CTE Online: An Investigation of the NIMM Program in North Central Idaho and Southeast Washington

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Abstract

While many schools are revisiting the importance of Career and Technology Education (CTE) in the K 9-12 curriculum, many face constraints in the form of instructional and laboratory resources. The 22 school districts of North Central Idaho and Southeast Washington region struggle to provide access to CTE programs due to geographic challenges, limited school resources, fund shortage, and insufficient population density. Co-locating these programs is nearly impossible because of distance. From a practical perspective, the Northwest Intermountain Metal Manufacturing (NIMM) project is an initiative that led to this study to illustrate programmatic models for the delivery of CTE to produce entry-level technicians from secondary schools in rural regions. This project can be replicated in regions that are facing similar issues relating to workforce shortages and the out-migration of youth, which are disruptive factors to the economy of rural regions. Findings show, this project helped students learn about local opportunities and think about an alternative career. Furthermore, the project ensured equity and accessibility. This project provides useful data to build an educational model for the delivery of CTE curriculum in rural regions to improve the availability of skilled workers.

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Dedication

To my beloved mother, Jahanara Begum (late) and my father, Mostafizur Rahman, who raised me with love, care, and knowledge that prepared me for life.

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Chapter 1: Introduction

Background

For hundreds of years, Career and Technical Education (CTE) programs have been around in one form or another. Evans (1971) and Keller (1948) indicated that in the past, parents passed on important survival skills to their children long before the United States as a nation was founded. While Keller (as cited in Wang, 2009, p. 1) informs formal education was typically reserved for religious training in past centuries, Tozer (2013) indicated apprenticeships that existed throughout Europe and early America were the root of today's CTE programs. He reasoned, however, as schooling became mandatory and curriculum evolved to address the needs of the workforce, the inclusion of skills training in the school curriculum became a hotly contested topic. CTE nonetheless continues to play a significant role in equipping students with workplace competencies, despite facing several challenges relating to its image and seemingly competing national policies that encourage students to pursue four-year college programs (Tierney, 2013; Hanushek et al., 2019; Bozarth & Strifler, 2019).

CTE programs in school districts across the country are facing significant challenges. Concurrent federal and state funding cuts for CTE programs in recent years have greatly impacted the delivery of CTE classes in many high schools (U.S. Department of Education, 2006). In fact, Theriault (2007) describes the rapid and extensive closing of shop classes as one of the most shocking impacts on CTE in public schools. For example, in the Los Angeles United School District, 90% of CTE workshops or laboratories were abolished (Brown, 2012). Benavot (1983), Camp (2007), Foster (2007), and Moye (2009) described these changes as alarming, as they are not limited to California, but stretch across the United

States, with poorer and more rural school districts affected more severely. In addition, both federal and state government funding cuts have resulted in a decrease in the number of graduating CTE teachers, leading to a severe shortage of high school CTE teachers (Bartholomew, 2014; Gray & Daugherty, 2004; Conneely & Uy, 2009). School districts continue to struggle to fill positions as CTE teachers retire (Wilkin, 2011).

The challenges facing CTE are particularly severe in rural regions because of the unique resource and demographic challenges these regions face. Rural schools struggle to build strong CTE programs, as they tend to have fewer resources to support CTE programs and have a lower density of businesses that can serve as valuable partners. In a given year, only 8 million of the 15 million high school students in the USA participate in a CTE course, and only 1 in 5 chooses to focus on a CTE program (Gewertz, 2017). Consequently, manufacturing companies are challenged by a severe skills gap and talent shortage (ed.gov, 2018). This situation is more pronounced in the manufacturing sector of states with large rural districts, such as Idaho (Dixon & Stricklin, 2014).

Acknowledging this challenge, the Association of Career and Technical Education (ACTE) stated:

> One such challenge is serving small populations that are geographically dispersed, making it difficult for school districts and community colleges to offer robust education programs. It may be hard to find teachers qualified to teach a particular course or course sequence, or to offer enough courses to meet the varied career interests of students and help them complete a career pathway, while a lack of technology infrastructure in rural areas can make it challenging to connect students and teachers across distances. It can also be difficult for schools to provide students

> with a range of career exploration and work-based learning experiences, as many rural areas have only a few employers or industries. Funding challenges underlay all these concerns. (2015, p. 1)

CTE has met these challenges over the years by using a variety of models to facilitate student learning and engagement while working with financial, geographic, and accessibility constraints. The strengthening of the technological infrastructure in rural regions can enable equity in access to some CTE programs. For example, online learning has connected rural students with opportunities to earn college credits, and computer-based simulations and virtual school options can be particularly beneficial to rural students who might not otherwise have access to specialized courses that enhance their career readiness (ACTE, 2015; Robertson & Aquino, 2016).

Challenges Facing Workforce Development in Rural Regions

According to the U.S. Department of Agriculture (USDA) survey data, one out of four businesses located outside metropolitan areas struggle to find qualified workers, compared with just one in six businesses in metro areas (USDA, 2015). Job applicants often lack skills in basic math, hands-on trades, information technology, and manufacturing (Bozarth & Striftler, 2019). The demographic trends correlate and underlie the shortage of labor and talent in rural areas. Besides being less densely populated, rural regions are seeing an aging population, on average, due to both out-migration of younger people and an increase in those reaching retirement age.

As of mid-2018, those 65 and older make up almost a quarter of the population in non-metro areas, and prime working-age adults (defined as those who are 25 to 54 years old) comprise less than half (43%) of the population. That compares to 50% of prime working age adults and 19% of adults 65 and older in metropolitan areas (Bozarth & Striftler, 2019; Winkler & Johnson, 2016). Specifically addressing the manufacturing industry, the Department of Labor (2012) reported these companies experience the most difficulties in finding employees with required technical skills.

Even though 30.4% of U.S. adults have a bachelor's degree or higher, most of the skills acquired from these degrees do not match the employers' requirements (White, 2012). One of the main reasons for the shortage of workers with technical skills is because fewer students are choosing manufacturing as a career choice due to its poor image (Nash-Hoffs, 2011). Rural economy is severely impacted by reasons like aging populations, out-migration of high school graduates along with companies' inability to obtain a pipeline of workers with required skills to keep them afloat. Revitalizing and reconceptualizing how CTE is delivered in high schools in non-metro or rural areas is necessary to save local and regional economies.

North Central Idaho and Southeast Washington

Northwest Intermountain Manufacturing Association (NIMA) region embraces the rural, North Central Idaho counties of Latah, Nez Perce, Clearwater, Lewis, and Idaho, and the southeast Washington counties of Asotin, Garfield, Whitman, and Columbia. Geographically, this location has low-elevation river valleys, high-elevation agrarian plateaus, and mountain ranges. Although historically the economy of this region was comprehensively dependent on agriculture and timber industries, gradually the region has lost agricultural, lumber, and wood product jobs (Tack, 2015). In the last three decades, this rural region has also endured wrenching economic structural changes. Employment opportunities have decreased as industries automated and as timber contracts on public lands significantly decreased. Between 1980 and 2012, the region lost about 54% percent of its forest product jobs and 57% of its farm jobs (Tack, 2015). As the existing workforce aged, the region's youth sought employment outside of the region. The number of 16-year-olds in the region declined 15% from 2000 to 2014, while the number of 65-year-olds grew 69%. Thus, the region has fewer individuals available for the workforce than it has retiring from it.

The manufacturing sector has replaced many lost jobs and has been growing faster than the national rate. Over 220 manufacturing businesses with 1 to 60 employees are located in the region. Of these, 56 make up a major industry sector that the region defines as the Northwest Intermountain Metal Manufacturing (NIMM) Supercluster (Tack, 2015). Clusters are generally formed based on an area's comparative advantages (Manning, 2012; Giuliani, 2005; Porter, 2003; Iammarino & McCann, 2006). This business cluster has a high concentration of metal fabricating firms and machine shops that are interconnected and specialized. They have similar workforce needs—workers who receive training in one firm can easily find work in another firm within the same cluster.

Statement of the Problem

In-depth interviews of approximately 100 manufacturers by the economic development association in 2007 identified the lack of an available and trained workforce as the most significant issue hampering growth in the NIMA region. In another survey during 2015, companies constituting the Metal Supercluster identified workforce as the largest impediment to growth as manufacturing companies recovered from the recession. Presently, with the Metal Supercluster at accelerated growth, companies are competing for talent and leaving many positions unfilled. Increased competition for workers has resulted in rising turnovers and higher entry-level wages (Frei, 2013; Tack, 2015).

Higher retirement rates combined with an out-migration of young people have resulted in a serious shortage of talent for entry-level technician positions. Geographic challenges, limited school resources, and scarce population density significantly impact the educational system’s ability to educate students and provide access to CTE programs. The region’s twenty-two school districts struggle financially to find and employ CTE instructors and school counselors, and co-locating CTE programs is nearly impossible because of distance.

An occupational analysis was conducted among companies in the Metal Supercluster to determine the jobs that were critical for the growth of companies within the cluster. This analysis was conducted to:

1. Provide a pipeline of high school graduates with competencies in entry-level manufacturing
2. Help the out-migration of high school graduates in search of living wage jobs
3. Offer CTE opportunities to schools in this geographically dispersed region in an equitable manner
4. Generate a skilled workforce for manufacturing companies to grow and remain competitive.

After each job was identified, a job analysis was done to determine their respective competencies.

Collaboration between NIMA, Clearwater Economic Development Association (CEDA), Idaho Department of Labor—Lewiston, Lewis Clark State College (LCSC), University of Idaho (UI), and Idaho Digital Learning Academy (IDLA) resulted in funding from the National Science Foundation (NSF) to implement the Northwest Intermountain

Metal Manufacturers (NIMM) Program. The NIMM Program includes two pathways for manufacturing technicians:

1. Mechanical Computer Aided Drafting and Designing Technician
2. Electro-Mechanical Technician

The curriculums were driven by competencies identified in the job analyses and represent competencies from the top three job areas identified for growth in the metal supercluster. The modality of delivery includes online asynchronous for the Mechanical Computer Aided Drafting and Designing pathway, and hybrid for the Electro-Mechanical pathway. Using online modality offers the most economical and pragmatic way to deliver the curriculum. In fact, the effectiveness of online education is becoming well established. Cavanaugh et al (2004) indicated that virtual instruction in K-12 schools produced results in students' achievements that were as good or better than traditional face-to-face instruction. Nguyen (2015) also reported that 92% of all distance and online education studies find that distance and online education is at least as effective, if not better than traditional education. Offering CTE in this format has never been done in this region before.

Purpose of the Study

The overarching goal of the NIMM program was to ensure equity in access to a CTE program in manufacturing to rural schools in North Central Idaho and Southeast Washington, the NIMA operating region. Contingent to this effort is a development of talent in critical skill areas identified by manufacturers in the metal super cluster where there is a chronic shortage of skilled labor. The purpose of this case study is to examine the extent to which the two implemented manufacturing pathways of the NIMM project were successful. It will also explore the weaknesses and strengths of the NIMM program to understand the factors or characteristics of delivering CTE in an online format in a rural region.

Research Questions

To better understand the intricacies of the issues faced and important lessons learned in implementing and delivering CTE online in a rural region, the following questions will guide this case study:

1. How did differences in the modality of delivery (asynchronous vs. hybridized) implicate the quality of online delivery in CTE online manufacturing curriculum?
2. What are stakeholders' perceptions about the outcomes of the NIMM program?

Significance of the Study

The significance of this study lies in its potential contribution to the literature on delivering CTE curriculum online. While many schools are revisiting the importance of CTE in the K9-12 curriculum, many face constraints in the form of instructional and laboratory resources. A case study of a CTE online program will add to the literature on online delivery in the K9-12 system. Findings from this case study will also provide a model for the delivery of CTE programs in an equitable manner for diverse populations living in rural regions. From a practical perspective, this study will illustrate programmatic models for the delivery of CTE to produce entry-level technicians from secondary schools in rural regions that can be replicated in regions that are facing similar issues relating to workforce shortages and the out-migration of youth, which are disruptive factors to the economy of rural regions.

Conceptual Framework Guiding the Study

Researchers have been using principles of multimodality theory, active learning theory, and connectivism to craft interactive, multimedia-based courses that are more relatable, hands-on, and multimodal to address student performance, engagement, and satisfaction affecting e-learning attrition (Oud, 2009; Zhang, 2006). Picciano (2009) presented a blending with pedagogical purpose model, where pedagogical objectives and activities are the main driving force for all methods of teaching and learning. This model suggests pedagogical objectives and activities must be blended in various modalities to ensure effective learning for all levels of students. It has six basic and very flexible pedagogical goals that can be achieved through learning modules. These six goal components (i.e., content, questioning, reflection, social-emotional support, collaborative learning, and evaluation) generate an integrated community of learning that ensures rich interaction in either online or face-to-face modules. One of the most flexible features of this model is, not all courses have to incorporate all the activities and approaches. Activities should be driven by pedagogical objectives.

Figure 1

Revised Multimodal Learning Model (Picciano, 2017)

Later, Picciano (2017) reviewed this model further and developed a new model named Multimodal Model for Online Education (see Figure 1). This model expands the pedagogical purpose approach and blends it with additional components, such as community, interaction, and self-paced and independent instruction (Anderson et al., 2011).

Concept of learning community, which is an important aspect of online learning, is highlighted in this program. Each course is taken as a learning community, which can be expanded to a larger academic program. This concept was highly promoted by Garrison et al. (2000) and Wenger and Lave (1991). Courses in NIMM projects are primarily asynchronous, where feeling connected to other learners and a strong presence of the instructor online is very important. Interaction is another important aspect for online learning, which is interrelated to the concept of learning community. Interaction among students, and between student and teacher lead to effective online learning. Also, one of the common features of any asynchronous course is to have students learn independently.

Limitation of the study

One of the significant limitations of case study method is, it is a bounded system. This case study is a unit analysis where the researcher looked at a specific program in a particular region, which is bounded by contexts. The results/findings cannot be generalized to the wider population. Case study is typically a system of action rather than an individual or group of individuals. It has been criticized that case studies provide very little basis for scientific generalization as a very small number of subjects are used as a sample. Often the question raised is “How can you generalize from a single case?” (Yin, 1984, p. 21). According to Yin (1993), case study is a ‘microscopic’ methodology because of the limited sampling cases. However, it is also noticeable that parameter establishment and objective setting of the research are far more important in case study method than a big sample size (Hamel et al., 1993; Yin, 1994).

Definition of Terms

Some key terms and concepts that are used in this research proposal are explained below:

Distance learning or online learning: A form of education in which the main elements include physical separation of teachers and students during instruction and the use of various technologies to facilitate student-teacher and student-student communication.

LMS: Learning Management System

LCMS: Learning Content Management System

CTE: Career and Technology Education

NIMM: Northwest Intermountain Metal Manufacturing

NIMA: Northwest Intermountain Manufacturing Association

CADD: Computer Aided Draft and Designing

IDLA: Idaho Digital Learning Academy

CEDA: Clearwater Economic Development Association

LCSC: Lewis Clark State College

NSF: National Science Foundation

Chapter 2: Literature Review

A Brief History of Career and Technical Education

Brewer (2009) points out that CTE programs are not too different from the survival skills that were passed from one generation to another for thousands of years leading up to the industrial revolution, known as vocational education. In fact, the further we move back in history, the more the education system resembles vocational training (Gray, 2008). Long before the agricultural revolution, when humans were hunter-gatherers, parents allowed their children to educate themselves through self-directed play and exploration (Gray, 2008). This self-motivated, hands-on education of antiquity, according to Gray, allowed children to develop skills to be adults in the hunter-gatherer world.

The self-directed exploration gave way to the next generation of education, when humans decided to turn to farming on mass scale for subsistence. During the agricultural revolution, mothers taught their daughters the “vocation” of cooking and sewing, while fathers taught their sons the “vocation” of hunting, farming, and navigation (Brewer, 2009). Yet other specialized vocations in the pre-industrial communities would include administration or legal training. In this pre-industrial world, technical education was not identified by all the activities associated with the academic CTE of today, but through various other tasks, like apprenticeships (Brewer, 2009). There were two types of apprenticeships in America, voluntary and involuntary. The voluntary apprenticeship was based on the European tradition and was not subject to the particular provision of law, although the agreements were entered in the town’s record. Involuntary apprenticeship involved a master, instead of the town, taking responsibility for the apprentice. Barlow (1967) stated, “the latter also provided a means for taking care of the poor,” (as cited in

Gordon, 2014). Both boys and girls remained as apprentice until they were about eighteen or were married. While engaged, the agreement was to provide food, clothing, and shelter; religious training and general education as needed in the trade; and the knowledge, understanding, and experience in the trade skills. It is not hard to see how the hands-on training offered to a high school student with a CTE career path in welding is not too different from the in-workshop training of a metalsmith or a glass blower's apprentice. It is, however, interesting to note that some teachers who passed on the vital skills of their crafts to their apprentices also chose to teach them basic reading and writing skills (Brewer, 2009).

However, with the dawn of the industrial revolution, the more contemporary meaning and scope of vocational education began to emerge. The administrative and skill-related workforce pressures of an emerging industrial society demanded deeper knowledge in certain fields, as well as broader knowledge of various other fields (Brewer, 2009). Gordon (2014), in retracing the history of CTE, mentioned five phases of technology development that impacted CTE and its evolution.

Phase One: Application of power to machine, characterized by the rapidly increasing dominance of power-driven machines, resulting in inventions such as the loom, the steam engine, and the spinning frame. The fraction system emerged in the USA as a result of these systems.

Phase Two: Introduction to mass production, characterized by the development of assembly-line techniques for mass production, resulting in more and better-quality goods. "This era of technology development in CTE elevated the artisan to the status of a technician" (p. 20).

Phase Three: Influence of automation, characterized by increasingly complicated systems of machinery that were interconnected. This trend in technology "produced more demands for vocational education and, therefore, an increase in the level of preparation needed for workers in America" (pp. 20-21).

Phase Four: Miniaturization, characterized by the miniaturization of electronics and replacement of many products with synthetic materials and plastics. Phase four began in the early 1970s.

Phase Five: Global network/technological explosion, took place during the 1980s and 1990s. With the advancement of computer technology and network systems, much of the machinery and equipment used in business and industry became more efficient due to computerization. This directly impacted CTE as "educators purchased new equipment, acquired competence in computer network systems, and developed curricula focusing on new technologies" (p. 21).

The evolution of technology had direct implications on how students are prepared for the workplace. In order to function efficiently, workers need both wider varieties of skills and higher levels of technical competence. They need to be able to function in teams, have good interpersonal skills, interface well with customers, be problem solvers, function under pressure, make decisions based on many unknowns, and be lifelong learners.

The wider range of competencies that is demanded by workplaces as technology evolves spurs the conversation about vocational education versus liberal arts education, a discourse that has continued to this day (Hyslop-Magison, 1999). The "practical arts movement," which began with a focus on agricultural education and domestic education, later started emphasizing a more general education (Brewer, 2009). The "trade school movement," on the other hand, stressed the importance of an in-depth knowledge of specific fields. Vocational education emerged from the latter movement (Brewer, 2009). However, trade schools differed from apprenticeship, since they offered a more formalized version of apprenticeship and deviated from the strictly hands-on nature of the apprenticeship (Brewer, 2009).

CTE vs. Liberal Arts Education

Starting in the 1980s, vocational education gradually began to get supplanted by CTE in the USA (Gray, 2004). At a secondary level today, in addition to schools that specifically focus on CTE, CTE programs are also provided by public schools, some private schools, career-focused academies within public schools, and programs within public schools that provide CTE in cooperation with technical schools. If students choose to pursue CTE after high school, postsecondary CTE could be completed in an additional two years or less (Dortch, 2014).

CTE is viewed as the opposite of liberal arts in several ways as the former is considered more "professional" and "career-oriented," while the latter is considered broader and offers a general education in a variety of subjects (Tierney, 2013). The liberal arts emphasize educating a student in subjects that run the gamut from history to English to language and mathematics, with an emphasis on critical thinking, problem solving, writing, and oral skills. Therefore, liberal arts curriculums do not offer, for example, pre-med or nursing programs, as these fields are considered too narrowly focused on a particular discipline. Usually, liberal arts colleges are smaller, but larger Ivy League universities, like Harvard and Yale, educate their undergraduate students in the liberal arts. The "core curriculum" in a high school that consists of literature, math, humanities, and language classes lean more towards liberal arts (Tierney, 2013).

While the term Career and Technical Education has been used for several years, Perkins IV is the first piece of legislation to officially implement this name change (Carl D. Perkins, 2006). The term is defined by Perkins IV as:

> Organized educational activities that offer a sequence of courses that provides individuals with coherent and rigorous content aligned with challenging academic standards and relevant technical knowledge and skills needed to prepare for further education and careers in current or emerging professions; provides technical skills proficiency, an industry-recognized credential, a certificate, or an associate degree; and may include prerequisite courses that meet the requirements of this subparagraph; and include competency-based applied learning that contributes to the academic knowledge, higher-order reasoning and problem-solving skills, work attitudes, general employability skills, technical skills, and occupation-specific skills, and knowledge of all aspects of an industry, including entrepreneurship, of an individual. (p. 1)

According to National Association of State Directors of Career Technical Education Consortium (2003, p. 1), CTE offers the following:

- Provides students and adults with the technical skills, knowledge, and training necessary to succeed in specific occupations and careers.
- Prepares students for the world of work by introducing them to workplace competencies that are essential no matter what career they choose.

- Takes academic content and makes it accessible to students by providing it in a hands-on context.

Unlike the liberal arts, CTE places emphasis on a particular occupation and instructs its students in the finer and more practical details of this occupation. The goal of CTE is to get students ready for entry into the professional world of their chosen fields upon graduation from either secondary school or postsecondary training. However, CTE's focus on one topic compromises exploration of a wide variety of subjects, and this is what creates the difference between liberal arts and CTE (Dortch, 2014). Common examples of such professional education career pathways include nursing, information and engineering technology, culinary arts, business, construction, welding, logistics, and health sciences. Proponents of CTE argue that once a student decides what career he wants to pursue, there is little point in burdening him with a broad category of topics at the expense of what he has decided to pursue (Dortch, 2014). In line with this logic, many CTE institutions have limited or no general education courses. Furthermore, this same work-readiness logic demands that students be trained practically; therefore, CTE schools foster programs with opportunities in internships and practical hands-on training. Students are expected to not simply understand the theoretical aspects of their respective fields, but also be well-trained in the practical and immediately employable skillsets that go along with it (Dortch, 2014; Gordon, 2014).

However, despite such strict attention to produce employment-ready students for a specific skill area, CTE-focused technical high schools today integrate career preparatory practice with traditional high school courses (Dortch, 2014). Similarly, high schools that are not solely technical high schools also offer vocational-centric CTE courses; in fact, as of 2009, 90% of high school students have at least taken one class in a CTE specific subject in addition to their regular high school curriculum (Kamin, 2018). According to Gordon (2014), the majority of technical programs are offered at public and private postsecondary institutions, including community colleges, technical institutes, technical centers, engineering schools, and four-year colleges offering technical programs at less than a baccalaureate level (p. 246).

Research conducted by Dougherty from The University of Connecticut in 2016 justifies why CTE, even at an introductory level, is so indispensable that such a high percentage of high schools offer it. Dougherty (2016) researched 100,000 Arkansas students entering high school between 2008-2010 to examine the effect of CTE's outcome on student's desirability to advance their education along with their job prospects. Dougherty (2016) discovered that the more a student is exposed to CTE courses, the more likely they are to procure a wage-earning job. Furthermore, Dougherty (2016) also learned that taking a CTE curriculum raises the likelihood a student will graduate high school by 21%, thus once again explaining the rising popularity of CTE in high schools.

After introduction to a CTE class, if a student decides to narrow his curriculum to a specific CTE topic, high schools offer a combination of CTE classes and practical training in the chosen field (Kamin, 2018). The chosen topic also determines the amount of coursework and training that is necessary at a high school level for a student to graduate. Certain CTE-heavy technical schools accommodate traditional high school classes by getting the CTE-committed students to hone their practical skills during certain weeks, while taking traditional coursework during other weeks (Kamin, 2018). Thus, even strictly CTE-centric career pathways do not neglect traditional courses.

CTE Clusters

Nationwide, all CTE pathways deal with the vast breadth of technical subjects by clustering the related ones into sixteen standard CTE clusters or career clusters. There are 16 career clusters in the US Department of Education model, and these illustrate broad groupings of related careers representative of the types of occupations in the world of work. Career clusters group occupations that are in the same field and require similar skills (National Association of State Directors of Career and Technical Education, 2013; Gordon, 2014; Dortch, 2014). The 16 clusters are:

1. Agriculture, food, and natural resources
2. Architecture and construction
3. Arts, audio/video technology, and communications
4. Business, management, and administration
5. Education and training
6. Finance
7. Government and public administration
8. Health science
9. Hospitality and tourism
10. Human science
11. Information technology
12. Law, public safety, corrections, and security
13. Manufacturing
14. Marketing
15. Science, technology, engineering, and mathematics

16. Transportation, distribution, and logistics

According to Dortch (2014), career pathways generally refer to: A series of connected education and training strategies and support services that enable individuals to secure industry relevant certification and obtain employment within an occupational area and to advance to higher levels of future education and employment in that area (p. 3).

The US Department of Education and various stakeholders like state educational agencies (SEAs), grouped together subjects that required similar skills and were in the same broader field of knowledge to help students narrow their focus to a particular set of skills (Dortch, 2014). For instance, any subject that is related to agricultural produce and its derivatives, like plants, food, animals, and even textiles, is grouped together in the career cluster of *Agriculture, food, and natural resources* (Torpey, 2015). Similarly, other career clusters, such as arts, business, and science are comprised of several related areas grouped into one career category. Students can select one of these career clusters and pick a career pathway within it that would eventually lead to obtaining certification and employment in that particular industry (Torpey, 2015).

Federal Legislations and CTE

According to Dortch (2014, p. 1), the “federal government has a long history of supporting workforce development which include Career and Technical Education.” In fact, the First Morrill Act, passed by Congress in 1862, was crucial to the development of the present land-grant colleges to teach the agricultural and mechanical arts to the “industrial classes.”

When the division between vocational education and liberal arts began to manifest itself at the high school level at the turn of the 20th century, government intervention was required to formally separate the two curriculums. In the early 1900s, the role of school was primarily to prepare students to be better citizens; therefore, the classical, liberal arts-leaning academic curriculum was emphasized without inclusion of occupational classes. Compounding the matter further was the argument that in order to keep the field of education within the ideals of democracy, one standard curriculum should be taught to every American child in school. Due to these two reasons, vocational education did not enter high school curriculum. However, ordinary citizens in the early 1900s became more capable of affording school beyond the 8th grade for their children. At this point, they found that the standard curriculum catered to benefit the liberal arts demanding elites only and was too limiting for their own working-class children. Soon these working-class children began to drop out of high schools in alarming numbers and roamed aimlessly on streets during school hours (Gray, 2004).

Witnessing the painful sight of aimless hordes of student squandering their learning years, education reformers were propelled into action to demand a new kind of curriculum for these working-class kids. Such a program was to serve high school students by providing "education through occupation" (Gray, 2004). Working class students who, previously, found little value in the liberal arts-centric curriculum in high school, welcomed the vocational education option that prepared them for work after school (Gray, 2004). This division proposed by the educational reformers began to gain national prominence. President Theodore Roosevelt himself urged Congress in 1907 to provide hands-on education to the industrial workers in the urban areas as well as agricultural education to the workers in rural areas. Reformers particularly argued that producing workers ready for the job market would add to American competitiveness on the world stage and help expand America's influence (Hyslop-Magison, 1999).

Eventually, the federal government passed the Smith-Hughes Act (also called the National Vocational Education Act) in 1917 that provided federal funding to the states to promote vocation-centric education and funds for the training and salaries of teachers in the fields of agriculture, industrial trades, and home economics (Webb, 2006). Since the early 1900s, America was primarily a combination of agrarian society and industrial economy. Earlier high school vocational curriculum limited itself to agriculture and industrial manufacturing related career paths. In line with these common occupations, the Smith-Hughes Act encouraged states to promote vocational education in agriculture, industry, and home economics (Gray, 2004).

Another significant legislation in the history of pre-CTE was the Vocational Education Act of 1963, which was developed by a panel of consultants on vocational education in response to the excessive emphasis on jobs in the service sector and was passed by parliament in 1963. The Act had several goals, which included maintaining, extending, and improving existing programs of vocational education, and to provide part-time education for those who needed to earn income in order to continue their schooling. Such provisions afforded through the Act made it possible for all persons to have access to vocational training or retraining, regardless of age (Gordon, 2014; Kliever, 1965). Funds could also be used for persons who had academic, socioeconomic, or other impediments that prevented them from succeeding in a regular vocational education program (Mason et al., 1989). Several amendments and acts followed. They included: Vocational Education Amendment of 1968, Comprehensive Employment Training Act of 1973, Vocational Amendment Act of 1976, and Job Training Act of 1984.

The modern iteration of Smith-Hughes Act—Carl D. Perkins Vocational Education and Applied Technology Act—was passed in 1984 and added an extra preparatory dimension to the Smith-Hughes Act. While emphasizing improvements in quality of vocational education, the Perkins Act advocated extending vocational education to students who were from at-risk populations and students with special needs (American Institutes of Research, 2013; Gordon, 2014). This would include students with physical disabilities, as well as students with other disadvantages like lack of proficiency in English language. Perkins Act was later reauthorized in 1998, 2006, and 2018 (Granovskiy, 2018).

Current Issues Facing Career and Technical Education

While CTE offers a broader curriculum today than vocational education, many educators and average citizens are not convinced of its effectiveness in producing well-rounded citizens (Tierney, 2013). There is the stigma associated with the image of CTE along with other challenges, such as the shortage of qualified teachers of CTE, securing partnerships with employers, and ensuring students have equitable access to CTE curriculums (American Institutes of Research, 2013; Lewis, 2001; Gray & Daugherty, 2004; Conneely & Uy, 2009; Blank, 1999; Gordon, 2014).

The Image Problem of CTE

John Tierney (2013), a former professor of Government at Boston College, laments that by far the biggest challenge for CTE is the outdated stigma that its curriculum is a pathway primarily taken by unambitious and failing students. This long-held perception is a remnant of what Americans used to think of vocational education, and despite CTE curriculum offering classes in broader categories and holding students to a more rigorous standard, this stigma still remains attached to CTE programs (Tierney, 2013). Haunshek et. al (2019) point out that parents and school counselors hear terms related to CTE career pathways, such as *automotive manufacturing* and *cosmetology*, and immediately associate them with unsophisticated careers that serve as a dumping ground for less promising students. This stigma also affects students' perceptions of themselves, with some, according to Bae et al. (2007), experiencing lower self-esteem and disengagement than non-CTE students. However, a study by National Research Center for Career and Technical Education discovered that, on average, CTE students outperform non-CTE students. This study shows, combining professional development with a pedagogic framework to identify and teach the mathematics that is inherent in CTE curriculum, students who received the enhanced instruction scored significantly higher on standardized math tests than students who received their regular curriculum. At the same time, scores on technical assessments did not decrease, showing that a high-quality contextual approach to improving academics could produce very valuable payoffs for students and their future employers (Stone III et al., 2006). In Arizona, where CTE courses are required to align with academic standards, CTE students outperformed the general high school population (Arizona Department of Education, Career and Technical Division, 2005).

Nonetheless, Hanushek et. al. (2019) also point out there is truth to the poor image of CTE curriculums as these curriculums indeed have a downside. According to them, even though students who focused on one occupational field benefitted in the short term due to better pay and immediate employment, such benefits did not last long. These same students suffered in the long term when the economy changed, and they lacked the general skills (offered by liberal arts) needed to survive these changes. Hanushek et. al. (2019) agree that students who do not opt for vocational training initially, do struggle with securing employment and higher wages, but later in life these students catch up and eventually surpass students who limited their school training to a specific topic.

Shortage of Qualified CTE Teachers

Access to well-qualified educators capable of providing high-quality CTE education and training is yet another challenge. This is attributed to an increase in student enrollment at the junior high and high school levels, recent expansion of secondary CTE education programs, CTE teachers retiring or changing professions, and a decrease in the number of universities offering CTE degrees (Gray & Daugherty, 2004; Conneely & Uy, 2009). The fact that CTE teachers must meet more stringent certification requirements than core academic teachers—that is they have to prove that they can handle both the academic and occupational classes (American Institutes of Research, 2013)—does not help the situation. Furthermore, CTE instructors also have to meet the strict standards of the 2002 reauthorization of the Elementary and Secondary Education Act (ESEA) to prove they are qualified to integrate Mathematics, Science, English, and other classes of the core curriculum. Often, aspiring CTE teachers who are committed to achieving the various CTE teaching certifications run into problems finding sufficient training as there are only a few colleges that have a track to train CTE teachers (American Institutes of Research, 2013).

The shortage of CTE teachers is particularly chronic in rural regions, because schools tend to be poorer and lack the resources to employ CTE teachers. These schools are also more inclined to close their CTE programs during economic downturns, as was the case in North Central Idaho. According to Gordon (2014, p. 379), results from impact evaluation studies by the Institute of Education Sciences indicated that "teachers who enter teaching through alternative routes to certification can help fill teacher shortages in hard-to-staff schools and subjects without reducing students' achievements."

Challenges in Securing Partnership with Employers

Finally, in addition to acquiring qualified instructors, high school CTE programs also face the challenge of finding employers who are willing to help high school students obtain practical training (American Institutes of Research, 2013). Gray et al. (2018) reported:

> Larger percentage of city districts than rural districts offered CTE programs with work-based learning activities, including student-run enterprises or services (72 percent compared to 43 percent); mentoring by local employers (87 percent compared to 55 percent); on-the-job training, internships, practicums, clinical experiences, or cooperative education (95 percent compared to 68 percent); and apprenticeships or pre-apprenticeship programs (35 percent compared to 26 percent). (p. 2)

Additionally, a larger percentage of districts in the northeast, compared to districts in the west, offered CTE programs with work-based learning activities.

Local businesses, government agencies, as well as the manufacturing branches of larger corporations are all candidates to provide the necessary hands-on training for students following a CTE career path. These employers are not expected to simply allocate a few hours to impart first-hand practical knowledge and training to the students every week. In fact, their multidimensional task also includes playing the role of teachers, advisors, and caregivers to the CTE students, as well as CTE instructors. They are expected to guide the CTE instructors in developing curriculums that are up to date in their particular area. Furthermore, these employers are expected to contribute equipment permanently or temporarily to the CTE programs, help CTE teachers learn how to teach students in effective and engaging ways, or sometimes even volunteer as a teacher themselves. Therefore, it is not hard to see why CTE programs find it challenging to develop partnerships with businesses that can fulfill these multiple responsibilities (American Institutes of Research, 2013).

However, this challenge can be easier to overcome once it is realized that the crucial role played by employers in nurturing CTE programs is a win-win situation for all parties involved, (i.e., the students, CTE educators, and employers). Taheri (2018) pointed out that if students learned skills in schools unsupervised by industry, there is a high likelihood due to the technologically accelerating marketplace, those skills learned could become obsolete by the time they graduate. Such a scenario would leave the students with obsolete skills and no job prospects. Furthermore, by choosing to not provide supervision and job-training aid to students, industries will also be negatively affected as they will be left with few or no trained workers with up-to-date skills to meet the market challenges (Taheri, 2018).

Todd (2018) reports a case where active industry supervision of high school CTE students and committed industry collaboration with CTE educators created a win-win scenario for all parties. In 2017, aviation corporation Boeing estimated the need for two million workers in the next 20 years to fly the planes, as well as to assist in other flying-related operations. An Arizona aviation educator, Sally Downey of East Valley Institute of Technology (EVIT), decided that a CTE aviation program would be the best option to provide relevant hands-on training to the next generation of pilots. Simultaneously, Arizona's aviation industry also realized that such in-demand and well-trained workers are crucial in contributing to the state's $58 billion-a-year aviation industry. Together, aviation educators and aviation industry of Arizona decided to open an EVIT central campus and EVIT eastern campus to train high school students in a career in aviation under direct supervision from the industry. One of the active instructors, Lou Amadee, commented that “all the partnerships we have developed over the years have really helped. The aerospace industry is growing, and they’re doing everything to get more youth involved” (Todd, 2018, p. 35). Such success stories provide immense credibility to CTE, and this success should boost the ambitions of CTE proponents to steer the discipline in fresh directions.

Inclusivity and Equitable Access to CTE

A challenge that faces modern CTE is having a curriculum that is inclusive. The demographic composition of the USA has been changing from one that is predominantly white and rooted in western culture to a global society composed of diverse racial and ethnic minorities (Thomas, 1996; Triandis et al., 1994). In addition, emphasis is being placed on recruiting more female students in nontraditional career areas, such as engineering, technology, computer science, welding, etc. (Milgram, 2011). Community and technical colleges are known to recruit a “considerable number of nontraditional, low-income, first-generation students, as well as students of color” (Gay, 2000, p. 106), which has implications for CTE curriculum, how it addresses students’ cultural experiences and perspectives, and how the knowledge and skills learned are situated within the lived experiences and frames of reference of students. This will spike students’ interests, increase the personal meaningfulness of the learning process, and thus student success (Gay, 2002; Ragoonaden & Mueller, 2017).

Another problem facing CTE, particularly in rural regions, is the loss of CTE programs in many school districts. This problem became pronounced during the last recession, when many schools closed their CTE program, because it became too expensive for these rural school districts, which are often poor, to support CTE programs that require courses that prepare students for manufacturing careers, which require hands-on technical education based on current industrial practices and the tools of those industries (Tack, 2015; CITEA, 2007). In addition to the forgoing, according to ACTE (2015), serving small populations that are geographically dispersed makes it difficult for school districts to offer robust CTE programs. It is often challenging to employ teachers qualified to teach a particular course or course sequence or to offer enough courses to meet the varied career interests of students. However, CTE must play a crucial role in providing pipelines of workers, because failure to do so can often have serious economic implication for rural regions. In these rural regions, there are often well-paying jobs that do not require a four-year degree, but there are not always enough skilled workers to fill these existing positions. Job applicants often lack necessary skills in basic math, hands-on trades, information technology, and manufacturing. According to Bozarth and Strifler (2019):

> Not only are rural areas less densely populated, but their populations are also getting older, on average, due to both outmigration of younger people, and, in some cases, older adults retiring to rural areas. As of mid-2018, those 65 and older make up almost a quarter of the population in non-metro areas, and prime working-age adults (defined as those who are 25 to 54 years old) comprise less than half (43 percent) of the population. That compares to a 50 percent share of prime working age adults and 19 percent of adults 65 and older in metro areas. (p. 3)

While CTE has a long history of serving farmers in the rural areas of the country, ironically the program still faces severe limitations in how to reach these farmers and other residents in the rural areas (Estes, 2018). Serving dispersed populations in rural areas requires educators to overcome problems like bringing together enough students in one place to justify hiring a teacher to commit to teaching and training these students (Career and Technical Education’s role in rural education, 2015). Furthermore, even if enough students decided to converge in one area to justify creating a single CTE class, there is a good chance that not all students would want to study the only discipline taught by this one teacher (Career and Technical Education’s role in rural education, 2015). To overcome such problems, Estes (2018) developed a list of five initiatives to guide policymakers to “strengthen CTE pathways in rural areas.” One of these five cornerstone strategies is to develop and implement a technological plan to expand access to CTE programs and reach as many rural citizens as possible.

Online Learning and K-12

The field of K-12 online distance education is continuing to expand and grow, specifically, through the increase of virtual schools throughout the United States. Online education at the K-12 level has grown from an innovation to a movement over the past decade. Cavanaugh & Clark (2007) pointed out, online education in K-12 is appreciated as a solution to many educational problems, including crowded schools, a shortage of secondary courses for remedial or accelerated students, a lack of access to qualified teachers in a local school, and the challenge to accommodate students who need to learn at a pace or in a place different from a classroom in most North American and industrialized countries (as cited in Cavanaugh et al., 2009). The U.S. Department of Education published an evaluation report on Washington State Digital Learning Commons (DLC) online courses in 2008. The report shows DLC online courses helped increase on-time graduation rates and college/workforce readiness at the schools studied in Washington State. According to the report, 33% among the 115 graduates would not have graduated without a course made available through the Digital Learning Commons and 61% of the participating students in the study took advanced classes to better prepare themselves for college (U.S Department of Education, 2008).

Apart from having some online sections or options, k-12 schools in the US and other parts of the world also have adopted the concept of ‘virtual schools.’ Virtual schools can be fully virtual or blended. National Education Policy Center published a detailed report on virtual schools in the US in 2019. According to the report there were 501 full time virtual schools and 300 blended schools in different school districts of USA (Archambault & Larson, 2015). Many schools in USA have either augment primarily face-to-face instruction with online content or lessons or provide blended learning courses, and/or enroll students in credit-bearing fully online courses (Schwartz, Heather & Ahmed et al., 2020). In 2020, 43 percent of math teachers, 38 percent of ELA teachers, and 25 percent of science teachers in the USA reported their school’s required or recommended curriculum included online software for students. The most recent estimate from federal government in 2015–2016 says, 58 percent of high schools offered one or more courses entirely online, compared to 13 percent of middle schools and 3 percent of primary schools (Schwartz, Heather & Ahmed et al., 2020). One of the main reasons that K-12 school districts offer online and blended learning is to meet the special needs of a variety of students and to allow them to take courses that otherwise would not have been available (Picciano, 2016).

In 2009, a meta-analysis of reviewed literature of 51 online learning studies release by U.S. Department of Education shows that on average, students in online learning conditions performed better than those receiving face-to-face instruction (U.S. Department of Education, 2009, p. ix). Study shows that, unlike a traditional learning environment, online allows for a more democratic communication environment and physical attributes such as gender, ethnicity, or physical disability that often shape our views of others are not immediately apparent in most forms of online communication. There is lower chance of discussions being dominated by a few students while all students are able to participate in a threaded-discussion board in online learning environments. (Wicks, 2010).

Wicks (2010) pointed out that an online learning environment is more suitable to bring together students from different backgrounds, and within that environment they are exposed to a variety of perspectives and can develop communication skills that are important for our global economy. A meta-analysis on K-12 online learning conducted by 6 International Association found that virtual instruction produced results that were as good or better than traditional face-to-face instruction (Picciano & Seaman, 2008).

It is important to understand the background of online teachers, how they have come to the profession, and the skills they feel are needed to succeed in very different educational environments (Davis, Roblyer, Charania, Ferdig, Harms, Compton & Cho, 2007; Miller & Ribble, 2010; Archambault, 2011). Though the amount of research focusing on the specific differences between teaching online and face-to-face is not very significant, however, there is a clear understanding that there are differences (Barbour, 2012). Teachers need to use new forms of communication, engagement, and assessment in an online setting of teaching (Searson, Jones, & Wold, 2011). Along with the basic teaching skills, an online teacher must also manage and engage students virtually and be more of an instructional designer and interaction facilitator (Kennedy & Archambault, 2012, Easton, 2003).

CTE and Online Education

Given the widespread nature of online classes, it is important to explore the deployability of the online education model to address the demands of CTE education. In order to do so, one must not only view the hardware and software elements of technological advancements, but also place more emphasis on examining the strengths and weaknesses of their applications. This examination of the applications should certainly cover how the content is delivered to the students, but it must also extend to exploring how administrative, operational, and managerial elements could be incorporated to offer more practical training online.

CTE programs have adopted the use of an in-class and online class “blended-learning” hybrid strategy to provide education to students who choose CTE career pathways. Fortunately, the strengths of one method of knowledge delivery complemented the weaknesses of the other method—in-class delivery offered personal contact while online education offered flexibility (Layton, 2017). The face-to-face element of in-class teaching is crucial in offering help at an emotional level (Wonacott, 2002). When students engage with each other face-to-face, they are more likely to learn actively, and it is more motivationally engaging than if they are left to study without their colleagues. Furthermore, in-class learning has an added benefit, particularly for CTE curriculums, due to the hands-on nature of in-class activities (Wonacott, 2002). Nonetheless, distance learning via information and communication technologies has the benefit of flexibility and interactivity. Updates in a particular field do not have to be accessed only when it is printed in the next edition of the textbook; rather this new knowledge can be dispensed immediately anywhere at little to no cost. Moreover, interactive media can add dynamism in the learning of difficult concepts by engaging numerous sensory and brain channels (Layton, 2017).

Despite the complementary nature of in-class and online teaching methods, Wonacott (2002) suggested that it is possible to compose better hybrid strategies. For instance, he suggested that it was possible for information and media technology to fully curtail the problems arising from no interaction and engagement due to long distance learning, and he encouraged future researchers to discover such methods (Wonacott, 2002). If the benefits of both in-class and long-distance education can be further blended, then not only will students benefit from more effective and engaging educational strategies, but educators will benefit from the economies of scale and offer CTE to more students.

Though the adoption of learning technologies for CTE has widely permeated, some quality issues of utilizing learning technologies for CTE are there as well. One example of this is the lack of learners' technical skills (Kang, Lim, & Kim, 2004), and the lack of social interaction during the learning process (Rovai, 2002). According to Lewis (2001) instructors' preparation was a main factor affecting the quality of instruction in both onsite and online CTE courses. In general, utilizing learning technologies for CTE typically required more effort in managing changes, keeping track of students' learning progress, and replying to students' questions and requests for learning support (Collis &Nijhuis, 2000). In a study, Zirkle (2003) found that access barriers, poor technology skills, negative attitude toward technology, and low involvement of instructors negatively influenced the quality of distance CTE courses. Likewise, Wonacott (2001) highlighted that access, cost, learning effectiveness, and the program fit were critical factors affecting the quality of online CTE programs. To design and deliver a technology-rich or enabled CTE course, various decision-making processes such as identifying learning needs, deciding learning levels, developing learning frameworks, and embedding effective learning activities or measurements utilizing technologies are required (Lim & Yoon et al., 2009).

An Integrated Theoretical Framework for Online Education

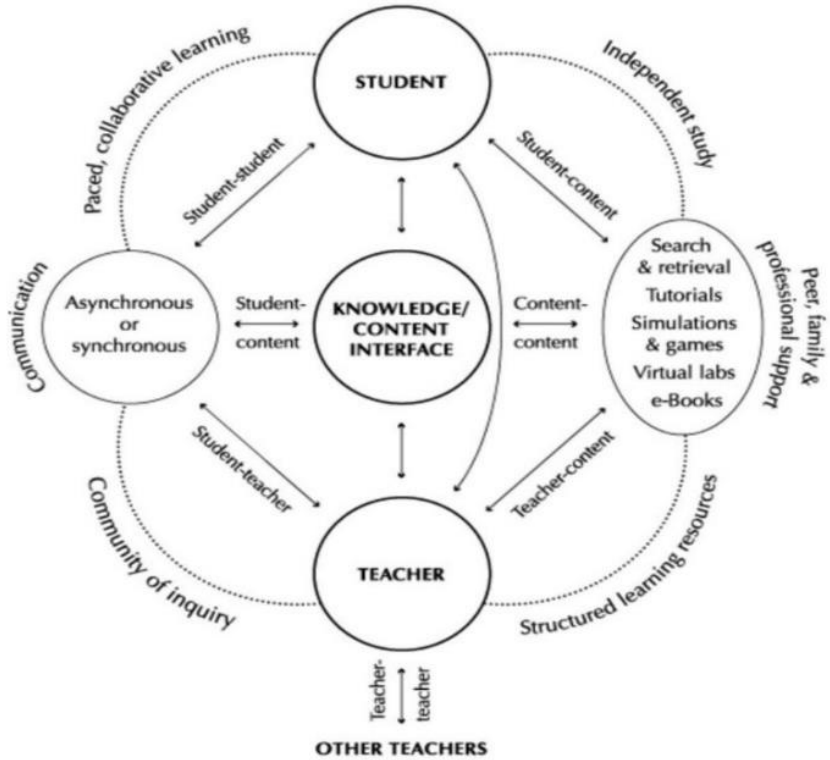
Starting with the assumption that it would be a difficult, and perhaps impossible task, Terry Anderson (2011) examined the prospect of building a theory of online education. Having spent much of his career at Athabasca University, a major higher education distance education provider in Canada, Anderson approached this activity from a distance education perspective. Anderson (2011) acknowledged that many theorists and practitioners consider online learning as “a subset of learning in general” (pp. 46-47). He also identified online learning as a subset of distance education, and he was concerned with provision of access to an educational experience that was at least more flexible in time and in space as campus-based education. Building a common theory for online education seemed very complicated while having these two perspectives. For instance, even though the idea of blended learning models is growing as a predominant component of traditional face-to-face and online education environments, it is not an easy fit into distance education schema (Picciano, 2017).

Bransford et al. (1999) suggested that effective learning environments are framed within the convergence of four overlapping lenses: community-centeredness, knowledge-centeredness, learner-centeredness, and assessment centeredness. Anderson (2011) used these lenses as the foundational framework for his approach to building an online education theory. He examined the characteristics and facilities in detail that the internet provides with regards to each of the four lenses. He noticed that gradually the internet has grown to an all media supported readily available form—from a text-based environment and the hyperlink capacity compatible with the way human knowledge is stored and accessed. He referred to the work of Jonassen (1992) and Shank (1993), who associated hyperlinking with constructivism (as cited in Picciano, 2017). Anderson (2011) referred to a number of distance education theorists, such as Holmberg (1989), Moore (1989), Moore and Kearsley (1996), and Garrison and Shale (1990), while extensively examining the importance of interaction in all forms of learning. In many theories of education, especially constructivism, the essence of interaction among students, teachers, and content is well referenced. According to Anderson's (2011) assessment, interactions are critical components of a theory. Anderson (2011) constructs a model (see Figure 2) with these three elements and adds one important element by distinguishing community/collaborative models from self-paced instructional models. He argued community/collaborative models and self-paced instructional models are inherently incompatible. He explained because of extensive student-teacher interaction, community/collaborative models do not scale up easily. In contrast, self-paced instructional models require less interaction among students and teachers as they are designed for independent learning (Picciano, 2017).

In ***Figure 2***, we can see the instructional flow within the two sides that represents the beginnings of a theory or model from the distance education perspective. Anderson (2011) argues, his model "will help us to deepen our understanding of this complex educational context" (p. 68).

Figure 2.

*Anderson's Online Learning Model (Anderson, 2011)***.**

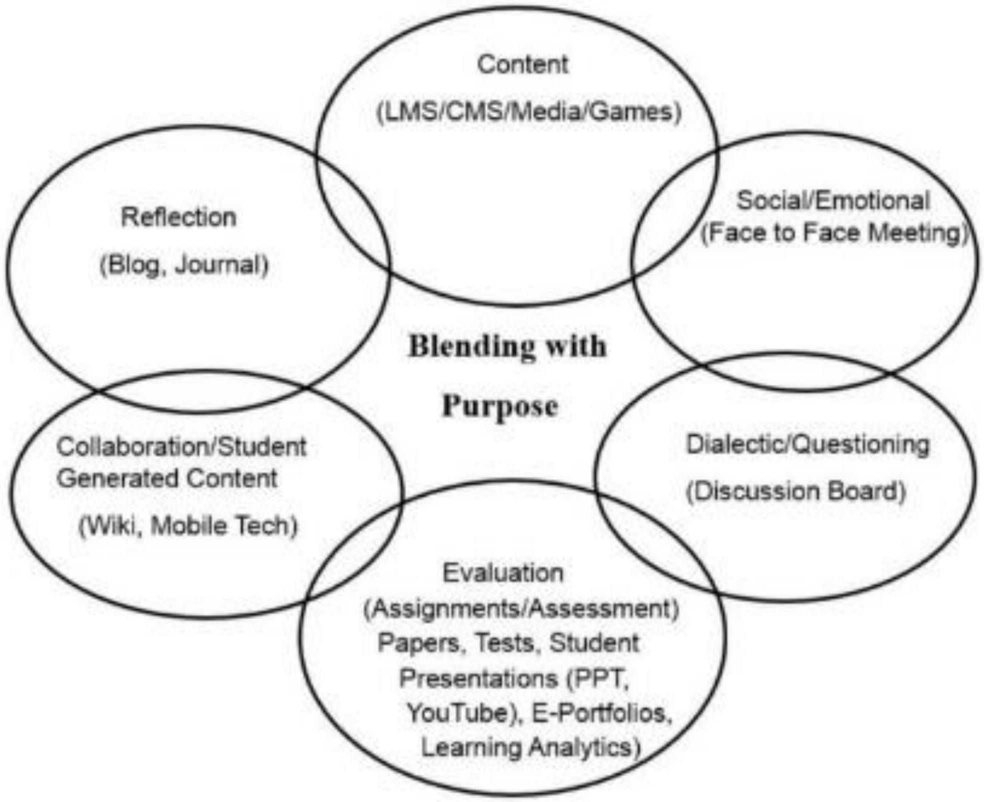


An Integrated Model

In his model, Anderson (2011) assumed that none of the instruction is delivered in traditional, face-to face mode, and so excluded blended learning models that have some face-to-face component (as cited in Picciano, 2017). The question that arises is whether it is possible to create an integrated model incorporating several of the components from other theories and models. In a review of instructional technology, Bosch (2016) identified and compared four blended learning models using twenty-one different design components and developed the Pedagogical Purpose Model (see ***Figure 3***).

Figure 3

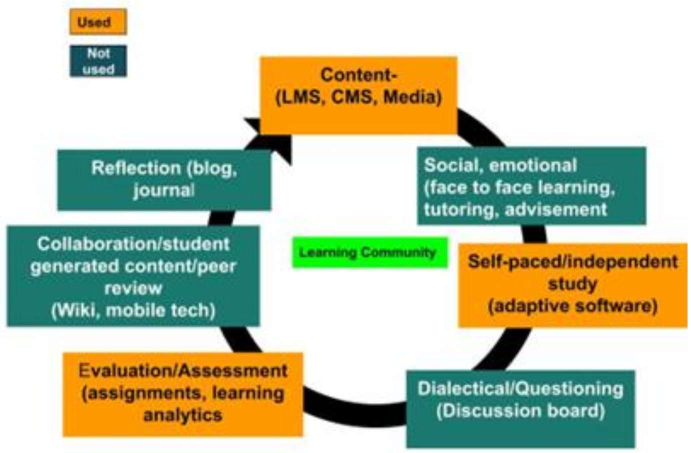
Blending with Pedagogical Purpose Model



This model argues for achieving six basic pedagogical goals for learning modules which are content, dialectics or questioning, collaborative learning, reflection, evaluation, and social/emotional support. It is a flexible model that assumes other modules can be added when and where needed. According to this model, pedagogy drives the approaches that will work best to support student learning (Bosch, 2016). Though modules are also shown as intersecting, this is optional. As an example, depending upon how the collaborative activity is designed, some reflection can be incorporated into collaboration or not. Similarly, other modules might experience the same situation. At the end, what is important is all modules used blend together into an understandable total. These six components of the model form an integrated community of learning perspective that involves rich interaction in both online and face-to-face classes and can be blended across all modules. It is not necessary for each course to incorporate all of the activities and approaches of the model; rather the pedagogical objectives of a course should drive the activities and approaches. For instance, every course does not require collaborative learning or dialectic questioning. Faculty and instructional designers might consider examining an entire academic program to determine which components of the model best fit individual courses by looking at overall programmatic goals and objectives (Bosch, 2016).

Figure 1(See page 10) presents a Multimodal Model for Online Education that expands on the Blending with Purpose approach and adds several new components from Anderson and others (Picciano, 2009). This Multimodal Model of Online Education attempts to address the issues that others, particularly Terry Anderson (2011), have raised regarding elements that might be needed for an integrated or unified theory or model for online education. The concept of a learning community was promoted by Garrison et al. (2000) and Wenger and Lave (1991), which is emphasized in this model. A course that is considered as a learning community can be extended to a larger academic program. Interaction is a basic characteristic of the community that helps the model to the needed extent. Self-study/independent learning module is the most important revision of this model that Anderson (2011) emphasized as incompatible with any of the community-based models. Howard Gardner's (1983) "Multiple intelligences" theory also influenced this model. According to Gardner (1983), intelligence is made up of multiple units and used by individuals in different proportions to understand and to learn about the world. Therefore, multiple modalities should be used for instruction, which will help learners to engage in their preferred ways.

Figure 4
Self-paced fully online course



Recent cognitive science research also shows students' learning ways depend on various factors including age, learning stimuli, the pace of instruction, etc. (William, 2008). Cognitive science also supports multiple intelligences and mental abilities exist within scales that help blend the mind to respond and learn from environmental and instructional stimuli. Theoretically, this recommends a framework for a multimodal instructional design built with a variety of pedagogical techniques, deliveries, and media (William, 2008). Anderson (2011) states self-study/independent learning can be integrated with other modules as needed or as the primary mode of instructional delivery. Popular forms of self-study like adaptive learning software can stand alone or be integrated into other components of the model. Issues that Terry Anderson has raised regarding elements for an integrated or unified theory or model for online education are addressed in this Multimodal Model of Online Education (Picciano, 2009).

Not all online courses need to or must include all of the components of this integrated model. ***Figure 4*** is an example of the model as a representation of a self-paced, fully online course. Here, three major components labeled in green for this course are: Content as provided on an LMS, a self-paced study module, and an assessment/evaluation. Components like a blog or discussion board to allow interaction among students are not necessarily needed but could be included. This model is most effective for online programs that have rolling admissions where students are not limited by a semester schedule. This model allows students to proceed at their own pace to complete the course, which is very common in online programs. It is a scalable example that can be used for large numbers of students.

Figure 5

Example of a Teacher-Led Fully Online Course

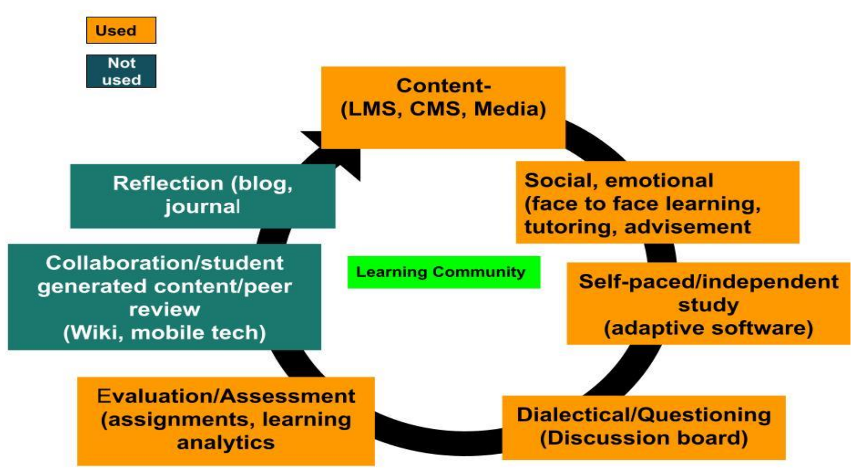


Figure 5 is an example of a fully online course that is teacher-led. Here, along with other media, teachers may use presentation of the course content as needed. Interaction

among teachers and students, students and students, and students and content is provided through discussion boards, blogs, and wikis. This model allows teachers to direct students to watch a fifteen-minute lecture available in the LMS database and ask them to respond to a series of questions on the discussion board. Guided by the teacher, these responses can then be used as the basis for an interactive discussion board activity among students. Reflection and collaborative activities are also provided in this model.

North Central Idaho & Southeast Washington Regional Workforce Needs

There is an urgent need for technicians to fill entry-level positions in manufacturing in North Central Idaho and Southeast Washington. This region has seen a re-emergence and sustained growth in small and medium size manufacturing enterprise since 2010. These companies have consistently experienced a shortage of skilled workers in engineering technician jobs that involve computer aided drafting, machining, fabrication, and electronics, which often hampers productivity and growth (Clearwater Economic Development Association, 2013). The present need for entry-level engineering technicians is consistent with national needs. Data indicate roughly 35 percent of the STEM workforce will be comprised of those with sub-baccalaureate training—including associate degrees, certificates, and industry-based certifications (Carnavale et al., 2011). The failure of schools in this mainly rural region to provide a pipeline of skilled entry-level workers for manufacturing is a major source of concern for manufacturers.

Comprised of low-elevation river valleys, high-elevation agrarian plateaus, and mountain ranges, the Northwest Intermountain Metal Manufacturing (NIMM) region encompasses the rural, North Central Idaho counties of Latah, Nez Perce, Clearwater, Lewis, and Idaho and the Southeast Washington counties of Asotin, Garfield, Whitman, and

Columbia. Home to 180,000 people in 17,800 square miles, the region's residents live in 46 small communities of 78 to 31,000 population. The average population density is 10 people per square mile. The average percentage of population in these counties with no more than a high school diploma is 44% (Community Needs Assessment, 2016, Twin County United Way).

In the last three decades, this rural region, dependent on timber and agriculture, endured wrenching economic structural changes. Employment opportunities decreased as industries automated and as timber contracts on public lands significantly decreased. Fortunately, the manufacturing sector is an economic bright spot and is the hope for industry diversification and improved regional, economic health. Manufacturing has replaced many lost jobs. If the region can provide the necessary workforce, the manufacturing sector is poised for continued growth.

Over 220 manufacturing businesses with 1 to 60 employees are located in the region. Of these, 56 make up a major industry sector that the region defines as the NIMM Supercluster (Tacke, 2015). Clusters are generally formed based on an area's comparative advantages (Manning, 2012; Giuliani, 2005; Porter, 2003; Iammarino & McCann, 2006). This business cluster has a high concentration of metal fabricating firms and machine shops that are interconnected and specialized. They have similar workforce needs with workers who receive training in one firm and are able to easily find work in another firm within the same cluster.

The NIMM Supercluster companies are tied together by common products, services, supply chains, and workforce needs. The supercluster encompasses approximately 20% of the Northwest Intermountain Region's manufacturers and includes recreational-technology manufacturing, metal parts fabricators, machine shops, and makers of farm and mining equipment (Tacke, 2015). The NIMM Supercluster has a National Location Quotient (LQ) of 1.63. This means that there are proportionately more jobs (63%) in that region than the nation (Tacke, 2015).

In 2007, through in-depth interviews of 100 manufacturers, the lack of an available and trained workforce was identified as the most significant issue hampering growth. Again, in a 2015 survey, the Metal Supercluster identified workforce as the largest impediment to growth. Presently, with the Metal Supercluster at accelerated growth, companies are competing for talent and leaving many positions unfilled. Increased competition for workers has resulted in rising turnovers and higher entry-level wages (Tacke, 2015). Higher retirement rates and a growing manufacturing sector combined with an out-migration of young people have resulted in a serious shortage of talent for entry level technician positions. The present situation has made the need to address the development of manufacturing competency as a part of the CTE curriculum in high schools in the region more urgent.

Chapter 3: Methodology

The purpose of this study is to examine the extent to which the two implemented manufacturing pathways of the NIMM project were successful. This study also explored the weaknesses and strengths of the NIMM program to understand the factors or characteristics of delivering CTE in an online format in a rural region.

The research questions that guided this study were:

1. How did differences in the modality of delivery (asynchronous vs. hybridized) implicate the quality of online delivery in CTE online manufacturing curriculum?
2. What are stakeholders' perceptions about the outcomes of the NIMM program?

Research Design

A Descriptive Case Study design was used. Case study research allows the exploration and understanding of complex issues, and it can be considered a robust research method particularly when a holistic, in-depth investigation is required (Zaidah, 2007). The role of case study method in research becomes more prominent when issues with regard to education (Gulsecen & Kubat, 2006), sociology (Grassel & Schirmer, 2006), and community-based problems (Johnson, 2006) need to be understood. Case study methods allow a researcher to go beyond quantitative statistical results and understand the behavioral conditions through the participant's perspective (Zaidah, 2007). In most cases, by selecting a limited number of individuals and a very small geographical area as the subject, case study allows a researcher to examine the data within a specific context (Zaidah, 2007).

Yin (1984, p. 23) defines the case study research method "as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used." Case study research is not only a methodology to conduct research, but also a set of choices that tell a researcher what to study (Stake, 2005). In their true essence, case studies explore and investigate contemporary real-life phenomenon through detailed contextual analysis of a limited number of events or conditions, and their relationships (Zainal, 2007). Explaining the purpose for conducting case study, Stake (1998) indicates it is to learn as much as possible from that case and not to generalize beyond it.

Yin (1984) describes three categories of case studies as exploratory, descriptive, and explanatory. Exploratory case studies explore a phenomenon. It is relevant for situations where the research question is in the form of what. A goal of the researcher is to develop pertinent hypothesis and propositions for further inquiry. Descriptive case studies "attempt to present a complete description of a phenomenon within its context" (Hancock & Algozzine, 2011, p. 37), with no attempt or presupposition to generalize to other situations. Explanatory case studies examine the data closely both at a surface and deep level in order to explain the phenomena. Explanatory case studies seek to answer how and why, and they strive to establish cause-and-effect relationships, determining how events occur and which ones may influence particular outcomes.

If a program is highly innovative, such as the NIMM program, then it may be extremely difficult to predict the program's positive and negative impacts. However, it is still necessary to document those impacts systematically, and to consider whether those impacts resulted from the program. In addition, the rich detail of a case study provides good information about the design of a program and the context in which it is delivered, thus allowing others to determine its appropriateness for their areas. For this research, case study methodology was selected for precisely this reason.

It was intended to be:

a. an intensive analysis and description of a single unit (examining NIMM), and
b. bounded by context and by time. As Hancock and Algozzine (2011) indicated, Descriptive Case Studies “attempt to present a complete description of a phenomenon within its context” (p. 23). They focus on one event in isolation with no attempt or presupposition to generalize to other situations.

Research approach

A qualitative approach was used. There are reasons behind selecting the qualitative approach. Firstly, the flexible nature of this approach was appropriate for this study. Patton (1990) stated that the purpose of inquiry and most useful and credible information are the prerequisites of qualitative study. He also said the sample size of the qualitative research does not have to follow a strict structure. Secondly, there is a scope of using a variety of sources for data. Judgments about usefulness and credibility are left to the researcher and the reader. Thirdly, the descriptive case study design required I consider and understand situations in an open-ended manner.

Case: The NIMM Program

The unit of analysis in this case study is the NIMM program developed for high schools in North Central Idaho and Southeast Washington. Twenty-two (22) schools participated in the NSF Advanced Technology Education Program designed to prepare high school students with entry-level manufacturing skills that are critical for manufacturing companies operating in the NIMM metal cluster. The program would also ensure there is equitable access of schools to CTE subjects in North Central Idaho and Southeastern Washington.

The program consisted of two tracks or career pathways for manufacturing technicians:

1. Mechanical CADD technician
2. Electro-Mechanical technician.

Figure 6

Online Curriculum (Mechanical CADD and Electro-Mechanical)

Online Courses (IDLA)		
People and Personal Skills **Hours: 30** **Level: Grade 11 (Fall)**	*Workplace Skills* **Hours: 30** **Level: Grade 12 (Spring)**	*3D Modelling* **Hours: 180** **Level: Grade 10/11 (Summer)**
Students will be able to: -Demonstrate the following personal traits • initiative, • dependability • reliability, • adaptability • professionalism -Demonstrate the ability to work in teams -Demonstrate the ability to work effectively with those who have diverse backgrounds -Perform effective communication	*Students will be able to:* -Plan and organize work to manage time effectively and accomplish task -Apply critical skills to solve problems, generate, evaluate and implement solutions -Demonstrate good decision making -Develop fundamental knowledge of organization and industry -Identify market demands and meet customer needs -Select appropriate tools and technology to facilitate work activity	*Students will be able to:* - Create advance loft, sweep, rib and shell features, and linear and circular patterns - Create complex assembles - Use advance mates, limit mates, and cam mates - Create sheet metal models and forming tools - Create weldments - Perform Top Down assembly - Perform engineering analysis - Create designs using Blocks - Understand and repair errors - Create photo views and simulations - Produce detailed 2D drawings
Applied STEM **Hours: 30** **Level: Grade 11 (Spring)**	*CADD & Blueprint Reading* **Hours: 90** **Level: Grade 10 (Spring)**	*Introduction to Engineering Design* **Hours: 90** **Level: Grade 12 (Fall)**
Students will be able to: -Understand written work related documents -Use standard English to communicate information in written form -Use math to solve problems -Solve simple mechanical, electrical/electronic systems -Solve simple hydraulic and pneumatic systems -Apply science principles to solve work related problems -Use Information Technology and related applications -Use logical thought processes to analyze and draw conclusions	*Students will be able to:* - Use parametric software to create boss and cut features, sketch relations, linear, circular, fill patterns, fillets and chamfers - Apply and edit smart dimensions - Apply material and obtain mass properties - Interpret blueprint symbols and drawings - Insert components into assembly and apply mates and constrain -Produce and communicate final drawings	*Students will be able to:* - Define the problem - Conduct background research - Specify requirements - Identify constraints - Brainstorm solutions - Perform analysis - Optimize design solution - Build a virtual prototype - Communicate design solutions

Sixty tenth-grade students enrolled in the Mechanical CADD Technician cohort and 30 tenth-grade students in the Electro-Mechanical technician cohort, a total of 90 students from schools in North Central Idaho and Southeast Washington initially enrolled in both courses. Two modalities of delivery were used: Online (asynchronous) through the Idaho Digital Learning Alliance (IDLA), and in-person summer skills academies at the campus of Lewis Clark State College. During the fall and spring semester, both programs offered common courses so students from both Tracks were enrolled in the same courses**Figure 6**). During the summer, however, the Mechanical CADD course was online and the Electro-Mechanical courses were delivered face-to-face through laboratory activities at the Lewis Clark State College (**Figure 7**). So, the mode of delivery for the Mechanical CADD Track was online, and the mode of delivery for the Electro-Mechanical was hybrid.

Figure 7

Summer Skills Academy (Electromechanical)

Machining **Hours: 108** **Level: Grade 10/11 (summer)**	**Electronics** **Hours: 108** **Level: Grade 10/11 (summer)**
Students will be able to: - Perform blueprint reading - Describe the property of metals, alloys and plastics - Perform bench work activities - Operate manual equipment (Lathe, Mill, Precision Grinder) - Write basic CNC machine M & G code - Operate CNC lathe and mill - Perform basic rigging operation - Perform safety shop procedures - Understand quality control concepts and techniques - Describe various types of manufacturing processes.	***Students will be able to***: - Follow proper safety procedures - Wire different types of devices - Test and Debug operation - Read, write and edit ladder logic program - Trouble shoot program - Develop & Review schematics - Implement design

The online program entailed synchronous and asynchronous sessions, interactive activities, simulations, learning communities, and group activities to enrich the learning process. Each course had an instructor and a graduate teaching assistant to ensure that students always had access to instructional assistance. In addition, to satisfy the hands-on experience that is crucial for workforce readiness, mentors from industry worked with students, students visited manufacturing facilities and got hand-on experience, and internships were arranged for students. These activities were organized by the regional economic association, CEDA, another collaborator in the project.

During the school year, academic coaches affiliated with the research university, one of the collaborators in the project, met with students monthly via video conferencing to review their progress, discuss career opportunities, and provide updates and information on metal manufacturing and career opportunities. Additionally, the coach was available ad hoc throughout the school year to provide other needed support. During the summer skills academies, the coach met weekly with students and was involved in evening programs to foster strong relationships.

Procedure

Data Sources

Sources of evidence were collected from three areas: Interviews of key stakeholders, examination of course content and other program documentations, and parent surveys and student evaluations (see **Table 1**).

Primary source of data was semi structured face to face-to-face interview via zoom with key stakeholders. I have interviewed four course developers, two instructional designers, four instructors, and project personnel. Interview questions were structured to discover the effectivity of the online learning method, what worked well and what did not in online courses, stakeholders' view on project implementation, reaching the goals, instructors experience on teaching online, course designer, developers experiences, and so forth.

Participants. Purposeful sampling was used. It involved selecting research participants according to the needs of the study (Glaser & Strauss; Morse, 1991), that is, researchers chose participants who gave a richness of information that was suitable for detailed research (Patton, 1980). Among key stakeholders there were course developers, instructional designers, instructors, administrative officials of the project and LCSC, the PI, and Co-PI.

Course content and program documents. Course content for several courses were examined. The courses including the summer skill academies courses (Machining and Electronics) were examined. Online courses examined included:

1. CADD and Blueprint Reading
2. Employability skills (Workplace skills & People and Personal Skills)
3. Applied STEM. Documentations included email exchanged about the program and newsletter that were sent out by the Clearwater Economic Development Association (CEDA) about the progress of the program. I have examined the course syllabus, online assessments, and course activities to understand the effectiveness of the instructional design, to get a clear idea on the level of rigor in content and the presence of interactive activities in the course. I also wanted to find out if the course design followed any online learning theory or framework. Specifically, I wanted to find out the presence of the six elements that Picciano mentioned in his integrated online learning model in online courses.

Surveys and Student Evaluations. Parents received a survey after every semester for each of the courses. I collected data on course design, assessment, content, rigor, resources, and so forth from their responses. End of semester course evaluations by students were another source of data in this research. Data from student evaluation helped me get the idea on students' level of online readiness, effectiveness of online courses, assessments, impact of online delivery on learning and so forth.

Table 1

Data Sources

Source of Data Collection	Objective
Interviews of key Stakeholders (instructors, course designers/developpers, project project personnels)	• To find out their perception on the impact of different modality of teaching-learning and the outcome of the NIMM program • Administrative officials of the NIMM project and LCSC • PI and Co-PI
Course Content (Summer skills academy, CASS and Blue print reading, Applied STEM, Employability Skills)	Looked at the Syllabus, course materials, assessments to find out the impact of different modality on teaching-learning.
Program Documentation	Program newsletters on CEDA website
Parent Survey	Examined parents survey that was sent after each semester to collect data on their perspective about online courses.
Student Evaluation	Collected data on student's perspective, experience about online teaching and learning

Data Collection Procedure

To find the answers to my research questions, I conducted semi-structured interviews with the project planning and implementation team and with instructors of the courses. I also reviewed the content of selected courses and analyzed parent response to surveys and student's course evaluation.

Interview Procedures

One-on-one interviews were conducted online using Zoom. I chose interviews as my primary data collection method as they provide more details than a survey, and general open-ended questions asked during interviews allow a participant to create options for responding and to voice their experiences and perspectives (Creswell, 2008). This study followed Creswell's (2008) recommended interview procedures. The specific procedures of this research were as follows:

1. To ensure equality and fairness, I sent a standard recruitment email to key stakeholders of the NIMM project asking their willingness to participate in the study. The email also stated the purpose of the research, the procedure of participation, and it also provided sample interview questions. The recruitment email also informed subjects that all information obtained during the investigation would be kept confidential. After obtaining participants' consent, pseudonyms were used to protect confidentiality.
2. I contacted each participant to schedule a time and provided Zoom links for the online interviews. Online interviews with video afforded me an opportunity to observe body language. Creswell (2008) recommended qualitative researchers use video cameras or audio recorders for in-depth interviews. For this study, all the interviews were video recorded using Zoom and later transcribed verbatim. During the interview, I asked probing questions while listening to interviewee responses.
3. After interviewing all the participants, I used pseudonyms to mark each interview. All conversations were transcribed. Interview transcripts were sent to participants to check for accuracy. Once this step was completed, all the original audio recordings were kept secure on the university's server in case

they were needed later in the study. Following IRB policy, research data will be stored for three years.

Data were also collected from the contents of a sample of two online courses, the summer skills academy (face-to-face course), and the associated evaluations. The focus of examining course content, as well as parent and student evaluations was on how the content was reflected in student-student, student-teacher, and student-content interactions, as well as in parents' views. I focused on finding data that reflected how these interactions were operationalized in the course content. Data collected from student evaluations focused on students' satisfaction level with the rigor of the content and the instructor. Also, I collected data from interviews that reflected stakeholders' views on the issues, challenges, and successes that the project faced.

Data Analysis

Qualitative researchers tend to use inductive analysis of data, meaning that the critical themes emerge out of the data. Qualitative analysis requires some creativity, for the challenge is to place the raw data into logical, meaningful categories; to examine them in a holistic fashion; and to find a way to communicate this interpretation to others (Patton, 1990). Following an inductive approach to qualitative data analysis, I worked from the "bottom up," where the lowest level consists of relatively descriptive codes that I applied directly to the data. At the next level, I identified similar codes into more conceptual categories. Finally, I summarized the categories into interpretive themes. I used priory codes for constructing the interview questions later to categorize/sectionalize the responses. Using a priori codes is frequently referred to as a "deductive" form of analysis, while building the codes during the analysis is "inductive”. Data was categorized according to the research purpose and research questions.

Codes. Data collected from interviews, course content analysis, parent survey, and student evaluations were coded and later analyzed through predetermined themes like multimodal delivery method, course content, and project goal. I categorized the data as themes like; impact of online method on teaching-learning, outcome of summer academy, and content efficiency. Project goal and instructional design issues were coded as; challenges in online course delivery, success of the project and so forth.

Table 2.

Analysis of Codes and Categories

	Priori codes	Codes	Categories
1.	Multimodal delivery method	• Communication • Resources availability • Administrative challenges • Class size • Online readiness • Equity and accessibility	• Impact of online method on teaching-learning • Outcome of summer academy
2.	Course content	• CTE online was a new concept for course developers. • Contents were not time tested. • Rigor. • Relevance with project goal.	Content efficiency
3.	Instructional design	• Navigation challenges and LMS issues • Grading issues/assessment challenge • Lack of interactive modules	Instructional design challenges

	Priori codes	Codes	Categories
4.	Project goal	• Reaching the rural communities	Mixed success in reaching rural schools,
		• Establishing a career preparatory program in manufacturing.	Students equipped with manufacturing competency
		• Preparing students for entry level positions in manufacturing.	Developed friendships and internship/job opportunities
		• Gap time between plan and execution of the project	Unfulfilled expectations and program duration

Data from interviews were transcribed to get a general sense of the whole, and the ideas presented. Next, significant statements and phrases pertaining to the main questions on the interview protocol were coded. There responses were further analyzed and coded using a combination of In-Vivo, Value and Emotion codes (Saldana, 2016). Meanings were formulated from these significant statements and organized into categories (**Figure 2**), and these categories serve the basis for the main themes that emerged in relation to each research question (Saldana, 2016). To ensure trustworthiness, the participants were asked to compare the researcher's descriptive results with their experiences on the NIMM project. Triangulation from different data sources were used to build a coherent justification for the themes. These sources include, comparing notes from the student evaluation of courses, parent response to survey questions, online and face-to face course content, program documentation, and newsletter.

Chapter 4: Findings

Based on the data analysis process described in chapter 3, I was led to four general categories. Therefore, I will describe my findings within these categories.

They are:

1. Impact of online method on teaching-learning
2. Instructional design issues
3. Content efficiency
4. Attaining project goals.

I am presenting the categories in line with the two research questions that guided me in this case study.

Research Question 1: How did differences in the modality of delivery (asynchronous vs. hybridized) implicate the quality of online delivery in CTE online manufacturing curriculum?

Several categories emerged in relation to this research question. They included impact of online methods on teaching and learning, outcome of summer academy, content efficiency (course content issues), and instructional design challenges.

Impact of Online Method on Teaching and Learning

Online Readiness

For CTE, the online method was something new for both instructors and students as many of the students had not taken an online course before and some instructors had never taught online previously. Data from instructor interviews, parent survey, and student evaluation indicates that online delivery impacted in a variety of ways. The impact ranges from providing effective learning and also acting as an obstacle to learning. One of the instructors described how the delivery method impacted teaching and learning for him, stating, *"I think with some students, it is effective for online courses. And for other students they are just there."*

Instructor interviews and parent survey indicates that many students were not ready for taking on the responsibilities that comes with learning online and this hampered their learning. One of the parents wrote in the survey, *"… my son was not prepared enough to learn online."* One instructor related his frustration when he said, *"If they skipped a paragraph or missed a sentence, an important part of it, they could get lost…"* He points to the difference in face-to-face classroom*, "… That's something I do in the classroom, because they can raise their hand immediately and say, 'I'm lost here. It's like, Oh, well, let's just back up a little bit and try it again."* In this regards, another instructor found students were not very fond of the online platform. He said, *"I had one or two really good students, but it didn't work out quite as well as I wanted. I really don't like the online format, because I was having a lot of students, the only way they could reach me was sending me an email message".* I said, *"Okay, send me an email message and really set the stage".* It's like, *"What's going on? What are you having problems with?"*

Instructor interviews suggest that instructors were frustrated about the online teaching-learning process, and they think high school students lack the maturity that hampered their learning in an online platform. One of the instructors stated, *"I feel like a lot of them short-cut the system, they didn't put in as much effort or had as much drive. Didn't do the readings that they should have done, that really would have helped fill in a lot of background information."*

Data from instructor interviews indicates that these gaps were visible and became an issue during face-to-face classes in summer. One instructor explained this,

> *I handed them drawings of parts that we were going to build out on the machine shop. Some of them could not understand what they were looking at. It's like, "Okay, that's depressing, because these are pretty straight, easy parts, and you don't know what you're looking at. Yet you passed the blueprint class. You passed my class. What's going on here?" That led me to believe, "Okay, they're, high schoolers, I think it's a maturity issue."*

From the project designers' perspective, though there was an orientation module to help students get oriented to the learning management system that was being used in the program, it obviously was not sufficient. Instructor interviews and student evaluations indicate that the orientation course wasn't very helpful. Supporting that, one instructor said, *"I do think they were not prepared to do what is meant to go into online coursework. So maybe we could have smoothed that over a bit... for those that have not done online courses, this is what you can expect."* Another instructor said, *"And maybe we could give, you know, a past student experience or a case study of what it's like to do online courses, and what's going to be required of you…"*. One student wrote in evaluation, *"It was difficult to find things on bblearn."*

Interviews of instructors and project personnel indicates that these issues resulted in higher drop-out rate in the first semester. One instructor described this and said, *"We definitely lost students in that first semester, with that first online course. Then there were other problems, factors in that first online course, that were our fault, weren't the students' fault."* A project personnel described this as follows:

"There were also students who dropped out because when they were introduced to the metal manufacturing certification program, they expected something hands-on, or they actually had these parent meetings talked about how they were really excited that metal manufacturing is something they can do hands-on, and yet the course was online, and didn't I think to provide enough bridges. It didn't really utilize the online format in a way that still personal hands-on experiences could be delivered."

Data from student evaluations, interviews of project personnel and instructors shows, in general, online delivery method presented challenges for instructors which also impacted their teaching. The challenges were mostly due to them having little or no training using LMS platforms. One of the instructors expressed his frustration: *"It was frustrating at first to work on IDLA platform, as I didn't have training on how to navigate it."* Students shared the same feelings about teachers being new to teaching online. One student stated in their evalaution, *"He didn't seem like he was the best for online teaching."*

Timely feedback to students was also an issue. One instructor described such situations as follows:

The online class, I had much higher expectation, I thought they'd really get it. We ran into a problem; I didn't put due dates on some of the homework. I realized after a while, I really need to put due dates on, a weekly, or every two weeks, put a due date on there. Because they were submitting homework. I'd get the same homework assignments turned in over the course of a month. For my own sanity, I wasn't grading any of them, until I had a dozen of them to grade all at once. They weren't getting feedback on it very quickly. I think I failed in that regard. I could have got them feedback on their parts much quicker.

A project personnel opined, *"The biggest challenge was, faculties of this project never taught an online course."* He further explained, *"A huge challenge of them teaching students that they never seen their faces. How much rigor do I put into this program and it's too much rigor? What can I actually teach online that is going to be comparable to a face-to-face hands-on class?"*

Equity and Accessibility

Data from student evaluation, interviews of project personnel and instructors indicates online delivery method helped reach out to many students from a huge geographical region. One of the project leaders explained:

> *"Most of the delivery method was online and the good part of the online stuff was we have to be in the same room to teach these students, we could reach out to. It was a huge geographic region that we were talking about, 22 different school districts from, I think, seven or eight counties here in Idaho and five counties in Washington, so we were able to reach a lot of students."*

Some students expressed working with a flexible timetable was something that they liked most about these online courses. Course evaluations done by IDLA and LCSC showed a noteworthy number of students liked having a flexible timetable in online settings. One student said, *"I love online classes since you can often travel at your own pace."* Another student stated, *"I think the classes are nice because you can work on them through your own time, but you got to be able to manage your time pretty easily to finish these courses."*

This online setting helped some students to carry on with their regular schoolwork and work on the NIMM courses at their own pace. Some students spoke in favor of having online courses, with one of them stating, *"It is a good way to get credits."* Another student said, *"Other than some of the material, I would still recommend any IDLA courses."* One student explained in further detail, *"I really like the fact that I can take a class that I can work around my schedule a little bit easier. I am often gone because of extracurricular activities, and it is easier for me to complete assignments on my own time."*

Some instructors also shared the view that online delivery method offered students more flexability in heir learning. One said, *"You know, it allows students to kind of go back and fix some of their mistakes as well. I mean, just like a traditional classroom, you know."*

Workload and Assessment

Data from student evaluation and interviews with instructors and project personnel suggests some online classes sizes early in the program were too large and it created challenges for instructors. One of project personnel explained this issue saying, *"They weren't giving a lot of feedback to these kids; there was 89 students, it was a big group of students."* Due to huge class size, instructors faced challenges managing timely communication with students. The gap between problems arising and resolution also became an issue due to delayed communication. One instructor stated: *"For online, the lag was a big problem; monitoring student progress was a big problem."* Another instructor described this issue:

> *Just the lag between when they would experience a problem, and when I could address that problem, was a big, big issue. In the beginning, some of the assignments I had were, you do a sketch, a hand sketching exercise, and how do you submit that online? I said, 'Well, you scan it in and send me an email with this, or you download it into Blackboard.' And students didn't have the device to scan it right at that moment.*

As the class size was too large for one instructor, he often failed to provide individual feedback to students when needed. One student shared his feelings on the course evalaution: *"I personally need specific feedback and suggestions to improve, and I did not get very much specific feedback."* Other students said in reference to instructors, *"They seem like they are not very reliable and do not have enough experience to help us." "He could answer emails a little faster and provide more resources to help with the materials." "I have had him twice now, and he is helpful sometimes, but he doesn't respond quickly, and half of the time his responses are not helpful."*

Class size hampered regular and timely communication as well. Especially, it became critical as students from some schools that participated have never taken an online class prior to enrolling in the NIMM program. In the beginning, most students didn't quite know what to expect or how to communicate. A project personnel explained, *"That was very new territory for them, and it's a bit of a foggy memory."*

Though the flexibility of the online program was a great point for students, data however shows that the average time they had to invest per week completing coursework was demanding as they also had to find time to complete their normal school work. The student evaluation showed during fall 2018, 75% of the students spent 4-7 hours and 12% of them spent 7-10 hours to complete their coursework. During spring 2018, 60% students spent 4-7 hours and 21% of them spent 7-10 hours per week on this coursework. Spending this amount of tme doing online work, in addition to their regular schooll work, was very challenging for most students. The NIMM project started with 90 students, and a significant number of students dropped out after one semester. Student and parent evaluations/surveys showed spending a lot of time was one of the reasons for the high dropout rate. One parent expressed their concern, stating:

> *First class was pretty bumpy overall. Our impression when joining the program was that the work could be done in their own time (in my mind, weekends). I didn't realize he would have to keep up with it nightly along with his other 8 classes. He works slower than other students on his homework because he is a perfectionist (and has excellent grades). So, in addition to the 3-4 hours of homework he was already doing, this added a lot more than he or I were expecting in order to keep up.*

Some students expressed their frustrations in evaluations: *"I find on-line learning hard so not sure I would recommend to others."* However, student evaluation data also shows some students realized online learning requires a certain level of maturity, and some took these courses as they saw the future benefit. One student explained this, *"It really depends on the kind of person you are. I'm personally terrible with them, but I desperately need a job after high school."* Others also seemed to indicate their level of disappointment, with one stating, *"Online classes are not for everyone."*

In response to concerns from the first-year evaluation, the project administration adjusted the form of assessment used to help stem the drop out. One project personnel describe this:

> *After a little bit of frustrations from the students and from some of the feedback that we got, that we needed to downplay it a lot, and so we removed the idea of the tests being graded for a grade. It basically became a pass/fail kind of a thing… it worked for the high school kids because it didn't count against their GPAs so some of them that had considered dropping out, some of them did drop out but some of them that*

> *were considering dropping out, it was just simply because they were getting a B in the course instead of an A, and they were worried that it was going to cost them some sort of a college scholarship because their GPA would have been reduced.*

Communication Challenges

Data from all the interviews, parent surveys and student interviews points out that, communication was a big challenge in online courses that hampered teaching and learning in many ways. An instructor expressed how this issue of communication created complicated situations and said, *"I could not manage grading on time, so students didn't get feedback on time. Because of the online platform, I could not get their real situation; communicating on email was not working well."*

One instructor linked this issue of delayed communication to problem solving time, saying:

> *Because sometimes they say, 'Well, I'm having problems with exercise number six,' I'm like, 'Okay, what part of number six?' There's this back and forth with the email. I check my email twice a day, and so their answer and my answer. There was just way too long of lag between giving them an answer, something that I could have solved in five minutes in a classroom setting if I can see their face. I go, 'Oh, here's what's wrong. Oh, you're pushing a left mouse click instead of a right mouse click. Well, here's your problem.' I don't have that tool available. I can't instantly see what's going on. It really bothered me as a teacher.*

Students expressed their frustration on lack of regular and timely communication in their course evaluations. They were asked what your teacher could have done to help you better and one student answered, *"more communication on what I got wrong''*. Another student answered, *"teacher could provide more feedback on assignments."* As time passed, there were fewer students, and communication improved. A project member had this to say, *"As the group got smaller, we got to about 60 students, it was better as far as being able to have a little more of connectivity."*

However, it was still a lot of work for instructors as they were teaching online courses alongside their regular teaching loads at their respective institutions. Overtime the number of students decreased to approximately 35, but that was still too large for one instructor. It was difficult for instructors to get enough time to reach out to each student. This created frustration among students. A project personnel described the situation further:

> *It would've been better to have had maybe 20 students per instructor, that way you can get a little bit quicker feedback because you have to think about where he was at, he was also teaching his own load of students here at the college, and then go home at night and try to go through 40 different students what they had sent him. And some of them certainly needing a lot more work, others were almost plug-and-play, they're getting it and the others weren't. And the ones that weren't, sometimes were the ones that got frustrated the most and complained the most.*

Instructors were disappointed about student performances, and they defined the online delivery method as the main problem. One project personnel stated, *"Communication was the biggest challenge, which is why the in-person classes were less problematic during summer."*

Due to lack of monitoring and less effective communication, students were not always on track with their work. One instructor said, *"I had a few students I'm confident, yes, it worked. But not all of them. I was rather disappointed in my online class."*

Lack of communication and delayed communication impacted students' feelings about the course. In the end-of-course survey, one student answered if they would recommend their teacher to other friends, *"I don't even know who my teacher is why would I recommend this teacher for others."* Another student said, *"My teacher did not respond quickly when I needed help on assignments and made the course more confusing than it has to be."* Lack of or delayed communication put students in a struggling situation.

Parents expressed their concern regarding lacking human touch in the online setting, which might have an impact on learning. One parent explained, *"My impression is a computer taught the course along with self-learning on the part of my son, while the instructor just double-checked grading."*

Availability of Resources and Administrative Issues

Online learning is completely dependent on smooth technical infrastructure and of course availability of high-speed internet. Online courses of the NIMM project even required more sophisticated technical structure as these CTE courses used various high-tech software and apps. Students expressed their frustration of not having internet and computers in their response questions about the online courses. One of them said, *"Because you can do an online class and do it on your own time and stuff. It's just a pain when you don't have internet or a computer."*

Project personnel shared the same feeling and described this issue:

> *There were things that we had to figure out on the way, like for instance computers for students. Initially we thought that the schools would have computers and that the schools would provide the time for the students, so they'd be able to use those computers. We soon found out that there wasn't, we also found out that there were*

students were having to do this stuff on their own and guess didn't have internet at home.

Students explained more about how lack of necessary resources hampered their learning. One of them said, *"It was difficult to complete assignments because most of them could only be completed on the singular computer at my school that had AutoCAD. So, if someone else was using it or I didn't have enough free time in the day, I could only use it for 50 minutes every day during the weekdays."*

There were administrative issues that also affected the online delivery method. One project official said, *"Online courses needed some tech/equipment buying which did not happen before we started the project. Students often failed to use the necessary tools, technologies as all the schools were not well equipped as well as didn't allow students to use certain things."* One instructor reflected on his frustrations:

> *We had to get the different IT departments to coordinate, just getting the software loaded on their machines. Administratively, we had to purchase SolidWorks, and then get that out to the schools. Our administrators had their work with, 'Okay, how do we pay for this many seats? How does that work into the grant?'*

Getting the equipment presented some initial challenge because the funding from the NIMM project did not allow for the purchasing of equipment. A project team member explained this issue:

> *… Then I think that was compounded, because the PI, … he wrote the grant, so he knew what was going on, got promoted and had to leave the grant. That caused some problems. Everybody was kind of feeling their way around, and I think floundering a little bit there.*

The initial unavaiblity of computers and CADD software for every student also presented some challenge initially. A project personnel described this issue:

> *We had students that had computer problems, and we talked with a few different computer companies here in town. We had one of the companies donated us I think, 20 company computers…all been refurbished. The reality is that most of these machines were quickly overloaded with memory and that was another one of the things you run into. Most of them didn't have the video cards… to drive things like the SOLIDWORKS, that 3D imaging software... the kind of software that we needed.*

Another issue was access to computers at school, the availbility of internet at the home of some students, and the school slowness in sharing relevant information with students who were in the NIMM program. One student said, *"I could only work on my assignments after finishing everything but could not do it at home as there was no internet."* Another said, *"My home computer could not open the programs and the school lab I could only use after school."* And a A parent mentioned, *"My daughter could not get any information from school about the course registration for the next courses."*

Online Method Proved to be Timely

Although initially teaching online was challenging, the data indicates that overtime instructors became interested in this alternative way of teaching and came out as better online instructors. A project personnel explained, *"I wouldn't say that all of their concerns and worries have been alleviated and now they're 100% on board with doing online courses, but they certainly don't have the reservations that they had before this project went down. The faculty now are certainly a little more open to at least now identify some things that can be taught."*

The NIMM project helped instructors of this rural region to develop confidence teaching online. One of the project personnel described,

> *When we had the pandemic this last spring, it was two of my faculty that helped create and taught the courses for the NIMM, they were the ones that had the least amount of anxiety about being forced to teach online, because they just came out of learning how to do all that so that was an unintended consequence from this project, it was positive.*

Outcome of the Summer Academy

Class Size and Activities

Along with online courses, face-to-face, hands-on laboratory activities were arranged for the Electro-mechanical cohort for machining and electronics at the technical college. This was called the Summer Skills Academy, which ran for eight weeks over two summers.

Findings from the interviews of project personnel and instructors show that for the most part, the Summer Skills Academy was successful. Data shows, one reason for this was the smaller class sizes made attending to students needs more manageable. Students enjoyed interacting with instructional staff, laboratory technicians, coaching staff, and touring manufacturing facilities. Summer academy was not just in-person instruction, but students were able to stay on campus for two weeks, participate in laboratory activities during the day, and had in-person social activities during the evening that were organized by STEM Access through the outreach program of University of Idaho. A project personnel explained how this combination helped the summer experience to be better, *"…And that in person and social activities combination overall was very successfully established for students to have a good, have a positive experience and, and really bond with their peers and feel positive about the* *overall program."* Another project personnel stated, *"In summer class students really enjoyed the face-to-face instruction. I think it was very successful. I noticed a substantial change in those students."* An instructor indicated, *"Students were working in groups in the workshops, so they had a lot of interaction at the summer academy."* Other instructors were also happy with the summer project as they found it moderately successful. One of the summer camp instructors stated, *"I was fairly happy with the summer academy courses. We didn't get as far as I had hoped, but I was pretty aggressive in my planning on it. I had a lot of activities. Then my lab is set up, I only had three lathes, and I had four milling machines."*

Data also shows the summer academy fared better mostly because the method of teaching and learning was more hands-on and experiential. One of the instructors explained, *"At the summer academies, it was mostly demonstration; instructors would demonstrate to them what to do. It was rarely any formal lecture type of interaction. It was always demonstration. And then, students would follow their instructor."*

Another instructor further clarified how the summer academy was effective in terms of delivery, instruction, and assessment. He said, *"I believe that the delivery methods were effective because those were hands-on activities. Having somebody demonstrate what to do, and then you're there, following step-by-step procedures, that was very effective."* The summer academy seemed to impact students' attitude towards learning and their participation in NIMM courses. One project personnel stated, *"I think summer academy was very successful. I actually saw a change of attitude in students. I mean, I noticed a substantial change in those students."*

Students were happy as they could apply all they learned online. One other instructor described, *"They were pretty excited about a motor, saying, 'Hey, this,' because I had a motor all done and finished. I put air to it, and they could actually see it running, and they could hear it. It's running away. They're like, 'Hey, neat. We want one of those.' I said like, 'Okay, go build one.' The excitement was more to see these things firsthand, and instructors think students 'got inspired to get mastery of the materials more in depth over the course of a two- or three-year long program.'"*

Class Assistance

Data from instructor interviews indicates, unlike the online classes, class size in the summer academy was smaller, and that helped instructors to manage their teaching better. One instructor said, *"…was doubling people up, and I was teaching simultaneously, some lathe, and some milling machine, and some drill press, and saws, and files, and that sort of thing, too. But I had 12 or 13 students in the summer academy, so we were pretty thin."*

There was also benefit in having laboratory assistants who helped instructors to manage their classes. This helped them maintain safety as well. One instructor expressed his satisfaction, saying, *"I did have an assistant each of those years. M helped me out, and then my son helped me out. They could be there as another set of eyeballs for safety purposes out in the lab."*

Homesickness

Findings show for some students, it was their first experience ever staying away from home. Instructors and project personnels explained this in interviews. One instructor explained that issue and said, "There are a lot of challenges between the students, you know homesickness, just the frustration of not seeing their friends, and that sort of stuff. So some of the students get a little more drawn away from the group. And some students really become agitated during that time." Despite these issues, students generally found the summer skill academy learning experience fullfilling. One project personnel described this and said:

> *I think one thing was you know, a lot of students had separation issues from their parents and from their home lives and friends, you know, it's a big task to kind of go through a whole like a part of your summer not being able to see your friends. But we definitely tried to make it fun and enjoyable, and the students had other students and friends there that they can hang out. And we tried to make it as much fun for the students as possible that we could so. So yeah, the students during the summer were usually pretty happy.*

Time Management Issues

During summer academy, students were staying at LCSC student dorms. The STEM outreach group from U of I was there to supervise the students in the dorms. According to instructors and some project personnel, they did a very good job monitoring and supervising students. One instructor reflected on it as:

> *Because it was a summer academy, it got done at 2:00 or 3:00 in the afternoon. It was very hot out, it was 103 degrees out. They would go back to the dorms, I was worried that they would, I didn't know what they were going to be doing, if they were in the dorms. But the group from the U of I did a very nice job of, 'Okay, let's go swimming, or let's go play frisbee golf or let's go do something.' Filling their times.*

However, there were some bumps in monitoring as well. One instructor shared their experience regarding this issue:

> *I had some very sleepy people in the mornings when they'd come in. One kid actually, it was remarkable. He could actually fall asleep, he just curl up in his chair in the*

> *computer lab and fall asleep. I let him, I'm like, 'Okay, if you're that tired, I don't want you on a piece of machinery.' That's just a safety hazard.*

One of the instructors described a very small but significant positive thing about summer academy. He said, *"I think the snacks afterwards were good. Good and it matters. You know, it's right after and in fact, I think we did snacks even before. So, you know, this is right after school for them. It's just a little something to have them. They kind of look forward to and builds that rapport a little bit."*

Content Efficiency

Course Development and Book

Data from course designer and instructor interviews points out that, there were challenging issues regarding course design/development and book availability. Converting courses that were normally taught face-to-face to an online format presented some challenge as some of the CTE instructors never taught online before, and so resources were not properly set to support students. Most CTE courses are face-to-face because of the practical/lab requirment. One of the course designers explained this issue:

> *One of the challenges in developing the course is that X, Y, and I worked together to develop the course but neither of them had any experience with online delivery. So, that created a challenge where, you know, delivering content face-to-face which they both do, is very different than delivering content online. So, we had some learning curve at the beginning about how you, you know, how you prepare lessons to be delivered asynchronously.*

Student evaluation done by IDLA shows that a significant number of students agreed that reading materials helped them to understand the content. One of the instructors said it was hopeful and described:

> *The book that they use with this particular one is a really good book along with it. So, it's an online eLearning book. And it has really good step by step instructions that most students could follow pretty well. So, I think the book helped a lot. Because that's what I use when I went through and make videos to kind of back up the book, kind of show the kids where to find the tools or other things like that. So, I think the delivery method, you know, online format with the book was really, really positive.*

However, student evaluations also shows difficulties accessing the textbook on time. One student explained, *"I was also not being able to print the textbook units all at one."* Another student explained availability of the textbook on time was another issue, *"at the beginning we did not have a textbook to refer to until over a month in and it was needed for some assignments."* Another student said, *"Halfway through the class the online textbook wasn't available."* Some comments made in the evaluation show students found the textbook difficult and not user friendly. For example, one student stated, *"The book was not very helpful to me, no matter how many times I would reread a chapter."* Also, the latest version of the book was not available to students, *"The book I had did not match because it was a different version, my loaded problem was 2019 but my book was 2018 so made it hard to use."* One student said, *"A lot of reading from a book then paperwork."*

Rigor

Data gathered from interviews and student-parent surveys, showed course content was difficult for high school students. Students found these courses very difficult and said, *"This class was very confusing and demanded you to be diligent with staying on task."* Parent surveys also contained specific feedback on this issue. One parent said, *"My son was so frustrated the whole class and each assignment took him an hour or two that he did not learn as much because he just wanted to get it done."*

Another parent expressed their concern, saying, *"Based on talking to and observing my child this course appears to be harder than the last in that the materials were not presented well. He had a different version of the program loaded on his computer than the book or teacher were referring to during lessons. When he asked the teacher about it, he was told they are close enough."* Instructors expressed the similar thought on content. One instructor commented on the content, *"Higher level for high school students."* However, project personnel cleared the reason for having difficult content as one of them stated, *"Content was rigorous, but it was for college credit."*

Another project personnel explained it further, *"The content was a little bit too heavy. You've got to think of it this way, we were giving them credit, college credit not high school credit, not junior high credit, they were getting college credit for these courses. Nothing different than any dual credit course that a student would take in high school, whether it's in English 101, or something else."*

Instructional Design Issue

Navigation

Student evaluations and instructor interviews points out, navigating through the LMS was a big issue for both students and teachers. One instructor explained this and suggested other platforms that are more intuitive:

> *That's a question of logistics of how these types of Blackboard style interfaces work, which is why I would not recommend them for high school students. They are not intuitive for them really. In getting started and stuff, a good alternate suggestion would be Google classroom, which most universities, however, don't endorse, but that's something more designed to work intuitively in terms of communication and, and the whole structure.*

Students faced constant issues navigating materials for study and assessment. One student said, *"It was very complicated to get to the page where I could create a new post or discussion."* Another student said, *"One thing especially was finding where to get the info needed to complete the assignments."*

Assessment and Social Interaction

Findings from student evaluation and instructor interviews reflect that, course assessments were not much useful and online courses lacked social interaction. Students have strong opinions about assessments and mostly they found them very difficult and not useful. One student said, *"Videos only tell me part of what I should know, assignments confuse me further, and tests are not a field that help me learn, they confuse me more."* It is evident from data that social connection was lacking in course design, which is explained by an instructor. "*Most of these students were used to face-to-face type learning and because it was being presented online, a lot of these students felt like they were in some sort of a silo, all by themselves and what complicated that even more was that there wasn't usually a large cohort of students within the same school that was taking this program."*

The lack of social interaction took students out of their comfort zone. One of the project leaders evaluated this situation and stated, *"Just think about a 15, 16-year-old kid, a* *lot of them don't have that kind of confidence in themselves anyway. So that struggle, we might say well the only way to get better is to just go do it, which is true but a 15, 16-year-old kid is going to say,'No, I don't like that, I don't like that.'"* One other project personnel said, *"We didn't have any form of interaction, with the exception of our discussion activities. We'd have some discussion questions, and students were supposed to respond to or at least give some feedback to at least two of their colleagues' response.*

An instructor mentioned the presence of some video presentations, which was helpful for students. He said, *"The format of most of the lessons, we had, of course, lecture slides or presentations, and we usually had videos so that students could use."* A course developer said,

> *"And, of course, we tried to include interactive activities built within the lessons. And I believe that, interactive activities, they were very helpful in particular. These are things that the students could play with, they could move things here and there to see just the different parts of a drafting document they could play with and get things explained to them."*

However, data from end of course evaluations shows students, for the most part, did not find these activities to be very helpful. One of the students described this in their survey, commenting, *"The mini games and videos were more difficult because my school uses security to block certain things and often the videos and games were blocked, plus I don't learn as well from those as I do written materials."*

Research Question 2: What are stakeholders' perceptions about the outcomes of the NIMM program?

The second research question generated three catagories:

1. Mixed Success in Reaching Rural Schools
2. Students Equipped with Manufacturing Competency
3. Developed Friendships and Internship/Job Opportunities, and Unfulfilled Expectations and Program Duration

Mixed Success in Reaching Rural Schools

This project was a first of its kind in the region. Thus, reaching the goals proved challenging. Findings from interviews with project personnel reflect this well as one project personnel described it this way, *"Lot of things in this project, you know, it was a pilot program and stuff. A lot of the stuff, especially towards the end was a little hard to kind of put into place, like getting students."*

One of the main goals of this project was to reach out to the students living in the rural areas of North Idaho and Eastern Washington. A project personnel stated this goal, *"The primary goal was to reach out to rural community, for the most part. There were also five other counties across the border into Washington that were also a part of it because they are part of our community."* Another project personnel explained further and said:

> *The main goals obviously were to actually reach out to our rural communities and provide some CTE education that otherwise wasn't available. Most CTE education requires a lot of equipment for students to learn, the courses that we decided to work with were basically machining-related and though the actual hands-on portion of teaching those types of courses is still a major requirement, what we were looking at were ways of reaching out to the individual communities by creating some online courses that had a minimum number of hands-on requirements for the students.*

It appeared from the interviews that the goal of reaching out to the target audience was moderately successful. One of the project personnel reflected on the results:

> *Despite challenges in the first course, I think, overall, yes, we did reach our targeted audience effectively. How do I explain it? Because one, we know that we were reaching out to high school students from different parts of North and Central Idaho and offering an online course or online program was the best solution since we didn't have teachers at these schools to teach all these different courses. So, offering an online program, I think that was quite effective to reach the targeted audience, I believe.*

However, one project personnel expressed a differing opinion on reaching the target audience. He expressed doubt, stating, *"With some of the information, yes. The summer academy, definitely. The online, I don't have that confidence."* Another project personnel said, *"I think we really messed up the communication early on and I think that that hurt our enrollment."*

Students Equipped with Manufacturing Competency

Preparing students with entry-level manufacturing skills for the workforce was one of the main objectives of this project. It is evident from the data gathered from interviews of project personnel and instructors that the project was notably successful in preparing students. One of the project personnel shared his thoughts:

> *Did we have a couple of students that did get jobs after the fact, after they went through the program? Yes. I believe they did, most of them were internship jobs and most of those internship jobs turned into something more after they had gone through the program. And they wouldn't have gotten the job, they wouldn't have got the internship if it wasn't for this program.*

Another project personnel explained how this project was successful in bringing out the interest among students to get prepared for the manufacturing workforce:

> *Number one goal to establish a career preparatory program specific to the metal manufacturing cluster for high school students so that they can get a certification that makes a difference for the students as well as the manufacturer, in order to then be able to get a higher-level job out of high school that was very successfully met.*

Students were excited and motivated because they could take the NIMM courses as dual credit, and these courses would ensure a job for them. One of the key personnel of the project describes this:

> *Because they knew like, 'hey, now I don't have to go to college for this, I can just go straight into what I want to do.' … they're really motivated to just get in, get done, get out and get a job.*

The project helped students to plan better for their future and prepare themselves better for jobs that are available in the region. One of the instructors explained:

> *Like two-year plan of all that they did and putting all these things together to give the students all that they needed to show that they actually completed this. And I think LCSC did a really good job of like putting that together and sending it out to those students.*

It was successful in creating a positive outlook among students, and it helped them to plan what they want to do next. One instructor described this:

> *The students we got, though, are very informed about what they're going to be going into. And very excited about being here. I think we got one electronic student; I think*

we got two guys going into the machining. Or they said, 'Yes, this is something I want to do. I want to go to the next level.' They go into an engineering program.

Students got confidence to apply for engineering programs as they have learned applied science through the NIMM project courses. One of the instructors described it as:

At least one of our students, I think two of the summer academy people went to the engineering program at the U of I. I don't know for certain, but that's really good, because now they have some experience saying, "Okay, all this calculus, and physics, and whatnot that I'm taking in college has an application here on this connecting rod inside this piston, inside this motor. This is when it's going to break. This is where it broke when I put too much air to it at college back in summer. This thing blew up."

Students were motivated and passionate about the courses, especially during the summer. A project personnel described:

And especially during the summer course, the instructors love the students, they were super appreciative to have high school students come in and work with college instructors and be so hands on and so driven because a lot of those students during the summer courses really, really were like driven and passionate about what they're doing.

Developed Friendships and Internship/Job Opportunities.

The interviews of instructors and project personnel also revealed some unexpected positive outcomes. One of the instructors described the situation:

I know that we had some students who absolutely loved what they did. And it took them in a completely different direction. So, like we had a couple students who just did phenomenally in the academies. And then because of that experience and what

> *they learn, they chose to go a different direction completely. Where they thought those skills helped them, but nothing into the manufacturing. So, I think that was sort of unexpected that it would, you know, we were, we were so focused on preparing them for the manufacturing sector. I don't think we thought about the other avenues that this could expose them to.*

Students build new friendships and bond. One instructor described this, *"A lot of friendships were formed. Kids from different schools, they said, 'Hey, those guys from Orofino, they're not so bad.' Or 'Man, that guy from Grangeville, he's all right.' A lot of friendships were formed with the afterhours things."*

A positive notion about online teaching and learning developed despite the initial challenges. One of the instructors explained, *"That's something that mostly of these students didn't have any online classes before they took this program, so I think a certain level of fear of that, those barriers were broken down for them, especially for the ones that finished."*

Several manufacturing companies offered internship and were interested in hiring students who completed the program. One instructor described this*, "so really the summer program is what motivated manufacturers to hire and give students internships. Because that is when most of the students got hired when we had our biggest section of tours."* Students enjoyed touring manufacturing facilities and the factory tours. Another project personnel described the positive impact of these tours:

> *We had support from the manufacturers, which included going and doing some of the, the tours that we did, letting the students get familiar with what was going on. I would like to see more of that if we did that again, because that was very well*

received by the students. So, I think that part of the implementation went well, and could get even more stronger next time if we did it again.

Some students received internship and job offers after completing the program and high school.

Students got jobs and most of them were internship jobs and most of those internship jobs turned into something more after they had gone through the program. And they wouldn't have gotten the job, they wouldn't have got the internship if it wasn't for this program.

Unfulfilled Expectations and Program Duration

Data from interviews of project personnel and instructors' points to unfulfilled expectations and duration of the program contributed to the high dropout rate initially. The multi-modality of this project had both advantageous and disadvantageous outcomes. One project personnel said, *"I think online courses match this goal and met the goal really halfway …"* Another stated, *"The course was established in that sense, it met the goal, but the course wasn't established in a way that the students really wanted to continue."* The overall curriculum design along with the instructional design, however, was not sufficient to fulfill students' "expectations".

The drop out of the students, from everything that we could tell, was twofold. Number one, we had students sign up into the program that weren't long term committed. So that makes sense for them to drop out. But there were also students who dropped out because they expected when they were introduced to the metal manufacturing certification program, they expected something hands-on. Or they actually, at parent meetings, talked about how they were really excited that metal manufacturing is *something they can do hands on. And yet the course was online, and didn't I think provide enough bridges. It didn't really utilize the online format in a way that personal hands-on experiences could be delivered. I believe that's a gap. I don't believe that's impossible. I think that's a question of designing it better.*

A few instructors thought the duration before true results was seen in teaching and students applying what they learned was long. This raised questions about the duration of the program,

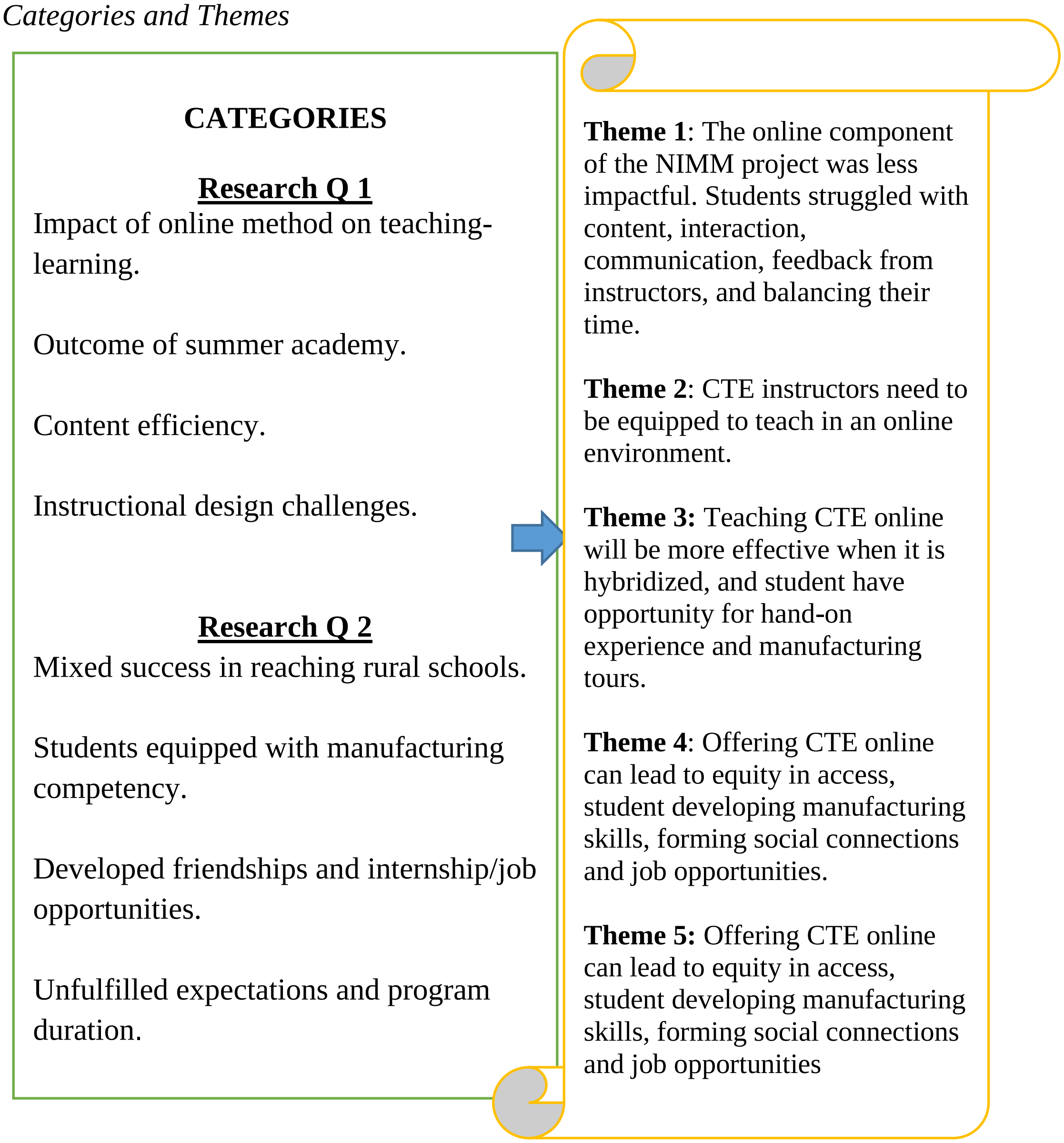
"When you were approached, and when you started working, and when you actually started getting the results of your teaching. It all was in a very wide time span, that's why the results were not visible. It was uncontrollable." Another said, *"They're learning it as 16 years old, and then trying to apply it as 18-year-olds. What I say is that rust never sleeps. We forget things, it fades. That was a frustration."*

Summary

Analysis of the transcripts from the various data sources produced eight main categories, four for each research question. A comparison of the main categories with each other and consolidation of them resulted in five main concepts or themes (**Figure 8** These themes will be discussion further in Chapter 5.

Figure 8

Categories and Themes



Chapter 5: Discussion and Conclusion

This chapter is a discussion of the key findings as they relate to the themes identified, relevant literature, and the guiding conceptual framework. The chapter concludes with the implications for research, lessons learned, and recommendations for future research.

Major Themes from Findings

From the key findings of this study, five major themes are drawn that answer the two research questions guiding this case study. These five themes are:

1. The online component of the NIMM project was less impactful. Students struggled with content, interaction, communication, feedback from instructors, and balancing their time.
2. CTE instructors need to be equipped to teach in an online environment.
3. A solid technical infrastructure is needed for a successful online course.
4. Teaching CTE online will be more effective when it is hybridized, students have opportunity for hands-on experience and manufacturing tours.
5. Offering CTE online can lead to equity in access, student developing manufacturing skills, forming social connections, and job opportunities.

Theme 1: The online component of the NIMM project was less impactful. Students struggled with content, interaction, communication, feedback from instructors, and balancing their time.

In the multimodal model for online education, Piccacino focuses on community and interaction along with other components (Piccacino, 2017; Anderson et al., 2011). The online courses of the NIMM program were asynchronous, and this presents a challenge to maintaining students' interest in the course content. In asynchronous courses, students show a preference when they are connected to other learners through regular interactive activities and there is a strong presence of the instructor. The concept of learning community is highly promoted for both online and face-to-face learning by scholars like Garrison et al. (2000) and Wenger and Lave (1991). Interaction is very important and is integral to the function of a learning community. Increase interaction among students and between students and instructor leads to online learning environments that are more conducive to learning. The design of the online courses in the NIMM program would improve if multimedia that engages interactive individual and group activities were integrated in the content.

Studies also indicate instructor presence is key to student satisfaction (Wang & Chen, 2011) and students claim higher satisfaction in courses that have higher instructor presence and availability (Picciano, 2002; Richardson & Swan, 2003; Shea et al., 2006; Blau, 2009). NIMM was a novel program, so doing manufacturing courses online was new to most students and instructors. In addition, because most instructors did not have formal training to teach online, they had challenge navigating and using the LMS platform of IDLA and LCSC. Most students had no experience with online learning and LMS platforms, as this was the first online course for many of them. Students reported that they rarely received immediate feedback or email communication from instructors. Instructors also said they were often not able to send feedback in a timely manner. The large class size was also an issue, particularly for the first class, thus email communication was not effective because it took instructors a great deal of time to respond to all students. This communication gap was critical, as it created frustration among students, and that impacted retention.

Scholars (Shih, 2013; Iachini, Buettner ,2013;Anderson-Butcher, & Reno, 2013; Palloff & Pratt, 1999;) suggest that, to develop a successful online course, building and sustaining an online learning community is crucial and necessary. Studies show that learning communities can increase the persistence of students in online programs, and also enhance information exchanges, learning support, group commitment, collaboration, and learning satisfaction (Dede, 1996; Stein & Glazer, 2003; Wellman, 1999). According to Palloff and Pratt (1999), "the learning community is the vehicle through which learning occurs online. Members depend on each other to achieve learning outcomes for the courses online….Without the support and participation of a learning community, there is no online course" (p. 29). The findings of the study shows that the instructional design of the online courses did not have any component that could help in the building of a learning community.

Picciano (2017) added self-study/independent learning in his revised model of multimodal learning and suggests that it can be integrated with other modules and primary mode of instructional delivery as needed. He further suggested that the use of adaptive learning software as either an integrated or standalone method would help for this modality. NIMM courses did not use any such software that could help students to excel in self-paced study. Online learning requires an environment that promotes self-directed learning, self-motivation, and a sense of responsibility, which many students lacked, and teachers did not know how to address this. As mentioned above, building a learning community could help address these issues.

Self-directed learning is a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes (Knowles, 1975). An effective instructional design could ensure an environment where students can develop the skills of self-directed learning. In such an environment, the instructor could provide appropriate scaffolding for learners' knowledge and skills to help develop autonomy and provide regular feedback to help learners accurately evaluate as well as validate learning accomplishments.

There were obvious online learning barriers that fall in the categories of learners, teachers, curriculum, organizational, and structural factors that Assareh and Bidokh (2011) alluded to that were present in this program. Individual schools that participated in the program had only a few students enrolled, and this limited the level of interaction that was possible between students. This lack of interaction with their peers at the same institution might have caused some students to feel a sense of isolation in the course. Some students also struggled to keep up with the pace and difficulty level of the content. While students, supported by their parents, reported that the flexible feature of online courses helped them, they also reported spending a lot of time completing assignments. This extra workload along with their regular classwork was a barrier for some to persist to completion. A few students were unable to complete their NIMM assignments during the regular school hours because of conflict with their regular classes, pointing to one of the structural constraints that was faced.

Theme 2: CTE instructors need to be equipped to teach in an online environment.

Some teachers were not properly prepared for the multimodal delivery approach used, as they did not have prior training to teach online. Most students were also new to taking online classes. Smith and associates indicated that time management, self-guidance skills, adopting the internal resources of motivation, recognition of personal learning style, and experiences as important online learning readiness skills for students (Smith et al., 2003). Teachers also need to be ready for teaching online. Gurley (2018) suggested teaching online requires technological skills, but also different pedagogical approaches than teaching face-to-face, to support learning. The lack of training to teach in an online environment explains why some instrucors did not handle the instructor-to-student and student-to-student interaction properly.

Theme 3: A solid technical infrastructure is needed for a successful online course

Online programs require an uninterrupted, reliable technological infrastructure to ensure student progress through courses without unnecessary distraction. Online learning tools should meet users' requirements to gain their trust and improve their acceptance of e-learning (Kanwal & Rehman, 2017). Findings of this study indicate deficiencies in the technological infrastructure of some schools. Students faced challenge in completing their assignments because multimedia that were integrated in course content were blocked by some schools' intranet system. Some schools lacked computers that could support software that students needed, while some students simply did not have access to a computer or have internet at home. Communication with schools where these issues existed resulted in an early resolution. Students received computers that were capable of supporting the software required by their courses, and schools built-in time in their schedule so students had access to the library to complete their assignments. All other resources required by each class were also provided to each student.

Theme 4: Teaching CTE online will be more effective when it is hybridized, and students have opportunity for hands-on experience and manufacturing tours.

The Summer Skills Academy was one of the unique features of the NIMM project, which ran for eight weeks over two summers at the Lewis-Clark State College. This case study indicates students were very satisfied with the hands-on learning activities at the summer skills academy. They applied the knowledge that they learned in their online courses to design and make products in the laboratories and workshops. Class sizes were smaller because of the capacity of the labs, students were highly motivated, and instructors worked with their laboratory assistants in the guiding of students through their hands-on, work-based activities. The summer academy also included the touring of manufacturing plants and evening social activities. These activities helped in the development of social bonding among students, which was lacking in the online classes. This finding stood out and is consistent with what the literature says about benefits of CTE and hands-on learning. For example, CTE has long been recognized as a form of education that uses a pedagogical framework built around hands-on, work-based problem solving, through the application of concepts and procedures from the STEM disciplines (Dixon & Hutton, 2016; Gordon, 2014). Students who take CTE courses learn many applicable skills, through hands-on experiences, that will help them become successfully employed later in life (Lundry et. al., 2015; Roberts & Ball, 2009). As was the case with the NIMM courses, the content reflected manufacturing workforce needs, so students are provided with hands-on, work-based activities to address those competencies.

Theme 5: Offering CTE online can lead to equitable access, student developing manufacturing skills, forming social connections and job opportunities

Equity in Access to Manufacturing Courses by School. The primary target of this project was to address talent development in critical skill areas identified by manufacturers in North Central Idaho and Southeast Washington where there is chronic shortage in skilled labor. Reaching out to as many students as possible in rural regions where they do not have access and resources to take CTE courses was also the overarching focus of this project. The findings suggest that overall, the NIMM project was successful in ensuring equitable access to students in rural schools who wanted to do manufacturing courses. While there were specific impediments early in the program such as conflicts with the regular school schedule, lack of access to computers during normal school hours, and the school or student not owning a computer that is capable of supporting CADD and other software, when these issues were addressed, students were able to complete their courses. Students can also be limited when they do not have internet connections at home. Access, however, to a library with internet connection or WIFI often resolves this issue. A limitation to offering manufacturing courses online is that certain types of manufacturing content require students to interface and manipulate machinery to create products. This would necessitate students being in a physical plant, laboratory, or workshop. The development of manipulating skills through working with modelling software or simulation software can allow manufacturing classes to be offered online. Manufacturing courses that target the development of soft, professional, employability competencies can also be offered online. Online format also helps to address the lack of instructional resources in schools in rural regions. The online format essentially allows a central school with resources to offer courses that students from other schools can take.

Development of Manufacturing Skills. The perception among stakeholders of the impact of the NIMM curriculum in the development of entry-level manufacturing skills among high school students was positive. The designing courses which were offered asynchronously to the Mechanical CADD cohort result in students developing drafting and designing skills that are crucial to manufacturing companies in the metal supercluster.

Students in the Electro-Mechanical cohort acquired drafting, mechanical, and electronic skills— competencies that are also required for the manufacturing companies in the region.

***Forming Social Connections and Job Opportunities*.** One of the findings that stood out was the social connections that students established with each other while they participated in the summer skills academy. This came about as a result of working in teams on projects, touring manufacturing facilities together, and participating in social activities at the summer skills academy. Manufacturers had the opportunity to interface with students as they participated in the tour of manufacturing plants during the fall and spring semester and also during the summer skills academy. Students had the opportunity to exhibit their work at the summer skills academy to manufacturers, parents, and other stakeholders. Some students were offered internships and the opportunity for employment after completing high school.

According to Ross et al. (2020), the mentorship that students receive from instructors with industrial experience and workers from manufacturing can produce positive relationships with adults that support students' growth and development, social capital that provides information and contacts regarding employment, and work experiences that offer opportunities for hands-on learning and exposure of young people to new environments and expectations. Most students participating in the summer skills academy were driven and passionate about what they were doing, because they came to appreciate, based on their interaction with manufactures and instructors, the knowledge and skills they were acquiring through NIMM courses will provide them with the competencies to secure jobs after graduating from high school.

Conclusion

This case study explored the NIMM program, a unique initiative implemented through the collaboration of the regional economic development associations, manufacturers, technical and higher education systems, and regional school districts to address the shortage of entry level skills in manufacturing by the offering of two curriculums in two formats, online and hybridized (online and face to face). The program was funded by the NSF ATE and was innovative in that it was the first of its kind to be implemented in North Central Idaho and Southeast Washington. Twenty-two rural schools participated over a period of three years (including two summers). Overall, the stakeholders perceived that the program was successful, and it proved that CTE courses in manufacturing can be offered in an online format. This, however, is not without caveat. The curriculum that was presented in a hybridized format was more successful, had a greater retention of students, and more students completing the program.

Implication for Offering CTE Online to Schools in Rural Regions

While the findings from this case study research cannot be generalized to other online programs, it provides insight on issues and factors that must be considered if CTE programs, such as manufacturing, are to be offered online to students in rural schools. The following must be taken into consideration.

1. A survey of students' experience and comfort level with the chosen LMS to be used must be carried out. If students do not have any experience using the LMS, then orientation must be done to properly introduce students to the features of the LMS.
2. Before commencing, authority must think of building capacity and interest among instructors for teaching online. Instructors need movitation for teaching online as it

requires more time, planning, and delivering. Their interest, confidence, and capacity would increase through training and incentives.

3. Courses that addresses professional, employability, and soft skills can be offered asynchronously, but student-to-student, student-to-instructor, and student-to-content interaction must be high. Learning communities must be built into the course, multimedia must be integrated in the content, students must recieve timely feedback from instructors, and courses must have formative assessments that are low stakes.
4. Technical courses that use modelling and simulation sofware for the development of technical competencies can be offered in an online format. Students, however, must have access to computers that are able to support the sofware.
5. Schools must have good technological infrastructure to support online learning.
6. Having hybridized courses, that is, courses where students can physically work on projects in a laboratory or workshop, along with opportunities for field trips to visit business facilities and where there possibly would be mentors from the relevant industry interacting with students, will likely motivate and result in increased persistence of students in CTE.

Recommendation for CTE Instructors and Course Designers Online CTE Courses

Online CTE course developers and instructors would benefit from the following recommendations:

1. The courses need to be designed following the learning theories and best practices in an online learning.

2. Course developer and instructor must be cognizant that students have other subjects to work on as well in each week. So, the workload needs to stay at a manageable level.
3. The courses should be designed to ensure instructor's presence.
4. Instructors need to email/communicate with students in a regular basis.
5. The assessments techniques need to range from low stake formatives assessment to summative assessment that carries higher weighting. Informal, low stakes formative assessments would help build students confidence as they acquire required knowledge for application at the end of the unit.
6. Assessments also should include peer assessment and groupwork. Students need to get the sense of a community and peer/group work is the best way to get there.
7. Assessment should also incorporate various innovative and interactive online tools such as voice thread, google forms, socrative, mentimeter, pole everywhere, kahoot, flipgrid and so forth. However, instructors must test each tool beforehand and select ones that are free and less complicated to use.

Recommendation for Future Research

Future research would benefit from the following areas that will help establish a successful online CTE program that could benefit rural regions to build a skilled workforce:

1. Quantitative studies on factors related to student and instructor readiness for online teaching-learning online in CTE.
2. Qualitative studies to explore the challenges of online CTE for high school students in rural regions.
3. Research to compare CTE online for high schools in urban and rural areas.

4. Research to explore partnership with industries to provide activities based on real-world workplace skills in online CTE programs for high school students.

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Appendix A

Informed Consent Letter

Farjahan Shawon
Ph.D. Candidate
College of Education, Health and Human Sciences
University of Idaho
Moscow ID 83844

Date:

Dear:

You are invited to participate in the case study, **CTE online: An investigation of the NIMM program in North central Idaho and Southeast Washington**.

I am Farjahan Rahman Shawon, a graduate student at College of Education of University of Idaho and this study is for my doctoral dissertation. The purpose of this study is to examine the Northwest Intermountain Metal Manufacturers (NIMM) project, an online/hybridized manufacturing program that was implemented in high schools in North central Idaho and Southeast Washington- the operating region of the Northwest Intermountain Manufacturing Association (NIMA). Using a case study methodology, this study will focus on the issues, concerns, success and failures of the program. This study will provide a model for rural regions to implement online Career and Technical Education programs. It is hoped that findings from this study will provide a model to ensure CTE programs are available in an equitable manner for the diverse population living in rural regions.

Data will be collected through semi-structured interviews with the project team members, instructors of the course, in addition documentation and course will be examined. I would like to interview you to know about your experiences working on the NIMM project. The goal of my study is to explore the effectiveness, success and failure of the online CTE courses offered in NIMM project. The interview will take approximately 10-15 minutes and will be recorded. Your decision whether to participate will certainly not affect your future relationship with me. If you decide to participate, you are also free to discontinue your participation at any time without hesitation. All the information that you will provide will be used in research purposes only and presented anonymously. Data will be stored in a protected computer under the University of Idaho College of Education Health and Human Sciences server and only researcher can access the data. This study will not cause any extra benefit to you but in future people similar to your position may get benefit from the study. You will be offered a copy of this form to keep.

Please feel free to contact me for any further query on my mobile no. 208-892-9097 or by email at fshawon@uidaho.edu. Thank you very much for your time and cooperation in this academic endeavor.

Sincerely,

Farjahan Rahman Shawon

Participant's Consent:

I, __________________________ have read the information presented earlier and I am consciously agreeing to participate in this study.

Signature of Participant and Date