CTE graduates in the apprenticeship program?**
    a. **Attendance**
    b. **Attentiveness**
    c. **Initiative**
    d. **Manufacturing Skill Set**
    e. **Learning Rate**

4. **How can the JAA program be improved?**

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